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Design and inkjet printing of a band-pass filter in the GHz range

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Abstract

This paper presents a radio frequency filter fabricated on a low cost substrate by inkjet printing of an ink composed of silver nanoparticles. The study focuses on the inkjet fabrication process and the setting of optimal printing conditions to achieve a band-pass filter working at 17 GHz. This radio frequency filter is, to our knowledge, the highest center frequency inkjet printed filter reported so far. The study demonstrates the potential of inkjet printing technology for high frequency filtering applications.

Keywords: inkjet printing, printing conditions, flexible substrates, band-pass filter, silver nanoparticles

1. Introduction

Printing processes are undergoing a major evolution toward the manufacturing of printed electronic devices. This evolution proceeds through an adjustment of existing printing equipment to new kinds of inks, which offer a whole spectrum of functional materials such as conductive nanoparticles (Lee, Chou and Huang, 2005), dielectric nanoparticles (Meyers et al., 2008), and organic semiconductors (Sirringhaus et al., 2000).

While printing processes cannot reach the nanometer resolution of photolithography, they allow patterning large areas with minimum gaps in the order of a few micrometers (Takano et al., 2010). Printing is a direct-writing and additive process, meaning that it delivers the exact quantity of required material, usually rare and expensive. Also, it is compatible with a large variety of substrates that can be rigid, flexible or even 3D shaped. These properties give printing technologies major advantages in the fabrication of large area devices. Such printed electronic components will not compete with silicon devices but rather target new opportunities and applications. As a consequence, the potential of printed functionalities is being explored for the fabrication of physical (Courbat et al., 2011; Sette, Mercier et al., 2013) and chemical sensors (O'Toole et al., 2009), and electronic components such as transistors (Sirringhaus et al. 2000).

The rapid development of telecommunication technologies, particularly in mobile devices and wireless applications, has boosted the demand for radio frequency (RF) components. In this field of application, printing technologies have played a major role in the manufacturing of radio frequency identification (RFID) tags in the Ultra High Frequency (UHF) range. All-printed RFID tags, including antennas and electronic components, have been fabricated using inkjet printing (Subramanian et al., 2005) and roll-to-roll printing (Jung et al., 2010). Several RF printed devices working in the GHz range have been developed, all using special substrates in order to reduce transmission losses. For example, antennas on liquid crystal polymer substrates at 60 GHz (Shaker et al., 2010), couplers on Chukoh substrates at 6 GHz (Arriola et al., 2011), and band-pass filters on alumina substrates at 2.4 GHz (Sridhar et al., 2009) have been demonstrated.

This paper describes the optimization of the inkjet printing process of conductive silver ink in order to achieve a 17 GHz band-pass filter on a polyimide substrate. The aim is to demonstrate that the inkjet printing process allows the manufacturing of RF devices on non-specific substrates that offer similar performance as devices fabricated by other techniques such as silicon micromachining (Blondy et al., 1998).

2. Filter design

The device to be printed is a two pole filter centered at 17 GHz. It has a 4 % bandwidth with transmission zeros to improve rejection. The filter is based on suspended microstrip lines enclosed between two brass cavities as shown in Figure 1, with coplanar feed lines to facilitate measurements.

The filter has been designed following the procedure detailed by Blondy et al. (1998) as well as by Hong and Lancaster (2001). The filter response has been computed and optimized using the Agilent Momentum software based on the method of moments. The layout is presented in Figure 1 and the optimized dimensions are given in Table 1. For further details, please, refer to the previous work of Sette, Blayo et al. (2013).

Table 1: Dimensions of the filter

	Length (µm)		Length (µm)
La	1 500	Lg	1 000
Lb	300	Lh	700
Lc	2 300	Li	2 200
Ld	800	Lj	500
Le	500	Lk	4 250
Lf	500	Ll	1 000

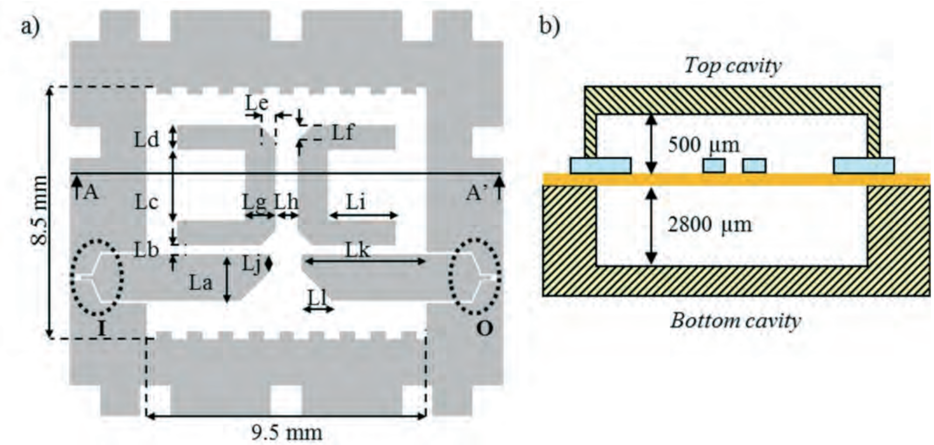

Figure 1: a) Top view of the printed pattern, b) Cross-sectional view along AA'

3. Filter fabrication

Printing a pattern with high conformity with the design relies on the equilibrium of the printing process, the ink rheological properties, and the substrate properties such as surface energy, porosity and roughness.

3.1 Topic analysis

Printing was done on a Dimatix DMP2800 printer with 21 µm side square nozzles. Each nozzle has a piezoelectric actuator that allows setting individual actuation voltages. Moreover, the printhead temperature can be adjusted. The substrate is held on a chuck that can be heated up to 60 °C. The input pattern format is binary bitmap. Droplet ejection can be observed using an embedded stroboscopic camera.

3.2 Ink and substrate properties

A commercial ink (Sun Chemical, n.d.), which is a colloidal dispersion of silver nanoparticles at 40 % in weight, was used to print the filter pattern on a 75 µm thick polyimide substrate (DuPont, n. d.).

The substrate surface energy measurement was carried out by the contact angle method using an OCA Dataphysics goniometer. The Owens-Wendt model (Owens and Wendt, 1969) was used to calculate the surface energy using five different probe liquids. For each liquid, the total surface energy σ^T, the dispersive component σ^D and the polar component σ^P are reported in Table 2.

Table 2:
Probe liquids for surface energy measurement and contact angle measured on Kapton HN

Surface tension at 25°C (mJ.m⁻²)	*Total σ^T*	*Dispersive component σ^D*	*Polar component σ^P*	*Contact angle (°)*
Water	72.8	21.8	51	73.9
Glycerol	63.4	37	26.4	70.4
Diiodomethane	50.8	50.8	0	38.7
Hexadecane	27.4	27.4	0	18.5
Bromonaphtalene	44.6	44.6	0	32.0

Five measurements of the contact angle for each probe liquid were made. The extracted value of the Kapton HN surface energy was 39 mJ.m-2 and the R^2 of the linear fit value was 0.86. The ink surface tension was measured on the same equipment using the pendant drop method.

This resulted in a value of 24 mJ.m-2 with a standard deviation of 8 mJ.m-2 on five measurements. The ink had a viscosity of 13.5 mPa.s measured on an Anton Paar Physica MCR 301 rheometer at 25°C and 1 000 m.s-1.

The measurements of the ink rheological properties and the substrate surface energy are in agreement with the manufacturers' data reported in Table 3. The filter performance improves with the electrical conductivity of the printed layer. Silver nanoparticle ink was chosen since it allows reaching conductivities higher than 10^7 S.m-1. The polyimide substrate was selected because of its low dielectric constant and tolerance to temperatures up to 400 °C. Moreover, it has a smooth surface and poor porosity, which prevents major defects on the printed layer and nanoparticle permeation into the substrate.

Table 3: Ink and substrate properties

Ink EMD5714 - SunChemical (SunChemical™)		
Viscosity at 25°C	10-13	mPa.s
Surface tension at 25°C	27-31	mJ.m-2
Density at 25°C	1560	kg.m-3
Substrate Kapton HN 75 µm - DuPont (Dupont™)		
Surface energy	46	mJ.m-2
Relative dielectric constant	3.5	-
Thermal Coefficient of Expansion	20 (Huang, 2003)	ppm/°C

3.3 Printing process

The main ink solvent was ethanol, thus the nozzle temperature was set to ambient to prevent solvent evaporation which may cause clogging at temperatures higher than 35 °C. The actuation voltage was set to approximately 23 V at a 5 kHz firing frequency resulting in a 14 µm diameter droplet, which corresponds to a volume of 11 pL.

During droplet formation there was no visible satellite droplets and the filament completely disappeared at 300 µm from the nozzle. The jetting waveform recommended by the ink supplier is illustrated in Figure 2. The meniscus was set to 5 in. of H_2O.

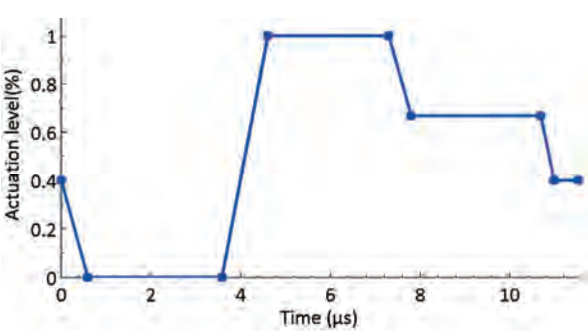

Figure 2: Jetting waveform

For pattern resolutions higher than 555 pixels/cm, corresponding to an 18 µm pitch between droplets, borders are well defined during printing, although a few minutes afterwards the ink spreads under the influence of gravity and the pattern loses its shape. Decreasing the resolution leads to a dewetting phenomenon during drying at ambient temperature as shown in Figure 3. In conclusion, high resolution brings too much matter and the gravity effect causes ink spreading, while the affinity between the ink and the substrate is not adequate for lower resolutions that hinder ink spreading. These unwanted phenomena were eliminated by accelerating the drying step by heating the substrate chuck to 60 °C. The best printing definition on the polyimide film was obtained at 476 pixels/cm (21 µm pitch) when heating the printer chuck to 60 °C.

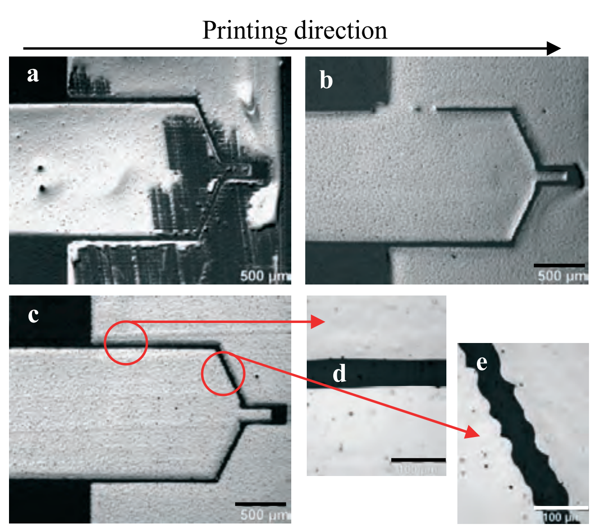

Figure 3:
a) Ink dewetting,
b) Ink spreading,
c) High quality printing,
d) Pattern edges parallel to printing direction,
e) Pattern edges not parallel to printing direction

3.4 Pattern design

The most critical parts to print are located at the input/output (I/O in Figure 1) lines of the filter. The gap between the feeding strip and the ground plane is 50 µm and just one single pixel connecting those two elements will cause a critical short-circuit. Figure 3 illustrates that edges parallel to the printing direction are well defined while the droplet shape (pixel) is visible when the printing direction is at an angle to the border orien-tation. The input binary bitmap pattern was created using the layout software CleWin4™. The automatic conversion from the desired design to a discrete pixelated pattern generates random and irregular spacing on the I/O feed-lines patterns. The random arrangement of the pixels has been identified as a cause of failure during the printing. To overcome this, the pixels of the border were manually set in a regular arrangement, e.g., as in Figure 4, and different configurations of spacing were printed in order to approximate the desired design while obtaining a reliable and repeatable printing.

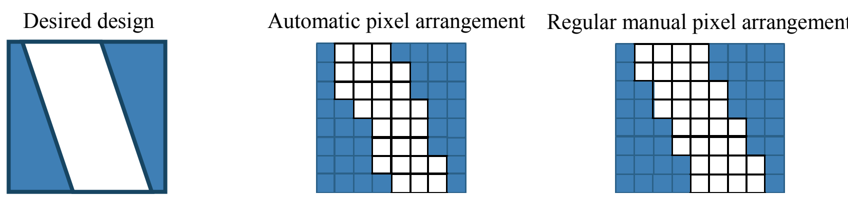

Figure 4: Examples of pixel arrangement

3.5 Annealing

Once the pattern is printed and dried, annealing is necessary to evaporate the remaining solvent, to burn organic compounds such as surfactants and nanoparticle steric coating and, finally, to activate nanoparticle coalescence. The annealing was performed in an oven and the conditions are specified in section 4.2.

Nanoparticles exhibit a melting temperature which depends on their size (Buffat and Borel, 1976). This property allows for modifying the microstructure of the printed silver layer at temperatures much lower than the bulk silver melting temperature, 961 °C (Slade, 1999), making the annealing step compatible with organic substrates. The Atomic Force Microscopy (AFM) scans in Figure 5 illustrate the surface modification of the printed layer at different annealing temperatures.

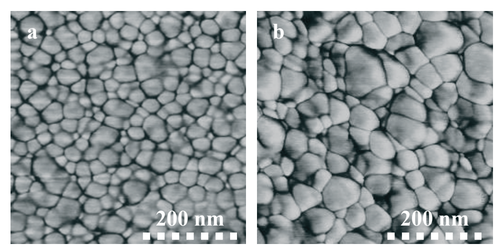

Figure 5: Phase data of AFM scans on the surface of printed silver ink under different annealing conditions, a) 150 °C - 1h, b) 250 °C - 1h

When increasing the temperature, the grain size increases while their number drops. The evolution of the granular microstructure of the printed layer has a strong effect on both its mechanical and electrical properties. The dependency of the electrical properties of the printed silver layer on the annealing temperature is studied in depth in the next section.

4. Experimental results

4.1 Electrical conductivity of the printed silver layer

The electrical conductivity of the silver printed layer is highly dependent on the annealing temperature. To study this dependency, conductivity measurements were performed using a four-point method on 1 mm² van der Pauw patterns (van der Pauw, 1958) printed on a SiO_2/Si substrate (see Figure 6). The silicon substrate was selected for its stability up to 1 000 °C. A silicon thermal oxide of 1 µm thickness was grown to ensure electrical isolation between the printed silver layer and the silicon. Also, SiO_2 has a similar surface energy as Kapton HN, thus the same printing parameters can be applied.

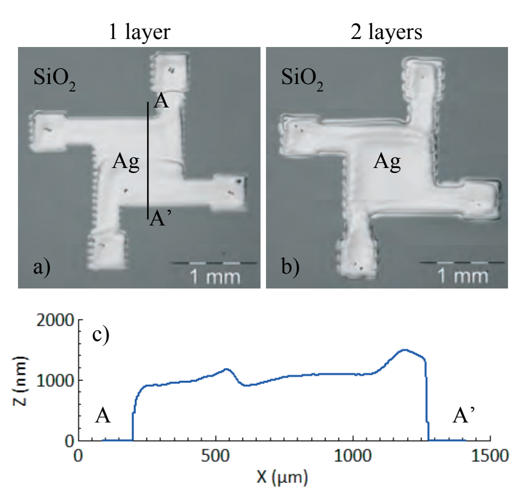

Figure 6: Van der Pauw patterns printed on SiO_2/Si substrate. a) One layer, b) Two layers, c) Profile AA'

Spring probes were used in order to prevent damaging the patterns and the electrical measurements were made using a Keithley 2182A nanovoltmeter. The electrical conductivity of the printed layer σ can be extracted using equation [1].

$$\sigma = \frac{1}{R}\frac{\ln(2)}{\pi t} \qquad [1]$$

R is the resistance of the van der Pauw patterns and t is their thickness. The measured thickness and the extracted conductivity are plotted as functions of the annealing temperature in Figure 7.

The electrical setup allows measuring the resistance of the van der Pauw patterns with high precision. However, an error in the conductivity extraction is introduced by the thickness measurement of the printed layer. Indeed, both on the top view microphotographs and in the profile in Figure 6, the thickness of the printed layer appears to be irregular. For the conductivity extraction, a mean value of the thickness, calculated from the ratio of the volume to the surface measured by optical interferometry, has been opted for.

The thickness of the printed layer decreases with increasing annealing temperature, indicating a densification of the microstructure. At the same time, the electrical conductivity increases, reaching near bulk values. The van der Pauw patterns with two printed layers exhibit both increased thickness and conductivity.

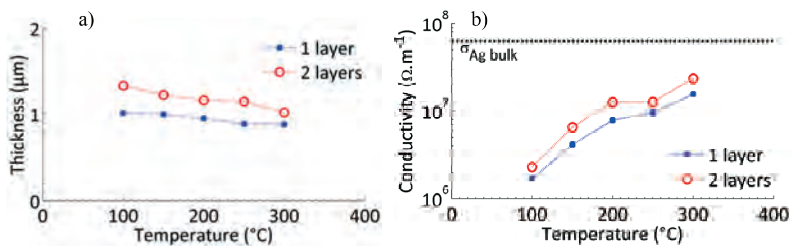

Figure 7:
a) Measured thickness of the printed van der Pauw patterns,
b) Extracted conductivity

The observed increase of conductivity is in agreement with the grain size evolution. Indeed, losses of electrical conduction in thin polycrystalline films occur at the grain boundaries, which behave like potential barriers to cross for the electrons (Sondheimer, 1952). A decrease in the grain number leads to a decrease of the grain boundaries and thus the conduction losses are reduced.

For annealing temperatures above 300 °C, the microstructure of the printed layer continues to evolve and the grain size reaches several micrometers. The thickness of the layer becomes highly irregular and the electrical contact with the spring probes is subjected to random contact resistances. As a consequence, even if electrical measurement is possible, the extraction of the intrinsic conductivity of the printed layer cannot be relevant.

4.2 Filter electrical properties

The observed relationship between electrical conductivity and annealing temperature led us to use the following annealing conditions: 220 °C during one hour.

The values of thickness and conductivity extracted from van der Pauw patterns printed on Kapton near the filter are given in Table 4.

Table 4: Conductivity of the printed layers

Number of passes	Thickness (µm)	Conductivity (S.m⁻¹)
1	0.85	1.4×10^7
2	1.30	1.5×10^7

Even though the increase in conductivity is smaller than 10 %, the layer printed with two passes better covers substrate defects and the surface state is more homogeneous, which highly decreases transmission losses.

4.3 Filter assembly

The final step in fabricating the filter is the assembly of the printed layer with top and bottom cavities. The top cavity is glued with silver paste on the ground plane while the substrate is glued with Araldite® on the bottom cavity. Both cavities are electrically connected with silver paste. Figure 8 shows the final device with top cavity open.

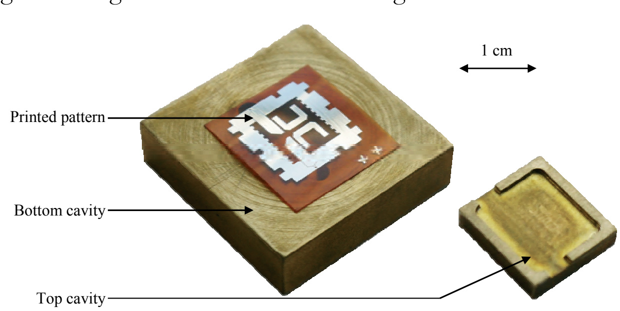

Figure 8:
Printed band-pass filter

4.4 Frequency response of the filter

The filter response was measured using an Agilent N5230A vectorial network analyzer and a SOLT calibration (Short, Open, Load, Thru). The measurements presented in Figure 9 show both the response of the one printed layer and the two printed layers filters. The filters are centered at 17 GHz and have a 4% bandwidth. The insertion loss (S21), corresponding to the attenuation of the transmitted signal in the passband value is 5.7 dB for the one layer filter and decreases to 3.6 dB for the two layers filter. Such a decrease in insertion loss is equivalent to an increase of a factor 1.6 in the signal amplitude.

For both filters, the return loss (S11) is better than -10 dB on the whole bandwidth and the rejection up to 20 GHz is better than -20 dB.

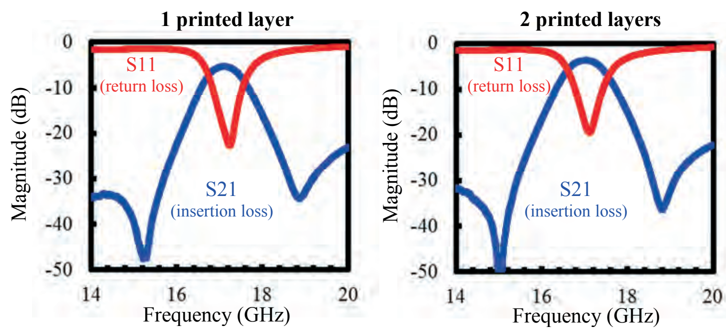

Figure 9: Measured response of filters printed with one and two layers

The improvement in the filter performance is due to a higher conductivity that decreases the conduction losses and a more homogeneous silver layer in the case of the two printed pattern.

In Figure 10 are plotted the measured response of the two printed layers filter and the simulation performed using the experimental value of pattern conductivity. There is a good agreement between simulated and measured response. The small observed shift may arise from the misalignment of the top cavity with the silver pattern and the irregular shape of the silver pattern. Indeed, the simulation considers the conductive layer as a bulk material with straight borders and steps. The shift may also arise from the porosity of the printed layer, the pixelated shape borders and the non-homogeneous thickness, which can cause significant skin effects at such high frequencies.

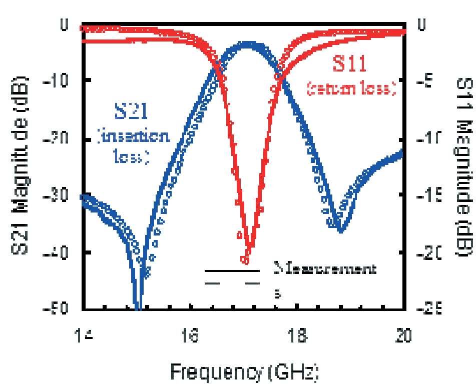

Figure 10: Measured and simulated response of the filter including metallic and dielectric losses

5. Conclusions

In this paper, we have presented an inkjet printed filter on polyimide substrate which has, to our knowledge, the highest center frequency reported so far.

Printing parameters on a Dimatix DMP2800 have been optimazed in order to achieve a printed pattern with high conformity with respect to the design. When dealing with inks loaded with metallic nanoparticles, an annealing step is necessary to trigger and improve the electrical properties of the printed pattern. The changes in these properties have been studied in depth at temperatures up to 300 °C, showing that the extraction of the intrinsic conductivity is a major issue because of the irregular thickness of the printed layers.

This work demonstrates the opportunity of using inkjet printing technology for the fabrication of RF devices working at frequencies higher than 10 GHz. Inkjet printing is a versatile technology which allows for simple development of inkjet printed millimeter-wave devices on ultralow-cost substrates.

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Surface properties of flexographic printing plates related to UVC post-treatment*

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Abstract

Flexography is a printing technique mostly used in packaging printing. Flexographic printing plates are made of photopolymer materials, formulated to meet mechanical and qualitative requirements in the graphic reproduction process. The printing plate making process includes three exposures to UV radiation, and post-treatment with exposure in the UVC wavelength range. The post-treatment has to be performed in order to terminate the photopolymerisation process. During the transfer of the printing ink from the printing plate to the printing substrate, the surface properties of the printing plate strongly influence the quality of the imprint. The aim of this paper is to determine the influence of the UVC post-treatment of a flexographic CtP printing plate on its surface properties by analysing contact angle, surface free energy and energy-dispersive X-ray spectroscopy (EDS). The results indicate that UVC post-treatment influences the printing plate's physico-chemical surface characteristics by changing the contact angle and the surface free energy components. This could result in a negative influence on the process of printing ink transfer from the printing plate to the printing substrate. EDS analysis shows that the changes in contact angles of probe liquids and surface free energy are caused by the increase of oxygen concentration in the surface layer of the printing plate, while Fourier transform infrared spectroscopy (FTIR) analysis points specifically to an increased ratio of carbonyl and hydroxyl bonds. Therefore, the duration and intensity of UVC post-treatment must be strictly controlled and regularly monitored in order to avoid unwanted changes of surface properties of the flexographic printing plate and, consequently, of its behaviour in the printing process.

Keywords: flexography, photopolymer, CtP, UVC post-treatment, contact angle, surface free energy, EDS, FTIR

1. Background

1.1 Flexographic printing plates - development, composition and production

Flexography is a printing technique of high complexity. Formerly used mostly for printing on corrugated board, this technique has developed and is nowadays applied to printing of various packaging materials and to printed electronics (Kipphan, 2001; Brajnović, 2011).

Formerly, printing plates for flexography were manufactured from rubber by means of mechanical methods. Because of the properties of the rubber material, these printing plates were applied to production of low-quality imprints used in packaging printing (Page Crouch, 2005). Following the development of synthetic polymer materials, the quality of flexography improved.

During the past years, the term "HD flexo" has described a new quality standard in flexographic reproduction, competing with that of offset printing.

Modern flexographic printing plates are based on the photopolymerisation of certain organic compounds under the exposure of UVA and UVC radiation, producing large and stable molecular structures insoluble in the defined developing solution. The composition of this type of printing plates includes different types of copolymers, most commonly styrene-butadiene-styrene (SBS) and styrene-isoprene-styrene (SIS) block copolymers, photoinitiators sensitive to UV radiation, plasticizers which provide elastic properties, colorants, and other additives. When exposed to UV radiation, the photoinitiator activates, double bonds in the structure break and a process of radical photopolymerisation occurs. The unexposed parts of the printing plate are then washed in a developing solution (Knoll, 2002; Matsubara and Oda, 2011). Depending on the type of developing solution used, flexographic printing plates can be solvent-washable or water-washable. The solvents used in the washing process are organic-based, volatile solutions.

Ecologically, water-washable printing plates are far more acceptable. Furthermore, water-washable printing plates do not require a stabilization period as solvent-washable plates do due to the swelling of photopolymer material in organic solutions (Theopold, Neumann, Massfelder and Dörsam, 2012).

The most common methods of image transfer from a computer file to the printing plate are based on Laser Ablated Mask Layer (LAMS) and Thermal Imaging Layer (TIL) technology. When producing printing plates using LAMS technology, the black mask layer - LAMS - must be ablated by means of a laser on the image area of the printing plate. After the ablation process, the printing plate is exposed to UV wavelengths (Bodwell and Scharfenberg, 2011). However, during the period between laser ablation and UV radiation, the photopolymer material is exposed to the destructive influence of oxygen in the air, resulting in round-top printing elements on the printing plate. TIL technology overcomes this problem by imaging the TIL layer separately and laminating it on the printing plate after the imaging process, starting the exposures to UV radiation immediately. The barrier layer, which is part of the TIL, inhibits the influence of oxygen on the printing plate.

1.2 Quality parameters in flexographic printing plate production

Many parameters influence the quality of the final product in flexography: the photopolymer material used in printing plate production (Matsubara and Oda, 2011), the quality of the file adjustment (i.e., the specific correction curves applied to the original image), the type of anilox roller, the type of base placed under the printing plate to regulate the pressure, the properties of the printing ink and the printing substrate, and a set of parameters associated with the printing plate production (Brajnović, 2011; Mahović, Cigula and Tomašegović, 2012).

When starting the process of flexographic printing plate making, one should, in addition to following the instructions by the plate manufacturer, adjust several parameters as well. The time of back and main exposure, the power output of the UV tubes, the pressure of the scrubber in the developing process, the temperature and saturation of the developing agent, the drying temperature, the stabilization period for solvent-washable plates and the post-treatment must be all adjusted to the specific system used.

In the graphic reproduction process, the transfer of printing ink from the anilox roller to the printing plate and finally to the imprint depends on the surface properties of the materials used. Since the printing plate is in the middle of the ink transfer chain, its surface free energy must be adequate to achieve an optimal transfer of the tone values from the anilox roller to the final product (Mahović, Cigula and Tomašegović, 2012; Page Crouch, 2005). The aim of this paper is to determine the influence of the post-treatment process on the printing plate, or more accurately, the influence of the UVC post-treatment on the contact angle of different liquids and the surface free energy of the printing plate. These insights can be used to determine the allowable tolerances in the UVC post-treatment.

Existing standards in flexography are mainly focused on process control concerning screen ruling and parameters related to process colors, printing substrates and dot gain (International Organization for Standardization, 2006). Further analysis and experiments have to be performed regarding the influences of printing plate quality on the graphic reproduction process.

Earlier research related to flexographic printing plates and UVC exposure in the plate making process has pointed out the influence of the duration of exposure on the performance of the printing plate in the printing process (Johnson, 2008), and the changes which occur on the printing plate surface when prolonging the post-treatment process (Andersson, Johnson and Järnström, 2009). However, the character of these changes and their importance for the graphic reproduction should be systematically determined. Therefore, the connection between surface phenomena, chemical changes in the photopolymer material and the potential influence on the reproduction process should be studied and elaborated.

2. Experimental settings

In this study, full-tone samples of solvent-washable MacDermid Digital Max flexographic printing plates with a thickness of 1.14 mm were used. Back and main exposure were performed in conditions defined for the specific workflow, taking into consideration the power of the UV tubes and the duration of the exposure. The developing process, stabilization and UVA post-treatment were also carried out under standard conditions, but the duration of the UVC post-treatment was varied. Standard conditions for the printing plates and production system used imply 4 minutes of UVC post-treatment (wavelength of ~255 nm, 18 $mWcm^{-2}$). In order to determine the influence of different duration of UVC post-treatment on the surface characteristics of the printing plate, samples used in this study were varied from a low UVC post-treatment duration (1 minute) to the extreme of 14 minutes in steps of 1 minute. When the UVC post-treatment reached 14 minutes, the chemical changes detected in the surface layer of the photopolymer material stabilized.

On the printing plate samples, contact angles of different probe liquids and surface free energy were measured by means of a goniometer, Data Physics OCA 30. Contact angle and surface free energy of the probe liquid are parameters which are used for calculating the surface free energy of the solid samples. Three probe liquids of known surface free energy were used for the measurements: water, glycerol and diiodomethane (Table 1). Contact angle was measured using the sessile drop method, ten times for each sample, on different parts of the printing plate. The shape of the probe liquid drops was a spherical cap and the volume of the drops was 1 μl. All measurements of the contact angle on the samples were performed at the same moment after the drop touched the photopolymer surface - with a delay of 5 frames - and the average value was calulated (Dataphysics Instruments, 2006; Owens and Wendt, 1969).

Table 1: Surface free energy (γ_{lv}) and its dispersive (γ^d_{lv}) and polar (γ^p_{lv}) components for probe liquids

Liquid	*Surface free energy γ (mNm⁻¹)*		
	γ_{lv}	γ^d_{lv}	γ^p_{lv}
Diiodomethane (Ström et al., 1987)	*50.8*	*50.8*	*0.0*
Glycerol (van Oss et al., 1997)	*64.0*	*34.0*	*30.0*
Water (Ström et al., 1987)	*72.8*	*21.8*	*51.0*

The mean value of the contact angle for each sample was calculated. Surface free energy was calculated using the OWRK method (Owens and Wendt, 1969), applicable for polymer, aluminium and coatings characterization. The results of the contact angle measurements enable calculation of the surface free energy and its polar and dispersive component [Equation 1]:

$$\frac{(1-\cos\theta)\cdot\gamma_s}{\sqrt[2]{\gamma_l^D}} = \sqrt{\gamma_s^P}\sqrt{\frac{\gamma_l^P}{\gamma_l^D}} + \sqrt{\gamma_s^D} \qquad [1]$$

where γ_s is the surface tension of the solid, γ_l is the surface tension of the liquid, γ^D the dispersive part of the surface tension, γ^P the polar phase of the surface tension, and θ the contact angle (Van Oss et al., 1993).

In addition to the surface free energy calculation, energy-dispersive X-ray spectroscopy (EDS) was used for further characterization of the printing plate surface (Figure 1).

Energy dispersive X-ray spectroscopy (EDS) is a technique which works by detecting X-rays that are produced by a sample placed in an electron beam and analyzes the elemental composition of the sample. EDS has a sensitivity of >0.1 % for elements heavier than C and is performed together with scanning electron microscopy (SEM) (Inca Energy, 2009).

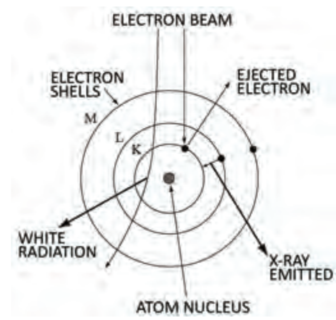

Figure 1: Principles of energy-dispersive X-ray spectroscopy

Electron beams that bombard the sample cause the ejection of electrons from the atoms. The resulting electron vacancies are filled by electrons from a higher state, and an X-ray is emitted to balance the energy difference between the states of the two electrons. Each element has characteristic emitted X-ray energy peaks. Moreover, elements can have more than one characterristic peak, and some peaks from different elements can overlap. The spectrum of X-ray energy is used to determine the elemental composition of the sampled volume (Herguth and Nadeau, 2004). In this experiment, a JEOL JSM-6460 low-vacuum device (1 - 270 Pa) with a tungsten electron source was used.

To further explore the results obtained by EDS analysis, Fourier transform infrared spectroscopy (FTIR) was used. FTIR spectroscopy is a technique used to identify the presence of certain functional groups in the molecule. IR radiation does not have enough energy to induce electronic transitions in a sample. Therefore, absorption of IR is restricted to compounds with small energy differences in the possible vibrational and rotational states which are specific for different functional groups and bonds. Vibrations and rotations at a certain wavelength in the IR area are detected by IR spectrometry and can help in determining molecular composition and impurities in the sample (Coates, 2000). In our study, the FTIR spectrometer Avatar was used.

3. Results and discussion

The results of the contact angle and surface free energy measurements as well as of the energy-dispersive X-ray spectroscopy indicate that UVC post-treatment causes noticeable changes in the chemical structure of the photopolymer surface, which result in changes in the surface free energy and in the distribution of its polar and dispersive component. Figure 2 shows the influence of different UVC post-treatment durations on the contact angle after application of water and glycerol.

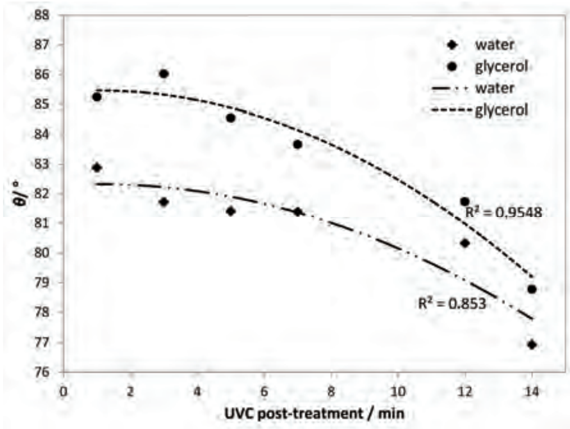

Figure 2: Contact angle of water and glycerol on the examined flexographic printing plate as a function of UV post-treatment duration

In Figure 2 we can see that, by prolonging the UVC post-treatment, the contact angle θ of both water and glycerol decreases, with a final difference between the first (1 minute of UVC post-treatment) and the last sample (14 minutes of UVC post-treatment) of approximately 8°. Water is a liquid of primary polar character while glycerol is a liquid of both polar and non-polar (dispersive) characteristics. The contact angles of both water and glycerol are relatively high, with values between 77° and 86°. The values obtained were highly stable and reproducible, with deviations not greater than 3%. The contact angle of diiodomethane is not displayed in Figure 2. It amounts to approximately 52° and we observed deviations of maximally 1° due to UVC post-treatment variation.

The deviations of the contact angle of the probe liquids from the contact angle on the sample with the standard duration of UVC post-treatment of 4 minutes can be seen in Figure 3. $\Delta\theta$ can be described as a difference between the contact angle of a particular liquid for each variation in the duration of UVC post-treatment and the contact angle of the specific liquid at the standard duration of UVC post-treatment [Equation 2]:

$$\Delta\theta = \theta_t - \theta_4 \quad [2]$$

The contact angle of diiodomethane deviates from the contact angle of the standardly produced sample by only up to 1°, while water and glycerol show more considerable deviations, up to 6°. These results show that it is important to monitor and adjust the UVC post-treatment in accordance to the contact angle value necessary for the correct transfer of the printing ink, especially if water-based, from the printing plate to the printing substrate.

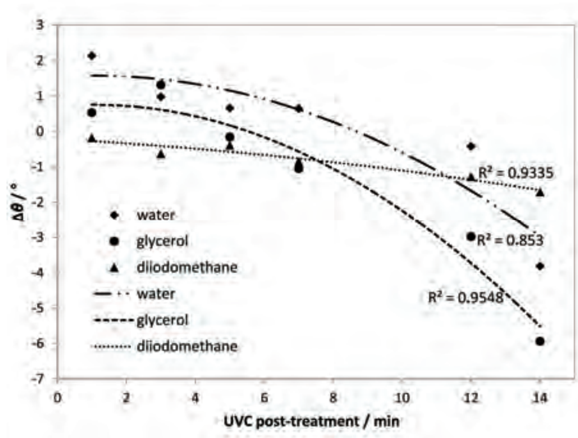

Figure 3: Changes in contact angle in comparison to the sample with standard UVC post-treatment

In Figure 4, the differences between the surface free energy of different variations in UVC post-treatment duration and that of the standardly prepared sample are shown.

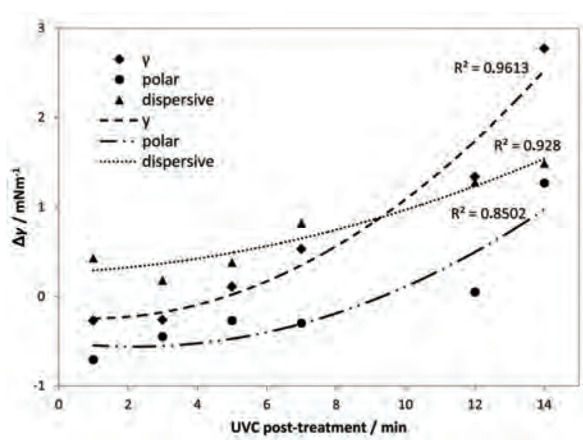

Figure 4: Changes in surface free energy in comparison to the sample with standard UVC post-treatment

Similarly to the $\Delta\theta$ in Figure 3, $\Delta\gamma$ can be described using Equation 3:

$$\Delta\gamma = \gamma_t - \gamma_4 \quad [3]$$

Figure 4 displays the changes in the surface free energy. The total surface free energy of the sample with the standard UVC post-treatment of 4 minutes was 31.85 mNm^{-1}.

With prolonged UVC post-treatment, total surface free energy and both its polar and dispersive components increase, with more pronounced enhancement of the polar component. After the surface free energy calculation, the EDS method was applied in order to define and characterize the changes in the surface free energy.

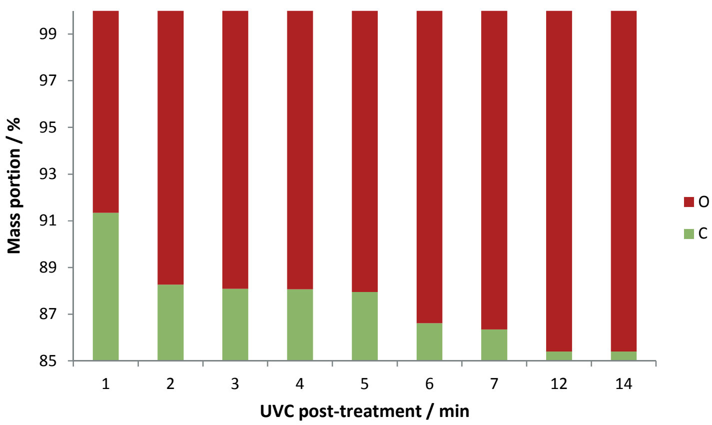

Figure 5: EDS analysis of the samples showing the mass proportions of carbon (C) and oxygen (O)

The EDS analysis shows that an increased duration of UVC post-treatment results in a higher mass proportion of oxygen in the photopolymer surface (Figure 5).

One can see that the mass ratio of oxygen increases from 8.66 % with 1 minute to 14.60 % with 12 and 14 minutes of UVC post-treatment. The UVC radiation is used in flexographic printing plate production in order to terminate the photopolymerisation process. In earlier steps in the flexographic printing plate making process, photopolymerisation is induced by UVA radiation, but UVC radiation of higher energy than UVA is necessary in order to remove stickiness from the printing plate.

The EDS analysis indicates that prolonged UVC exposure causes placement of the radicals containing oxygen on the photopolymer chain ends or their insertion in the macromolecule, thereby increasing the polar component of the surface free energy. Hence, the changes in contact angle of the polar liquid (water) and the liquid with a share of polar phase (glycerol) is caused by an increase of the oxygen concentration in the surface layer of the photopolymer (Lee et al., 2004). In addition, the increase of the dispersive component of the surface free energy is probably caused by changes in intermolecular forces which can be also caused by the UVC radiation energy (McKeen, 2013).

In Figures 6 and 7, we can see the FTIR spectra of samples exposed to shortest and longest UVC exposure, respectively. The FTIR analysis supports the results obtained by means of the EDS analysis. The main differences in spectra are visible in the region of 3 200 to 3 500 wavenumbers per centimeter and 1 650 to 1 750 wavenumbers per centimeter.

The areas of interest correspond to vibrations of hydroxyl (OH) and carbonyl (C=O) bonds, respectively. Therefore, the increased mass proportion of the oxygen in the EDS analysis can be explained by an increased proportion of hydroxyl and carbonyl bonds in the sample with an UVC exposure of 14 minutes. Both groups increase the polarity of the surface, resulting in a lower contact angle of the applied polar liquid and an increased polar component of the surface free energy.

This could result in inadequate adsorption of a printing ink with surface properties adapted to the flexographic printing process and printing substrates to the printing plate, and therefore cause problems in the graphic reproduction process (Galton, Bould and Claypole, 2010). Furthermore, chemical changes which occur in the photopolymer structure as a result of prolonged UVC post-treatment appear to have similar effect as an oxidation process.

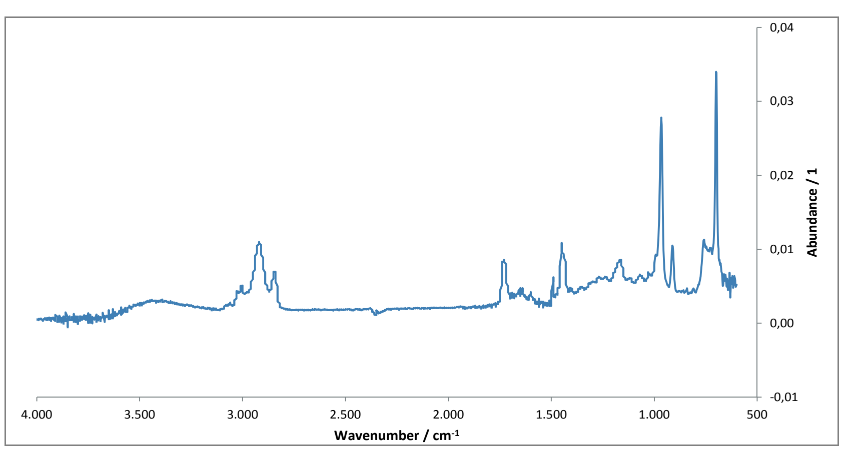

Figure 6: FTIR analysis of a printing plate sample exposed to UVC radiation for 1 minute

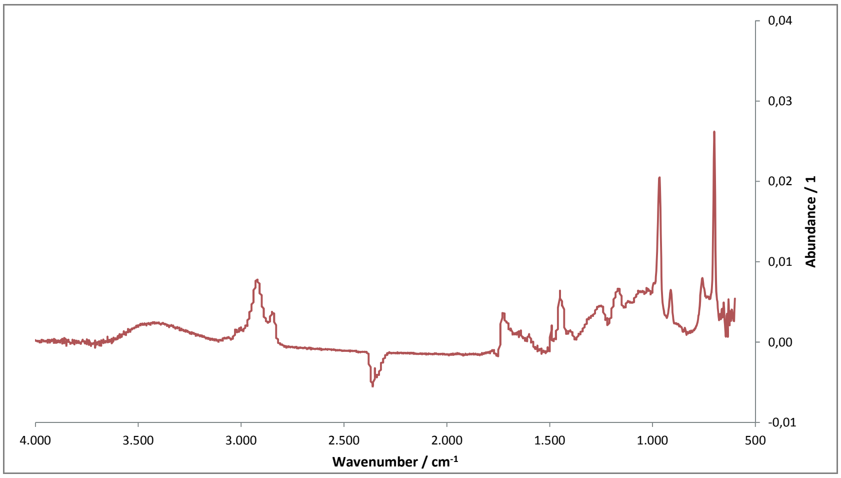

Figure 7: FTIR analysis of a printing plate sample exposed to UVC radiation for 14 minutes

In order to examine the mechanism of UVC radiation impact on the photopolymer surface and the wetting process, measurement of the contact angle hysteresis should be performed. Also, chemical changes in the photopolymer related to UV-induced progression and/or termination of the photopolymerisation process could affect the hardness and roughness of the printing plate. Therefore, in further research, the impact of UVC post-treatment will be studied with the aim of determining not only the changes in the chemical and surface properties of the photopolymer material but also the changes of mechanical properties which occur in the material.

4. Conclusions

In the process of flexographic printing plate production it is very important to be acquainted with the properties of the photopolymer material of which the flexographic printing plate is made. These properties, apart from mechanical features such as hardness and elasticity, include physico-chemical characteristics that are important in the graphic arts reproduction process.

In this study, contact angle measurements and surface free energy calculations were performed on samples of flexographic printing plates produced with variations in the duration of the UVC post-treatment. The measurements indicate that prolonged UVC radiation results in lower contact angle, primarily of the polar probe liquid, leading to an increase in the total surface free energy.

Moreover, EDS analysis shows that the reason for the surface free energy increase with prolonged UVC post-treatment time could be the higher amount of the oxygen in the surface layer of the flexographic printing plate. This assumption was confirmed by means of FTIR analysis which shows an increased amount of hydroxyl bonds in the surface layer of the photopolymer material. Therefore, the increase in the dispersive phase of the surface free energy could also be induced by changes in intermolecular forces caused by UVC radiation.

Based on the information obtained in this study, we can conclude that changes in the surface free energy can influence the process of printing ink transfer from anilox roller to the printing substrate in the flexographic reproduction process. Taking into account the different types of printing substrates used in flexography, with their specific surface free energy and their ability to adsorb different types of printing inks, the surface properties of the printing plates must be strictly controlled and monitored. Modification of the surface free energy of the flexographic printing plate could easily alter the quality of the final product, resulting in unwanted consequences for the high quality flexography present on the market nowadays. In future studies, other types of photopolymer materials will be tested in order to expand the application of the current findings to other types of flexographic printing plates.

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Investigation of the effect of ink penetration and gloss on a proposed spectral trapping model for high quality glossy coated paper

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Abstract

The amount of trapping has a great impact on the gray balance and color reproduction of printed products. Therefore, conventional print density based models to estimate the effect of trapping have been created, which only give percentage values. In an earlier paper (Hauck and Gooran, 2011) we have proposed a trapping model based on reflectance spectra, which defines the trapping effect as the ΔE^*_{ab} colorimetric differences between the measurements and the calculated values. Therefore, this model is more useful and meaningful for the press machine operators than the conventional trapping models. The surface (gloss) and ground (ink penetration) effect may have an impact on the print results depending on the substrate and inks but these effects have mainly been ignored in all previous trapping models. In the present paper, we extend our earlier model to investigate the impact of both effects for high quality glossy coated paper and a set of sheet-fed offset inks. An ink mileage test was carried out to find the surface and ink penetration effects. The results of our investigation demonstrates that these two effects compensate each other and their total impact is almost negligible for the tested materials. This means that our previously proposed model can successfully be used for high quality glossy coated papers to determine the trapping value.

Keywords: ink trapping in offset, ink component penetration, surface effects on reflectance, color difference (ΔE^*_{ab}), print quality, modeling ink trapping response

1. Introduction

In a multicolor offset printing machine, the process inks (KCMY) are printed consecutively on the substrate in one printing unit after the other. The dots in different ink units are printed either isolated, or partly or completely overprinted and the overprinted inks are printed wet on wet. The thickness or the amount of the second printed ink on the first one is not the same as when the second ink is printed on the paper. This phenomenon is called trapping. Trapping varies due to different parameters such as ink temperature, dampening (Hauck, 2007a; 2009), printing speed, etc. Trapping affects the gray balance and the color appearance (secondary and tertiary colors) of the printed products. Therefore, it is very important to have an explicit value for measuring trapping.

There are different conventional trapping models, such as Preucil (1952), Childer (1980), Brunner (Du Pont, 1979), Ritz (1995), Hamilton (1989) and Viggiano and Prakhya (2008), all trapping formulas named after their inventors, which give a trapping value based on the amount of the second printed ink on the top of the first one in percent. The Preucil and Ritz models are the most well known trapping models, and they will briefly be discussed in the following section.

In order to determine the trapping value, it is necessary to make a comparison between the ideal (calculated) and the actual (printed and measured) overlapping. The actual (real) overlapping is the measured overlapped reflectance value of two different overprinted inks in solid image areas (e.g., magenta on cyan which results in blue). The ideal overlapping is calculated using the reflectance of both single printed inks on paper, which results in an "absolute value" or a "best value" (Figure 1). Although both the first and the second single printed inks changes the incoming light due to the surface effects (such as gloss, etc.), the surface effects only play a role for the second (over-)printed ink in the actual overlapping. On the other hand, the ink penetration plays a role mainly for the first (under-)printed ink in the actual overlapping. In the design of all trapping models proposed so far, the surface effects and ink penetration are ignored in the calculation of the ideal overlapping.

In a previous paper, we have proposed a spectral trapping model for calculating the trapping value (Hauck and Gooran, 2011). One of the advantages of this model in relation to the conventional models is that the trapping is presented by a color difference value, ΔE^*_{ab}. In this model (Hauck and Gooran, 2011) the effects of ink penetration (ground effect) and gloss (surface effect) were ignored.

In the present paper, we propose a modification to this model in order to take into account the ink penetration and the gloss effect. Furthermore, we compare the results of these two proposed spectral trapping models by carrying out experiments on a high quality glossy paper.

We will first give a short introduction to the Preucil and Ritz conventional trapping models, followed by a brief description of our previous spectral trapping model. The modification of the previous model in order to consider ink penetration and gloss is thoroughly described. Finally the experimental results are illustrated.

2. Previous work

2.1 Conventional formulas

As mentioned above, the conventional trapping models are based only on density (Kipphan, 2008). In this section we give a short introduction to the two most well known conventional models, i.e., those designed by Preucil (1953) and Ritz (1996). These conventional formulas for trapping only provide the amount of the second printed ink on the top of the first one in percent. This value on its own (e.g., 63 %) is not very useful or meaningful for printing machine operators.

The results obtained through these formulas also differ from each other. At the 63th Annual Conference of TAGA in Pittsburgh, a new trapping model based on reflectance spectra for computation of trapping was introduced (Hauck and Gooran, 2011) and this will be described later in this section.

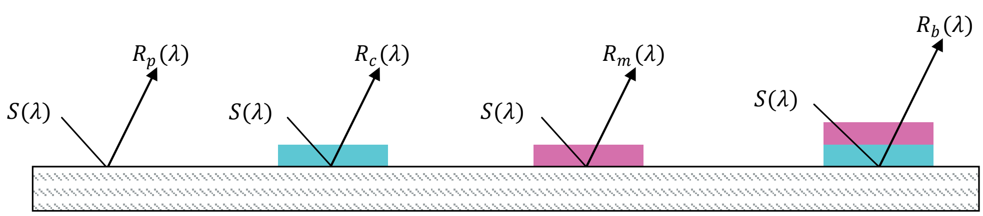

Figure 1: A schematic of a solid value print involving paper, cyan, magenta and ideal ink overlapping

2.2 The Preucil trapping formula (Preucil, 1995)

The overprinting of cyan and magenta inks is illustrated in Figure 1. A simple method for measuring and evaluating the trapping value is given by the Preucil formula (Equation 1). Here, the overprint of cyan (density D_1) and magenta (density D_2) results in a blue color (density D_{12}). Tr is the amount of trapping which is always less than 1.

$$D_{12} = D_1 + D_2 . Tr \qquad [1]$$

We factor out Tr and obtain Equation 2, which is the Preucil trapping formula, multiplied with 100 to achieve a percentage value:

$$Tr = \left(\frac{D_{12} - D_1}{D_2}\right) \cdot 100 \qquad [2]$$

2.3 The Ritz trapping formula (Ritz, 1995)

Ritz used the Murray Davies model and modified it as follows:

$$R_{12} = R_1 + R_2 \ . \ Tr + (1 - Tr) \ . \ R_P \qquad [3]$$

where,

R_1: denotes the reflectance of the first printed ink
R_2 : denotes the reflectance of the second printed ink
R_{12}: denotes the reflectance of the overlapped printed inks
R_p: denotes the reflectance of paper

which gives Equation 4:

$$Tr = \frac{R_P - (R_{12} - R_1)}{R_P - R_2} \qquad [4]$$

Equation 4 can be written using the density value multiplied with 100:

$$\mathrm{Tr} = \left[\frac{1-10^{-(D_{12}-D_1)}}{1-10^{-(D_2)}}\right] \cdot 100 \qquad [5]$$

which is the Ritz formula for determining the percentage of the trapping value.

2.4 Our earlier model

Our earlier model is based on the reflectance spectra, and the determined trapping value is not "only" a percentage value (Hauck and Gooran, 2011). The effect of trapping in this model is presented as the color difference, which is much more understandable and useful for the printing machine operators. The color difference is computed between the calculated overlapped and the measured overlapped spectra. For a single printed ink, for example cyan and magenta in Figure 1, the reflectances $R_c(\lambda)$ and $R_m(\lambda)$ can be calculated by Equation 6 and 7, respectively. $R_p(\lambda)$, $T_c(\lambda)$ and $T_m(\lambda)$ denote the reflectance of the paper, the transmittance of full-tone cyan and the transmittance of full-tone magenta, respectively. Note, that the incoming light passes through the ink layer twice before it is reflected back. The reflectance of the overlapped inks, in this case magenta printed on cyan (blue), is calculated by Equation 8.

$$R_c(\lambda) = T_c^2(\lambda).\,R_p(\lambda) \qquad [6]$$

$$R_m(\lambda) = T_m^2(\lambda).\,R_p(\lambda) \qquad [7]$$

$$R_b^{calculated}(\lambda) = T_c^2(\lambda).\,T_m^2(\lambda).\,R_p(\lambda) \qquad [8]$$

Inserting Equations 6 and 7 in Equation 8 gives Equation 9, which is the calculated overlapped spectral reflectance based on the reflectance of the single inks printed on paper and the reflectance of the paper.

$$R_b^{calculated}(\lambda) = \frac{R_c(\lambda)\cdot R_m(\lambda)}{R_p(\lambda)} \qquad [9]$$

For the calculation of trapping, both the measured and the calculated overlapped spectral reflectance of blue is needed.

In the next step, the XYZ tristimulus values have to be calculated from the spectral reflectance of the measured overlapped spectrum and the calculated overlapped spectrum.

The calculation of X, Y, Z according to the CIE recommendation is as follows (Equation 10).

$$X = \frac{100}{\sum_\lambda S(\lambda).\bar{y}(\lambda)\Delta(\lambda)} \,.\sum_\lambda R(\lambda)\,.\,S(\lambda)\,.\,\bar{x}(\lambda)\,\Delta(\lambda) \qquad [10]$$

The other two tristimulus values (Y and Z) are calculated correspondingly. From the XYZ tristimulus values the Lab values are determined (Kang, 2006). The Lab values in our test are calculated using X_n, Y_n, Z_n for the light source D50 and the CIE 1976 standard observer (2° observer).

In a last step, the ΔE^*_{ab} is calculated between the theoretically overlapped ink values and the measured overlapped ink values according to the CIE 1976 color difference (Equation 11).

$$\Delta E^*_{ab} = \sqrt[2]{[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]} \qquad [11]$$

where ΔL^* denotes the difference between the L value of the measured reflectance and the L value of the reflectance of the calculated (ideal) overlapping. Δa^* and Δb^* denote the differences in a and b color coordinates.

Figure 2 shows the correlation between the trapping value according to ΔE^*_{ab} and the conventional models according to percentage value, which exhibits a linear trend. It can also be observed that the dynamic range of the Preucil model is larger than that of the Ritz model. However, the dynamic range of our proposed model is the largest as demonstrated in Figure 2.

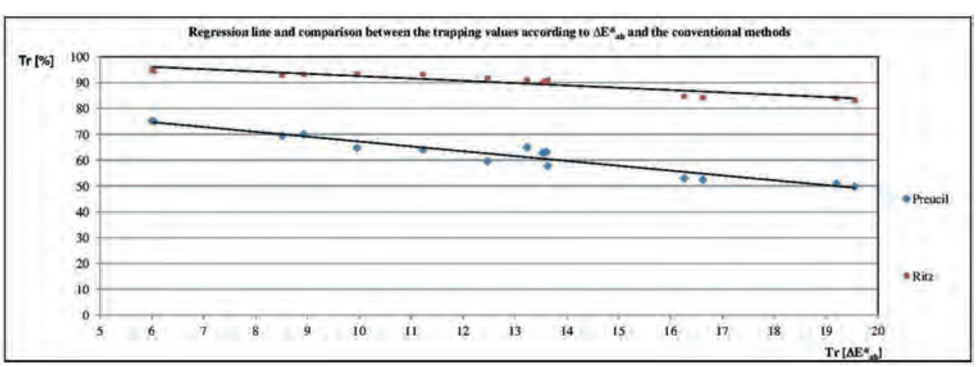

Figure 2: The correlation between the Trapping Value according to ΔE^*_{ab} and the conventional models

The main improvement in our earlier approach is the extension of the very low dynamic range of the conventional models into a more sensitive and understandable trapping value (ΔE^*_{ab}), which helps the printing machine operator to differentiate the results of trapping much better and thereby to react faster and control the printing process earlier (Hauck and Gooran, 2011). Another advantage of this model is that, unlike the conventional density models that can only determine the trapping value for process inks, this spectral model can determine the trapping value both for process inks and special inks.

3. Modification of the spectral trapping model

3.1 Ink penetration and gloss

As discussed above, the previously proposed trapping models ignore gloss and ink penetration, (see Figure 1). In this paper, we expand our earlier trapping model to take into account also ink penetration and gloss effects.

Ink penetration has a great impact on the print result. In order to explain ink penetration we would like to clarify the following concepts: ink components, separation effect, penetrability of different substrates, and ink drying and absorption.

Ink components: Conventional offset inks may contain the following elements: colorant agents (pigments, organic as well as certain inorganic pigments), vehicles (hard resins, alkyd resins, vegetable and mineral oils), auxiliaries (waxes, drying agents (siccative), fillers, inhibitors) and thinners (mineral and/or vegetable oils) (Ink academy, 2013).

Separation effect: The paper coating is a barrier for the ink, resisting penetration (Ozaki, Bousfield and Shaler, 2008). The preparation of the paper fibers and the calendering process in the paper manufacturing process can also be important for the behavior of the penetration of ink components (Schoelkopf et al., 2003a; 2003b). The fresh printed ink penetrates (with all of its components, i.e., pigments, vehicles, auxiliaries and thinners) into the layer of the paper coating and the paper fibers in a way that is dependent on the separation effect. The separation effect is a result of the capillary characteristics of the paper fibers and the structure of the coating layer on the paper. Just like a sieve filled with a mixture of particles, the surface characteristics of the paper separates some components of the ink (mostly colorant pigments) from the other components of the ink (such as the ink vehicle). The amount of penetration depends on the average diameter of pores and the capillarity of the sieve mesh. If the pore diameter is small enough, mainly the oil penetrates into the paper while the colorant pigments and parts of the vehicle remain on the surface. This is called ink vehicle penetration. If the pore diameter is large (or there is no coating layer as in newsprint), both colorant pigments and vehicle can penetrate (ink penetration) into the paper, leading to an increase in reflectance and a reduced density and color saturation of the printed ink (Ink academy, 2013). It is important to mention that because of the separation effect the different ink components (pigments, vehicles, auxiliaries and thinners) do not penetrate equally into the paper. Usually, for a high quality glossy paper (the paper investigated in the present research), most of the colorant pigments remain on the coating surface. But the pore and capillary diameter of the tested paper (and its coating) does not create absolute (100 %) barrier.

Penetrability of different substrates: According to the penetration and separation effect, printing substrates can be categorized into three groups: non-penetrative (metal sheet, plastic and foil), partly penetrative (e.g., glossy coated paper, which is investigated in this study), and totally penetrative (uncoated paper, newsprint). For non-penetrative substrates neither the ink vehicle nor the rest of the ink components can penetrate into the substrate. For a penetrative substrate, mainly the ink oil and partly the auxiliaries, thinners and ink vehicle can penetrate into the substrate (this is a time dependent process). Depending on the paper fibers, the coating mixture and the calendering process of substrate, the number of penetrated pigments into the coating varies but most of the pigments remain on the surface while only a small portion of the pigments penetrate into the substrate. For a totally penetrative substrate, all ink components penetrate into the paper. Hence, in order to achieve the target ink density, the thickness of the printed ink has to be greater than in the other two cases in order to compensate for the high rate of ink penetration.

Ink drying and absorption: Conventional offset inks dry chemically, physically or, mostly, as a combination of both (as the ink investigated in our study). Chemical drying means that when the ink vehicles (vegetable oils and alkyds) are exposed to atmospheric oxygen, they polymerize to form a tough, elastic film which fixes the ink on the stock. This process is generally referred to as "oxidative drying", and represents the most common form of chemical drying. Chemical drying of inks can be described as cross-linking of components and can take many hours. Physical drying means that mineral oils and many esters of vegetable oils do not polymerize when exposed to air, as drying oils do, but they penetrate into absorbent substrates and separate from the other ink components. This specific form of physical drying is called "setting". The absorption process is an interaction between ink and printing substrate (Rousu et al., 2000). The absorption rate is dependent on the diameter and the number of the pores and the viscosity of the ink vehicle. Larger pore diameters result in a higher absorption rate. The higher the viscosity of the ink vehicle, the lower the absorption rate. As discussed above, the coating layer of a high glossy paper sieves most of the ink pigments onto the surface. But, depending on the coating quality of a high glossy paper, the diameter and form of the paper fibers, and the colorant pigment size, some pigments can also penetrate into the paper. Due to the ink penetration, the reflectance increases and the density decreases (Yang, Lenz and Kruse, 2001). It must be observed that the ink vehicle penetrated into the paper (print-underlying coating of paper) results in a reduction of the refractive index (air changes to ink vehicle), which leads to a loss of reflectance (increase of density). This means that the ink penetration into paper may have two opposite effects on the reflectance. As will be shown later in Figure 6, the total effect of ink penetration into the paper causes a decrease of density (increase of reflectance) after the drying process is completed. Please note, that from now on in this paper the term ink penetration is used to denote mainly ink vehicle penetration and only a minor pigment penetration of ink into the coating layer of the paper. Combination drying means that the drying process is a combination of physical and chemical drying. Most modern inks for conventional offset printing dry both physically and chemically (Ink academy, 2013).

In addition to ink penetration, gloss has also an impact on the reflectance (density) of the print. The fresh printed ink is at first uneven, wavy and hence not glossy. Very rapidly it will acquire a relatively even and glossy surface. Part of the incoming light will be specularly reflected at the surface of the printed ink and will therefore not pass though the ink layer. The gloss therefore has an effect on the measured results depending on the physical and optical principles of the measuring device. The gloss value of the fresh printed ink changes with time after the printing. The drying process starts immediately after the printing and continues until the ink is completely dry. Because of the fast drying of the upper layer of the ink surface compared to the lower layers, the ink builds a rough skin and crust, which reduce the gloss effect. Because of this rough skin, more incoming light will be absorbed in the same measuring area (2D- to 3D-effect). This effect causes a decrease of the reflectance and consequently an increase of the density, assuming that no ink penetration occurs. This explains the fact that sometimes the gloss value and also the reflectance decreases after printing (on plastic or foil which have no ink penetration). This paradoxical behavior of gloss is also illustrated and demonstrated later in Figure 6.

In Figure 3 we show the relationship between the reflectance levels for the first and second single printed inks, the actual overlapping (printed and measured overlapping), and our previous model. As illustrated, in reality the effective thickness of magenta is smaller if magenta is printed on cyan than on the paper (because of trapping). As mentioned before, the cause of this effect (trapping) is wet on wet printing. Therefore the reflectance level of the actual overlapping is higher than the ideal overlapping in our previous model (due to trapping). The difference between these two cases in CIELab was approximated as the effect of trapping in our previous model.

In our modified model we take into account the gloss and ink penetration effect on high quality glossy coated papers. As we know, the ink penetration of magenta leads to a lower density. If we now exclude the ink penetration effect of magenta in our proposed model, it will mean that the effective thickness of magenta is larger than that in our previous model, as illustrated in Figure 3.

As the surface effect is generally smaller than the ink penetration, especially for cyan and yellow (on the materials used in our test), the effective thickness of cyan is almost the same in both models.

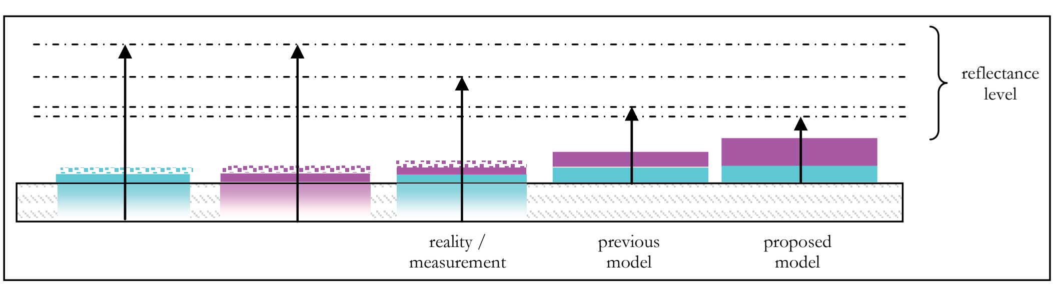

Figure 3:
A schematic of a solid value print involving paper, cyan including gloss and ink penetration, magenta including gloss and ink penetration, actual ink overlapping, our previous overlapping model and the proposed modified model

In the modified model, we wish to approximate the trapping effect when the measurements are done at 30 seconds (wet). This is the average time that the press operator needs to measure the fresh printed sheets. For simplicity, let us describe the case for blue (magenta on cyan).

We take 30 seconds as our reference point and study what happens between 30 seconds and 48 hours. All that has happened before 30 seconds is of no interest in this study. It is also very difficult for the operator of a sheetfed offset press to carry out the measurements of the fresh printed sheet before 30 seconds.

In order to have a realistic model for trapping we need to take into account the ink penetration for cyan and the surface effect (gloss effect) for magenta. Our modified model will then be as in Equation 12.

$$R_{b,model}(\lambda) = \left[T_m^{meas,wet}(\lambda) \cdot T_m^{gl}(\lambda) \cdot T_c^{meas,wet}(\lambda) \cdot T_c^{ip}(\lambda)\right]^2 \cdot R_p(\lambda) \quad [12]$$

$R_{b,model}(\lambda)$ denotes the reflectance of blue (cyan on magenta) according to our proposed model when the measurements are done at 30 seconds (wet). $T_m^{meas,wet}(\lambda)$ and $T_c^{meas,wet}(\lambda)$ denote the measured transmittance for single magenta and single cyan at 30 seconds, respectively. $T_m^{gl}(\lambda)$ and $T_c^{ip}(\lambda)$, denote the transmittance of the gloss effect for magenta and the ink penetration for cyan, respectively.

It can be argued that the effects of gloss (which is dependent on the shrinking and roughness of the ink surface) and ink penetration (ink vehicle penetration) are normally not mutually independent. This will be discussed in detail at the end of section 3.2.

Please observe that in equation 12 the following relationship is valid between the transmittance and reflectance of the measurement data.

$$[T^{meas}(\lambda)]^2 = \frac{R^{meas}(\lambda)}{R_p(\lambda)} \quad [13]$$

3.2 Approximating gloss and ink penetration

In order to determine the gloss and ink penetration effects, we perform an ink mileage test. Note, that the ink mileage is not a measure of ink penetration but a complex combination of transfer dynamic, ink solids content, rheology of the ink, surface energy relationships, roughness of surface and blanket, etc. In this study, our goal is to use the ink mileage test to determine the interaction between paper and ink. A typical use for the ink mileage test is to determine the relationship between the density or reflectance of an ink and the printed ink volume. The procedure is as follows:

A definite ink volume (a few grams) will be filled into an inking unit. During the rotation and oscillation of the rollers the ink will be distributed in the inking unit (Figure 4-A). At the inking unit, a printing form (a small cylinder with an offset printing blanket) is inked up for a limited time (in our tests for 1 minute). The printing form is removed from the inking unit and weighed on a precision balance (Figure 4-B) prior to the printing procedure. During printing, part of the ink is transferred onto the printing substrate (Figure 4-C). After the printing procedure, the printing form is removed from the inking unit and weighed again on the precision balance. The weight difference of the printing form before and after the printing is the weight of the printed ink. The exact amount of ink weight per unit area [g m^{-2}] can be determined by the ratio of the weight of the printed ink and the size of the printed area (in our case 102.5 cm^2).

It is important to perform the sampling of ink mileage with the highest possible accuracy. The accuracy of the ink mileage test has a great impact on the accuracy of the results of the trapping model. All our experiments were carried out at 22° C at a relative humidity of 55 %. The pressure and printing speed were constant all over the sampling time.

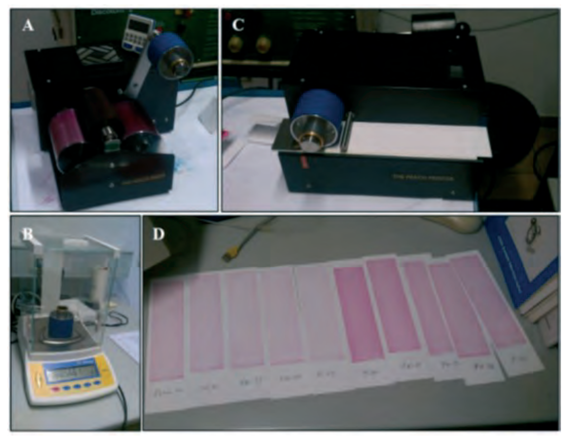

Figure 4: Ink mileage test and the needed equipment. 4-A) inking unit and the printing form. 4-B) the precision balance and the printing form. 4-C) the printing unit with mounted printing form and the printing substrate. 4-D) the produced sample with different density and reflectance dependent on the used ink weights per unit area (g m^{-2})

We performed the ink mileage test using the same glossy paper as in our experiments with the offset press. In addition to the ink mileage test on paper, we also printed on foil. A coated paper has both surface effect and ink penetration. But a foil only includes gloss and has no ink penetration, which is important for the separation and determination of both the gloss and the ink penetration. A white foil with similar surface roughness as the coated glossy paper used was used in order to have similar printing conditions (Figure 5).

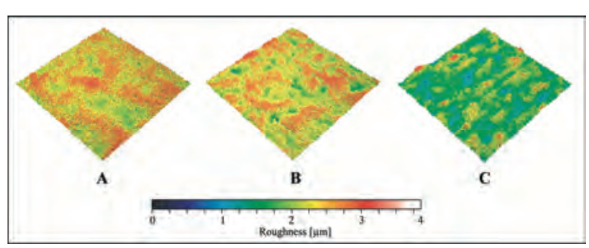

Figure 5: The roughness of the surface of our sample paper and of two different foils. The roughness is visualized using different colors. A) the roughness of the paper used, B) the roughness of a foil with a similar roughness as the paper used, C) a foil with a very even and smooth surface comparable to the paper used. At the bottom, a colored scale shows the level of roughness in µm

During the ink mileage test we printed ten different ink weights per unit area [g m^{-2}] for paper and foil and used the same cyan, magenta and yellow inks as in the test offset press.

For each of the ink weights per unit area [g m^{-2}] and substrate (paper and foil) we measured the density and the reflectance spectra as well as the gloss value between 30 seconds and 48 hours.

Figure 6 shows the relationship between the relative density and the ink weights per unit area for magenta on both paper and foil. The curves show the cubic spline interpolation for the ten data points.

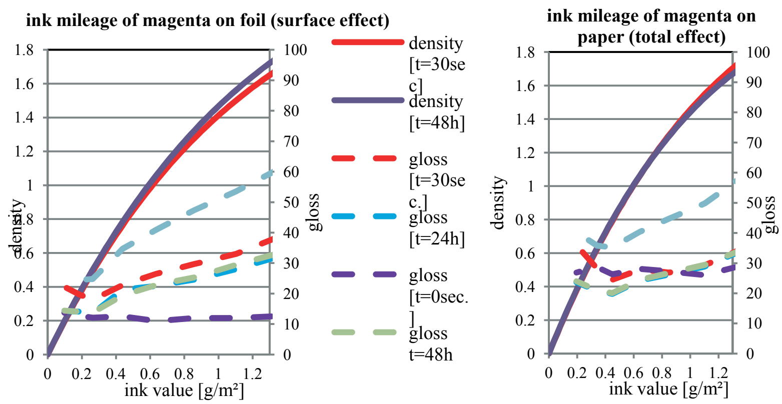

Figure 6: Graphs of the results of the ink mileage test for magenta ink. It demonstrates the relationship between density and ink weight per unit area [g m^{-2}] for magenta. Each graph shows the wet (red curve) and dry density (blue curve). Left: magenta ink printed on foil (including only the surface effect). Right: magenta ink printed on the sample paper (including the surface effect and ink penetration). For both substrates, the gloss values (dashed lines) are measured at different times

For each single printed ink on the offset sample we measure the density at 30 seconds and 48 hours. For example, the relative density for magenta in our test print is 1.43 at 30 seconds and 1.40 at 48 hours. Then one of these two densities is used to find the ink mileage by using the corresponding curve in Figure 6 (right part curves for paper). Since we have used the same paper in offset printing and in the ink mileage test, the density of the paper is the same in both cases. The difference between the density at 30 seconds and 48 hours (Figure 6) gives the total effect (gloss and ink penetration) at this ink mileage. The density difference at the same ink mileage in the curves for foil in Figure 6 (left part) gives the gloss effect. Note, that the curves shown in Figure 6 are for magenta. Cyan and yellow have their own corresponding curves.

We noticed that the cyan and yellow inks that we used dried out slower than the magenta ink. We also observed that an ink that dries fast has a stronger gloss effect. As discussed in section 3.1, the reason is that during this fast drying process the ink surface builds a rough skin and crust. The building of this rough skin is dependent on the drying speed, which depends on the type of the ink, the ink volume and the drying room temperature. Because of this rough skin, more incoming light is absorbed (2D- to 3D-effect), which can lead to an increased density (reduced reflectance level). Hence, the gloss effect for the magenta ink used in our experiments is more evident than that for the other two inks.

In order to find the ink penetration for magenta to be used in our modified model (see Equations 14 and 15) we need to use the spectrum for magenta on paper and foil (not the density), once after 30 seconds and once again after 48 hours. As discussed above, when printing on foil there is no ink penetration involved in the measurements. Therefore, the difference between the density at 30 seconds (wet) and 48 hours (dry) on the foil is approximated to be only the gloss effect, see Equation 15, which is positive for magenta and almost zero for cyan and yellow in our experiment.

$$D^{gl} = D_{dry}^{foil} - D_{wet}^{foil} \qquad [14]$$

where D^{gl}, D_{dry}^{foil} and D_{wet}^{foil} denote the density of the gloss effect and the density of the dried and wet ink on foil, respectively. Equation 14 can be expressed for transmittance spectra by Equation 15.

$$T^{gl}(\lambda) = \frac{T_{dry}^{foil}(\lambda)}{T_{wet}^{foil}(\lambda)} \qquad [15]$$

On the other hand, the density difference of the inks on the paper at 30 seconds and 48 hours depends on both ink penetration and the gloss effect, see Equation 16.

$$D^{total} = D_{dry}^{p} - D_{wet}^{p} \qquad [16]$$

where D^{total}, D_{dry}^{p} and D_{wet}^{p} denote the density of the total effect (gloss and ink penetration) and the density of the dried and wet ink on paper, respectively. When we now exclude the gloss effect (Equation 15) from the total effect (Equation 16) we can find the ink penetration effect (D^{ip}), see Equation 17.

$$D^{ip} = D^{total} - D^{gl} = (D^{p}_{dry} - D^{p}_{wet}) - (D^{foil}_{dry} - D^{foil}_{wet}) \quad [17]$$

As discussed in section 3.1, the effects of gloss and ink penetration are normally not mutually independent. The reason is that the gloss is a function of roughness associated with the substrate, the amount of ink applied and ink vehicle penetration in relation to ink setting. The reason why, in the proposed model, these two effects are assumed to be independent is to make the model feasible and simple. But the investigated foil and paper were also chosen in a way that supports this assumption.

First of all, a foil with similar surface structure as the paper was chosen (Figure 5). The measured gloss values of paper and foil before print (t=0, Figure 6) are far from each other, although they have similar surface structure. The reason is that even if the structure of both substrates are similar, the surface materials are different (paper and foil) and hence have different refracttive indices. On the other hand, the measured gloss value of the fresh printed ink and especially the completely dried ink on paper is close to those printed on the foil (the gloss value is around 30 gloss points in Figure 6). The reason is that now both surfaces are covered by the same kind of ink layer and have a similar roughness. This shows that we can assume that, regardless of the ink vehicle penetration, we can treat these two effects (gloss and ink vehicle penetration) independently in our investigation and with the materials we have used.

Equation 17 can be expressed for the transmittance spectra as in Equation 18.

$$T^{ip}(\lambda) = \frac{T^{total}(\lambda)}{T^{gl}(\lambda)} = \frac{T^{p}_{dry}(\lambda)}{T^{p}_{wet}(\lambda)} \cdot \frac{T^{foil}_{wet}(\lambda)}{T^{foil}_{dry}(\lambda)} \quad [18]$$

Inserting Equations 15 and 18 into Equation 12 results in Equation 19.

Note, that the indices c and m in Equation 19 stand for cyan and magenta.

$$R_{b,model}(\lambda) = \left[\frac{T^{meas,wet}_{m}(\lambda) \cdot T^{p}_{c,dry}(\lambda) \cdot T^{foil}_{c,wet}(\lambda) \cdot T^{foil}_{m,dry}(\lambda) \cdot T^{meas,wet}_{c}(\lambda)}{T^{p}_{c,wet}(\lambda) \cdot T^{foil}_{c,dry}(\lambda) \cdot T^{foil}_{m,wet}(\lambda)}\right]^2 \cdot R_p(\lambda) \quad [19]$$

Let us now explain Equation 19. It is assumed that the measurements (of the printed cyan and magenta at the printing press) are done at 30 seconds. $T^{meas,wet}_{m}$ is the measurement result of the transmittance of magenta around 30 seconds. Note, that we actually measure the reflectance, which can be transformed to transmittance by Equation 18. $T^{meas,wet}_{c}$ is the measurement result of the transmittance of cyan around 30 seconds. $R_p(\lambda)$ is the reflectance of the paper. The remaining variables in Equation 19 are known from the ink mileage experiment data and the necessary interpolation. Equation 19 thus gives a prediction of the reflectance of blue when the print is dried out, considering the gloss and ink penetration effects. In order to find the trapping value, this predicted reflectance has to be compared with the reflectance measurement of the printed blue at the press around 30 seconds. The ΔE^{*}_{ab} difference between these two reflectances gives the trapping value. For red (yellow on magenta), and green (yellow on cyan), Equation 19 can be modified correspondingly.

Note, that for black (yellow on magenta on cyan), cyan only has ink penetration, magenta has neither ink penetration nor gloss effect, and yellow only has gloss effect.

4. Experimental results and discussion

In order to compare the results of our earlier model with those of its modification, we carried out an experiment. In the experiment we used a high quality glossy paper and a sheet fed offset press.

Table 1 and Table 2 illustrate the trapping values for red (m+y), green (c+y), blue (c+m) and black (blue+y) using our earlier model and its modified version, respectively.

Table 1: The result of the earlier spectrometry based trapping model

	combination	measured overlapping data			calculated overlapping data			ΔE Trapping value
		L*	a*	b*	L*	a*	b*	
Earlier model	m+y	46.7	68.7	46.3	46.6	67.0	59.7	13.5
	c+y	52.3	-67.1	38.5	52.6	-63.1	43.6	6.5
	c+m	24.5	23.8	-47.5	20.6	26.7	-48.1	4.9
	blue+y	22.9	0.5	0.5	16.3	9.0	10.7	14.8

Therefore, in the results in Table 2, the gloss and ink penetration effect are included. A comparison between Tables 1 and 2 shows that the effect of trapping was somewhat underestimated in our earlier model. It is worth emphasizing that all conventional trapping models underestimate the effect of trapping. As seen from these two tables, the maximum difference between the trapping values of these two models is almost 1 ΔE^*_{ab} for the primary color and less than 2 ΔE^*_{ab} for the tertiary color. For our target paper substrate, which was a high quality glossy coated paper, we can conclude that our earlier, simple model, works satisfactory.

Table 2: The result of the modified spectrometry based model, which takes into account the ink penetration and gloss effect

Modified model	combination	measured overlapping data			calculated overlapping data			ΔE Trapping value
		L*	a*	b*	L*	a*	b*	
	m+y	46.7	68.7	46.3	46.7	67.5	61.0	14.7
	c+y	52.3	-67.1	38.5	52.9	-64.5	44.4	6.4
	c+m	24.5	23.8	-47.5	20.7	28.2	-49.2	6.0
	blue+y	22.9	0.5	0.5	15.9	9.7	12.5	16.6

Note, that the proposed model has been applied to a high quality glossy paper and the ink mileage test was done using a foil with a similar surface structure as the paper. For a totally penetrative paper, the proposed model may need modifications since the model considers the effects of the ink penetration and gloss independently.

5. Future work

Normally all ink mileage tests are carried out without any dampening solution. The dampening solution in the ink evaporates into the air. Hence the control of the concentration of dampening in ink/dampening emulsification is necessary.

It does not make sense to do an ink mileage test with dampening without a strict control and balancing of the dampening level. Therefore it is difficult to use dampening in an ink mileage test. Hence our ink mileage tests were done without dampening solution.

As mentioned before, the achieved results are acceptable. Nevertheless it is important to discuss how the accuracy of the estimation of the surface effect and ink penetration can be increased.

We would like to suggest the following two approaches for future research:

1) Fountaining of dampening solution in the inking unit of the ink mileage equipment. For future tests we recommend to fountain the dampening solution very precisely by using a jet-dampening system (Hauck, 2007a). Such a unit can be controlled in a closed loop system using the dampening measurement sensor.

2) A closed loop system for the precise measurement of dampening concentration in the ink/dampening emulsification. For future tests we recommend to measure and control the concentration of dampening solution using microwave technology in a microwave sensor (Hauck, 2009).

6. Used material and equipment

In this paper we have investigated the drying parameters and effects of conventional ink systems, i.e., excluding UV-ink systems. Our proposed model works especially well with oxidation inks or alternatively also with combination inks (oxidation and penetration). In this paper we have focused on glossy coated paper with 150 g m^{-2}. We used the following materials and equipment:

- Paper for the ink mileage test and for the offset printing: Sappi, Mega Gloss, 150 g m^{-2}
- Blanket for the ink mileage test and for the offset printing: Vulcan Folio
- Inks for the ink mileage test and for the offset printing: printcom, S118V
- Spectrophotometer: Gretag Spectroeye. Setting: no polarization filter, absolute, D50, DIN-NB (for density).
- We also used the ink mileage equipment of Thwing-Albert EUROPE and a precision balance with the ability to measure 0.0001 grams. We printed on a manroland R710 DirectDrive printing machine in the Print Technology Center of the manroland company in Germany.

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Consumer attitudes towards AR applications in Finland and Canada

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Abstract

This study aims to understand consumer attitudes towards augmented reality (AR) applications. The work was carried out with students and professionals in Finland and Canada as users, in order to investigate the similarities and differences between Finnish and Canadian consumers, following up on a study conducted by Gauttier and Schubert (2011), which was conducted in France and Russia. To understand the consumer attitudes towards AR applications, focus group interviews were carried out in both Finland and Canada. The Finnish group was composed of participants from the Nordic countries. The focus group interviews were analysed and statements for testing were drawn from the analysis. Q-sort analysis was then used for further testing.

AR is seen as offering great potential for innovation. People would like to try the applications and would also find time for using them. AR is still a new technology for applications targeted toward consumers. The study participants valued the pragmatic aspects of the experience more than the hedonic ones, which is typical for new technologies. The expectations placed on AR applications are clearly high. In the results minor differences between countries were identified, however, users in both regions were very positive towards the use and future development of the technology. Moreover, using Q-sort methodology allowed the researchers to develop a framework of six user types. This framework can be used for further research as well as being useful for marketers who need to target specific groups of consumers.

Keywords: augmented reality, consumer perception, mobile media, Q-sort

1. Introduction

1.1 Augmented reality (AR)

Augmented Reality (AR) is a technology that augments virtual information on top of a camera view of the real world in real time. The virtual content and real world form a new combined environment, typically visible on a display screen (Azuma, 1997; Höllerer and Feiner, 2004; Vallino, 1998). The benefits of utilizing AR technology, as well as the user experience and acceptance of information presented in this way are still unclear. While most studies in the field are case based and not easily generalizable, a user-centric study by Seisto et al. (2012) focused on the technology acceptance of magazine advertisements that utilize AR technology. In this study, we focus on mobile media applications.

1.2 User experience of augmented reality applications

User experience is a widely used term in several research areas although there is no uniform theory of experience, and there is a multitude of definitions for the concept of 'user experience'. The role of emotion is in the centre of any human experience and, thus, it is an essential component of user experience in all disciplines (Forlizzi and Battarbee, 2004). Typically, an experience is divided into different components or levels. For example, according to Desmet and Hekkert (2007), experience can be divided into aesthetic experience, experience of meaning, and emotional experience. Hassenzahl (2003) has identified that a product's features, such as content, presentation, functionality and interaction, affect pragmatic and hedonic attributes of the product character.

The pragmatic and hedonic attributes, together with the context of use, can lead to an appealing, pleasurable and satisfactory experience. Buccini and Padovani (2007) have identified six classes describing user experience. These have been applied by Olsson (2013) in the context of mobile augmented reality. They are as follows:

(1) *Instrumental experiences,* which are pragmatic experiences that originate, for example, from utility, user's accomplishments, and product performance.

(2) *Cognitive and epistemic experiences,* which are related to thoughts, human information processing and rationality. These experiences originate from the semantic features of the product or service and its abilities to arouse interest and fulfil the need for knowledge.

(3) *Emotional experiences*, which are related to the subjective emotional reactions stemming from the use of the product or service.

(4) *Motivational experiences,* which are created when the use of a product or service causes a particular behaviour in the users.

(5) *Sensory experiences,* which relate to the product's or service's ability to arouse sensory and physical pleasure.

(6) *Social experiences,* which originate from interactions between humans that are intermediated by technology.

In user experience studies of augmented reality applications, pragmatic usefulness plays an important role. The information content affects the overall user experience, because the quality and the relevance of the content are major components in building long-term value and positive experience. (Olsson et al., 2009; Olsson and Salo, 2011; Olsson et al., 2012) Interestingly, the most unsatisfying experiences are often linked with instrumental dissatisfaction (Olsson and Salo, 2012). Although the expected user experience relates strongly to immersion in the augmented environment, the intuitiveness in interacting with the augmented information is also valued. Thus, ease of use of the AR service is required, and the content should be relevant, personalized and reliable. In addition, a positive user experience relates also to playfulness, inspiration and creativity (Olsson et al. 2013). The main motivators for installing AR applications seem to be curiosity and the novelty value of AR. Also, the continued use has been mainly motivated by an interest in the technology and its novelty value. (Olsson and Salo, 2011). There are few studies where the user attitudes toward AR applications are studied across countries. Olsson and Salo (2011) have conducted an on-line survey on mobile augmented reality applications. They concentrated on applications without any link to print media, as well as comprising their user group of early adopters. The results show that the early adopter group had quite a positive experience with currently available AR applications. Gauttier and Schubert (2011) studied consumer perception of AR in the context of shopping, including packaging applications, in France and Russia. The study reveals that perceived usefulness is the main driver to use AR. In both countries, it appeared that the younger the users are, the more likely they are to perceive AR positively and to use it.

1.3 Research questions

This research paper extends the study made by Gauttier and Schubert (2011) to other geographic regions, namely Finland and Canada, in order to investigate the similarities and differences between the user perceptions of AR in additional countries and cultures, improving the generalizability of the findings. Further, including a variety of media applications, rather than focusing on packaging alone, widens the scope. Similar methodology has been used in both studies, while adjusting the procedures to meet the needs of Finnish and Canadian consumers.

The aim of the research was to investigate, what kind of attitudes consumers in Finland and Canada have towards augmented reality applications in general and specifically with respect to mobile media. In addition, the study anecdotally explored whether the Finnish and Canadian attitudes towards augmented reality applications differ from one another. Lastly, given the research methods used, the data was used to categorize user types into comprehensible groups. We hope, that this contribution will allow companies that use AR technology to better focus their efforts on specific groups that they have identified. The research questions are formulated as follows:

Q1: What kind of attitudes do consumers in Finland and Canada have towards augmented reality applications?

Q2: Do Finnish and Canadian attitudes towards augmented reality applications differ from one another?

2. Research methods

The study was conducted in two parts. First, the attitudes towards augmented reality applications were studied at the Nordic level in Finland, Iceland, Norway and Sweden. A set of statements of consumer attitudes towards augmented reality applications were then derived from the transcripts of the focus group interviews and tested using Q-sort methodology among the Finnish interviewees. The Nordic study is reported in detail in Mensonen et al. (2013). Secondly, the process was repeated with Canadian professionals. The Q-sort statements derived from part one were kept consistent for the Canadian study to allow for easy comparison. Finally, the process was repeated with Finnish students and the same statements were tested by Finnish student after they were interviewed in focus groups. The analysis of the focus group interviews among the students was carried out as a students' practical work and thus only the Q-sort analysis is reported in this study. The progress of the study is presented in the Figure 1.

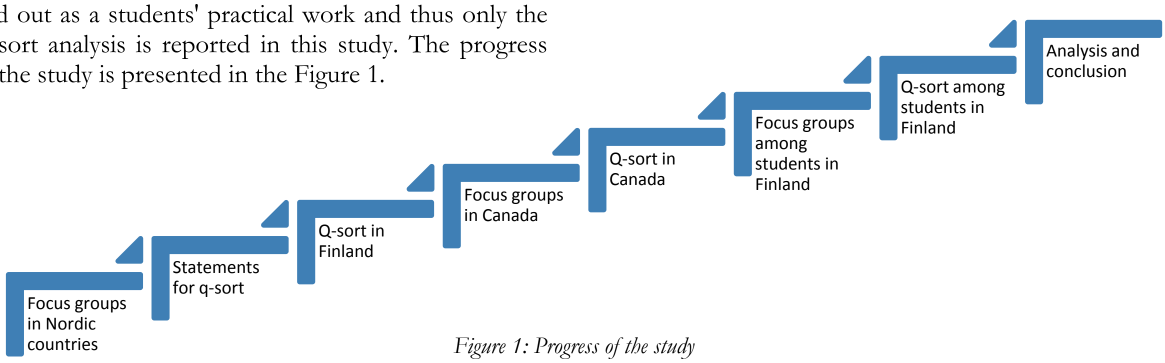

Figure 1: Progress of the study

Focus group interviews and Q-methodology were used as research methods. The aim of the focus group interviews was to investigate consumer opinions, views and hesitations connected with AR applications. The interviews also served as occasions for giving a short briefing about AR to participants. The interview sessions consisted of four steps as follows:

1. Interviewees filled out a background information questionnaire concerning the communication devices they were using and their use habits
2. Interviewees were shown three examples of augmented reality applications (Figure 2)
   a. Trying on eyeglasses with mobile augmented reality <http://www.youtube.com/watch?v=agwFbTwg9HA> (Total Immersion, 2011)
   b. Looking inside a closed box <http://www.youtube.com/watch?v=PGu0N3eL2D0>) (Cycloptop.us, 2009)
   c. Interacting with print media utilizing AR <http://www.youtube.com/watch?v=AjDjsmr0G14> (Aller Media, 2011)
3. Interviewees wrote down their first impressions of AR based on the examples
4. Interviewees discussed their first impressions, sharing their thoughts on the mixture of virtual and real images, the practicality of AR applications, and other application ideas.

a *b* *c*

Figure 2: Screen shots of the example videos

Based on the focus groups, 25 statements describing interviewee attitudes towards AR were identified and tested using Q-sort methodology. A list of statements was presented to each study participant and the participant was requested to indicate to what extent he/she agrees with each statement. The convention in Q-methodology is that the statements are sorted into a quasi-normal distribution, i.e., a bell-shaped curve (Figure 3). Thus, the respondents may agree and disagree completely on only one statement and be neutral on several statements (Davis and Michelle, 2011). This has the additional benefit of avoiding answers that lack decisiveness and allow an overly neutral position. As an example, if people were asked to give a score between 1 and 5 to each statement, they might give the score 3 on every statement. However, in Q-sort methodology this is not possible. Factor analysis by person is then run from the Q-sorts in order to identify a set of factors that represent inter-correlated groups of Q-sorts. The groups of similar Q-sorts typically have a shared and uniform point-of-view on the topic of interest (Davis and Michelle, 2011).

Based on their backgrounds, the participants formed three subgroups: two professional groups, one in Finland and one in Canada, and one student group in Finland. The main differentiator between the groups was whether the members were working or studying, with the professional group members working in a variety of fields. Background information on the professsional participants is presented in Table 1. The participants' knowledge about the possibilities of AR in consumer markets varied. The student participants were primarily studying graphic arts and media technology in a broad sense. There were 25 participants in each of the subgroups. The purpose of the study is not to compare the

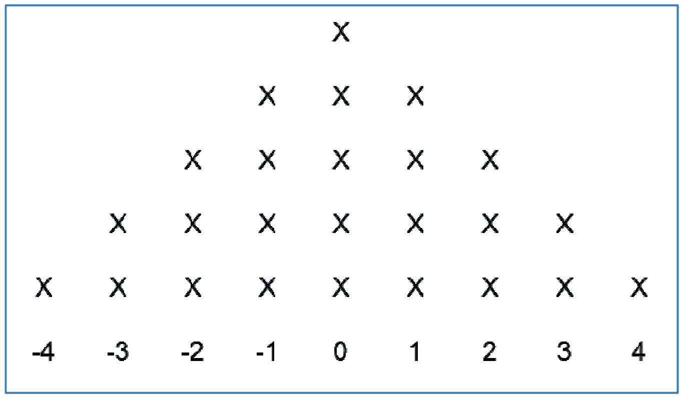

Figure 3: Ranking of statements into a Q-sort. Value -4 denotes 'most strongly disagree' and value 4 denotes 'most strongly agree'. 'X' denotes a statement

differences in AR use between students and professsionals, rather we separate them because the focus groups did reveal differences in attitude and thus we do not want the results to be skewed by combining the groups. Further research could include the addition of a student group in Canada as well as an investigation of why the students and professionals may exhibit different results. While our study did not contain enough participants to comment on age-based differences, this could be another area of research in the future.

Table 1: The background of participants

Professional background	Country
Brand owner (cosmetics)	Finland
Brand owner (brewery)	Finland
Brand owner (dairy products)	Iceland
Advertising	Iceland, Norway, Canada
Publishing	Finland, Sweden, Norway, Canada
Printing/Graphic arts	Sweden, Canada
Information technology	Iceland
Digital marketing	Canada
Graphic design	Canada

3. Results

3.1. Focus group interviews

The results of the Nordic focus groups indicated that AR was found to be useful, beneficial, attractive, interesting, fascinating as well as having a "wow" factor. Some participants thought that AR usage was time consuming, while others deemed it to be time saving. In Canada, the impressions of AR technology were primarily positive. The study participants felt that the technology is interesting, has potential value, and has a futuristic feel. In particular, there was a general agreement that there is a potential for the technology to improve the online shopping experience. Some participants also pointed out that AR could serve as a learning tool.

The need for a universal AR code reader is commonly cited as a key requirement for continued success. Costs from different perspectives were seen as an obstacle by the attendees of the focus groups in all Nordic countries. Later, however, the Q-sort results showed that the costs were not viewed as an obstacle. We perceive this to mean that the participants in the focus groups had second thoughts about the costs, and, when they filled in the Q-sort form, costs were seen as a minor issue. The applications must be easy to use and fast. The mobility aspect was also highlighted as the applications and content would primarily be designed for mobile use, i.e., for small screens. In Canada, cost was not an area of focus; however ease of use was important. Furthermore, there was definitely a special type of user associated with AR; the young technology savvy individual who enjoys online shopping. This kind of persona was evident in the Icelandic focus groups as well. Likewise, the group was interested in the mix of physical and digital content, but seemed also to find it a bit intimidating (always referring to the technology savvy persona) and very futuristic. In the Nordic countries, there was a distinct willingness to try AR technology, test its usefulness and value, and reap its benefits. AR was considered to encompass both information complexity as well as being ideal for leisure activities such as games. Furthermore, AR was considered to have a win-win potential for both consumers and brand owners. In Canada, on the other hand, the emphasis was on the consumer applications of AR. Over 80 % of the participants agreed that AR has the potential to be practical and to offer some value, while over 90 % agreed that it has the potential to be fun. The practical application was most commonly identified as shopping (online or in-store) with the value-added consisting of additional and more engaging product information. From an entertainment perspective, AR was also seen positively, however, some participants thought that it is a bit simplistic for gaming, and that it is a challenge to create interest in return visits to the application once users had tried it. There were also discussions concerning the motivation for the use of AR.

Some of the participants commented on the cumbersome task of needing to download a separate application to use AR, as opposed to the technology already built into the mobile phone. We have seen this also with other mobile technologies such as near field communication (NFC) chips and mobile visual search (MVS) (Lumby, 2012). While participants in Canada were technically very capable, only about half of them had ever personally tried AR technology before.

In the Nordic results, the group of printing professsionals from Sweden was sceptical about the business potential of AR technology in relation to print media applications. One concern was that the AR application would shift the users' focus to the phone, thus keeping them on their mobile devices instead of returning to the printed product. However, the interactivity was seen as a clear benefit and AR was considered a plausible extension of printing. Also, AR was seen as valuable for the advertising industry in both geographical areas. Some of the Nordic focus groups were quite innovative, providing somewhat whimsical ideas - an example being one in which enhancement of other senses could be involved. Odour and tactile properties were mentioned in that context.

Based on the interviews, 25 statements concerning the attitudes towards AR were identified. The statements were categorized into six classes based on the aspect of user experience they convey:

(1) instrumental experiences,
(2) cognitive and epistemic experiences,
(3) emotional experiences,
(4) sensory experiences,
(5) motivationnal experiences, and
(6) social experiences.

The statements and their categories are presented in Table 2. The main focus was on instrumental, cognitive and epistemic, emotional and motivational experiences.

3.2. Q-sort analysis

In the factor analysis of the Q-sorts, six factors were identified. Each factor depicts a group of shared points-of-view regarding AR, based on similar rankings of the Q-sort statements. Table 3 presents the factors and the experience classes describing the most important statements for each factor. Once the factors were identified, descriptive names were added to each of the six groups to more easily establish meaning in the results. The groups were named as follows: (1) Techno Believers; (2) Pragmatics; (3) Entertainment Seekers; (4) Sceptics; (5) Marketers, and (6) Non-committals. Each factor represents a shared attitude towards AR. A brief description of each group follows.

Techno Believers

The motivational aspects of experience are the most important ones for Techno Believers. They think that *"AR is a great possibility for innovation"* and they disagree with negative statements such as *"I don't understand how it works, it's too complicated. I don't want to try"*, *"AR is too expensive for me"*, and *"I wouldn't have time to use AR."* For Techno Believers technology is not an obstacle. They do not have a problem using and reusing mobile applications. However, the Techno Believers are neutral on emotional, sensory and social aspects of experience.

This group was represented in all three focus groups within the study: professionals in Canada and Finland, as well as students in Finland.

Pragmatics

For the Pragmatics, the instrumental aspects of experience were the most important ones. They voiced doubts about the ease of use of the applications and of AR more generally. They strongly agree with the statement *"The threshold for using AR is too high; you have to find it, and then install it, and after that you are able to use the application. You must have a strong motivation to do this."* and strongly disagree with the statement *"Everyone is able to use AR."* However, they believe that *"AR is a great possibility for innovation; we have not seen the best ideas yet."*, and *"there are benefits that AR brings along, for example in assembly and installation applications."* Interestingly, the Pragmatics group was represented only in the Finnish professionals subgroup.

Entertainment Seekers

For the Entertainment Seekers group, the emotional and sensory elements of experience are important. They find AR *"surprising"*, *"playful and funny"* and they *"like the way AR can be used to tell stories: it makes them interested because it stimulates variety of senses."* They believe that AR will be popular in the future. They have rather neutral attitudes towards the instrumental and motivational aspects of experience. The Entertainment Seekers comprised Canadian professionals and Finnish students.

Table 2: Statements concerning attitudes towards AR

Instrumental experiences	Cognitive and epistemic experiences	Emotional experiences	Motivational experiences	Sensory experiences	Social experiences
Using AR with a webcam is too complicated. With a phone, it is ok.	I want to use AR to familiarize myself with products that I am not already familiar with.	AR is not surprising. I've already seen things like this before.	I don't understand how it works, it's too complicated. I don't want to try it.	One needs to be able to touch the product.	The combination of AR and social media would strengthen the effect of an ad.
The threshold for using AR is too high; you have to find it, and then install it, and after that you are able to use the application. You must have a strong motivation to do this.	Seeing an object through AR, it's good in store when you can neither see the object nor open the box.	It's playful and fun.	There is a risk that AR apps in a magazine will cause a focus shift and that the reader stays using the mobile phone after using the apps and does not come back to the printed magazine.		
AR needs to give added value to the readers of print media to be interesting for the publisher.	AR applications must involve all senses before I would use them for purchasing on the web.	AR is not a problem solver for print media but may increase consumers' interests towards magazines.	I wouldn't have time to use AR.		
In the future AR would help consumer to see something concrete already in its planning stages (for example in interior design).		I like the way AR can be used to tell stories: it makes me interested because it stimulates a variety of senses.	AR is a great possibility for innovation; we have not seen the best ideas yet.		
One would use AR more, if the applications were accessible through screens inside stores.			Seeing a product through AR is not enough to make me buy it.		
AR gives print media the potential of interactivity which is a clear benefit.			AR is too expensive for me.		
AR would be helpful in assembly and installation application areas.					
Some articles are not commonly sold in web shops because consumer needs to try them on. If one could "try on" an article with AR, this could increase sale of those articles.					
Everyone is able to use AR.					
AR will be popular in the near future.					

Sceptics

This group was most sceptical regarding the benefits that AR could bring to print media, as well as having very neutral opinions more broadly. They strongly agree with the statement *"there is a risk that AR apps in a magazine will cause a focus shift and that the reader stays using the mobile phone after using the apps and does not come back to the printed magazine"*, they neither agree nor disagree with the statement *"AR gives print media the potential of interactivity which is a clear benefit"*, and they disagree with the statement *"AR is not a problem solver for print media but may increase consumers' interests towards magazines"*. They find it difficult to start using AR applications, but on the other hand, they are not worried about the ease of use in general. They have neutral attitudes concerning the price, spending time with AR applications as well as the general future of AR.

The Sceptics viewpoint was based on the evaluations of Finnish professionals and students.

Marketers

This group was the only one that agreed with the statement *"The combination of AR and social media would strengthen the effect of an ad."* They also believe that AR will be a successful technology in the future and they did not find technology acceptance or the ease of use as obstacles to achieving the goals of AR.

In this group there were representatives from each subgroup: professionals in Canada and Finland, and students in Finland.

Non-committals

Non-committals see AR applications as a possible risk for print media, because the applications might *"cause a focus shift and that the reader stays in the mobile phone after using the apps and doesn't come back to printed magazine."* While they *"like the way AR can be used to tell stories: it makes them interested because it stimulates variety of senses,"* they have a neutral attitude towards instrumental experiences. In addition to the motivational aspects of experience, the non-committals group finds that the emotionnal experiences are also relevant.

The Non-committals viewpoint was based on the evaluations of Canadian professionals and Finnish students.

4. Discussion

The purpose of this study was to clarify, what kind of attitudes consumers in Finland and Canada have towards augmented reality applications. In addition, the study explored whether the Finnish and Canadian attitudes towards augmented reality applications differ from one another. Based on focus group interviews in the Nordic countries, a variety of attitudes towards AR applications could be identified. The attitudes were rephrased in the form of statements, which were ranked utilizing Q-methodology. AR is seen as offering great potential for innovation. People would like to try the applications and would also find time for using them. The expectations placed on AR applications are clearly high.

In the analysis of the results, six viewpoints towards AR applications were identified. According to the results, the pragmatic aspects of experience were clearly more important for the participants than the hedonic ones. This is typical for new technologies. Augmented reality is still a new technology for applications targeted toward consumers. Such technologies tend to be evaluated based on their novelty value, as well as by their pragmatic aspects such as ease of use (Olsson and Salo, 2011).

In the results, minor differences between countries were identified. There were two viewpoints, namely 'Pragmatics' and 'Sceptics' that were solely based on evaluations of Finnish participants. In addition, the viewpoints 'Techno Believers' and 'Marketers' were based on evaluations of all three subgroups. The other two viewpoints, 'Entertainment Seekers' and 'Non-committals', were based on the rankings of Canadian professionals and Finnish students. Thus, the results indicate that there probably are some differences between the countries but they are not the only explanation. The results are in line with the findings of the study by Gauttier and Schubert (2011). They studied perceptions towards AR in France and Russia, and identified six viewpoints towards AR, three of which were common to both countries, two were typical for Russian participants and one was typical for the French (Gauttier and Schubert, 2011). The reasons behind the differences are possibly partly related to cultural differences but also to differences in technology penetration. For example, smart phone penetration and its development vary in different countries. According to statistics from eMarketer, reported by Print in the Mix (2013), the smartphone penetration 2011-2012 in Canada was slightly higher than in Finland (approximately 5 percentage units), and clearly higher than in France (15 percentage units) or in Russia (almost 20 percentage units).

It is interesting, that there were two viewpoints in which Canadian professionals and Finnish students displayed the same attitudes. This may indicate that, in Canada, companies are less likely to think of AR technologies as a professional marketing tool. This could be because not many professional applications currently exist or because of the novel nature of interactive technologies.

The European market has certainly been quicker to absorb some of the potential uses of this technology and the results of this study indirectly support this.

The benefit of the Q-methodology is in quantification of qualitative data. Based on the focus group interviews, different attitudes towards the AR applications were identified and Q-methodology was then used for evaluation of the importance of the attitudes. As an example, people in the focus groups were uneasy about the costs, however, when they filled in the Q-sort formula costs were seen as a minor issue. Interestingly, the Q-sort results show that the costs were not seen as an obstacle. Here we can see the benefit of using this methodology as it allows us to prioritize the results of the less structured focus group data

5. Conclusions

For AR technology to succeed, a business model for digital advertisements needs to be developed. Furthermore, AR should be developed for a variety of technological platforms, extending beyond focusing on mobile phones. For example, while the Canadian results show that today most participants felt that AR offers shopping advantages, many saw the future of AR in the medical field. Interestingly, the suggestions for the future were moving away from combining print and AR and rather moving into a world that is augmented through the use of some technical device (such as a mobile phone or AR glasses). This indicates that consumers are media agnostics, looking at what the technology could achieve independently from the media platform they are currently utilizing.

The results thus far show exciting theoretical and practical implications for AR technology that are not limited to its use for entertainment alone but rather can be integrated into our media, providing additional usefulness. Furthermore, this research has contributed to our understanding of AR while maintaining a culturally sensitive perspective. As many brands in today's world are global, this knowledge will be very useful. In particular, it is interesting to note that the attitudes of Canadian professionals closely match those of Finnish students, rather than aligning with Finnish professionals. The two viewpoints for which this is the case are 'Entertainment Seekers' and 'Non-committals'. One could presume that students are less likely to interact with AR in a professsional capacity, with a majority of the applications for this target market being entertaining in nature. Thus, one could then extrapolate that the Canadian market has had a stronger focus in this area as well. In a sense, this means that there is an opportunity to extend the use of AR in Canada. This conclusion is further supported by the 'Marketers' and 'Techno Believers' viewpoints being represented by all three subgroups. Very optimistically, the study thus shows that, while some cultural differences in attitudes toward AR technology may exist, both countries show promise for future uses of AR that extend beyond how we are using it today. With the newly developed categories of users presented here, we hope that developers of AR technology can better focus on those uses in appropriate target markets to further ensure adoption success.

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This paper is based on a preliminary version presented at the 40th International Research Conference of IARIGAI in Chemnitz, Germany, September 8-11, 2013.

Topicalities

Edited by Raša Urbas

Contents

News & more

Web break analysis system

The new system is designed to provide web offset printers with a greater level of control over their day-to-day production efficiency. Enabling the identification of the precise cause of a web break, the *Goss ContiVision* web break analysis system can help prevent web break recurrences, as well as provide essential evidence for achieving compensation in the case of paper flaws.

At least half of all web breaks currently remain unexplained and unresolved, leaving the printer no option but to absorb the resulting costs from press downtime, while the new system represents a powerful tool to control such occurrences.

Receiving up to 80 signals from cameras and sensors strategically positioned throughout the pressline, the web break analysis system is able to monitor, measure and analyze the forces interacting with the paper web through its entire print production way. Immediately on detecting the small changes in web tension that signal a web break, the system correlates all data to determine crucial factors, including:

- Precise time and location of a web break
- Process circumstances at the moment of the web break
- Variations in paper quality, such as holes or cracks

Operational algorithms consider the data in relation to approximately 300 possible system failures to establish the most likely cause, providing step-by-step validation of the conclusion and automatically generating a report. This report can be reviewed locally as well as remotely via VPN connection by the specialist in the control center.

Successful beta-testing of the *ContiVision* system has confirmed that this technology truly takes the guesswork out of identifying the cause of web breaks and preventing repeated breaks. This allows more efficient and cost-effective web offset production.

Press simulators

Press training simulation software remarkably recreates press operations, even to the extent of printing specific jobs. Schools and companies use the software as a practice press to expose trainees to a variety of printing conditions and problems. It provides an interactive, "hands on" component to a training class and can also be used to assess an individual's skill level.

Press simulator is available to students any time. It doesn't have to be supervised, wastes no materials, and presents no safety issues. It can be used to demonstrate printing basics in an introductory-level course and is an ideal teaching tool for an advanced press course.

Printing Industries of America currently offers two versions of press simulators, for sheetfed offset press and for web offset press training. Similar software for gravure and flexographic press operations is considered.

Form or function:

What is the defining factor of functional printing?

The diverse interpretations of functional print as a term demonstrate the dynamism and relative novelty of this market. Some experts consider that audiences for functional print applications are attracted by their concrete and workable properties, and any aesthetic aspect, while important is of secondary importance compared to product functionality.

In contrast, some manufacturers are addressing several sectors within the broad scope of industrial printing - in particular the decoration of ceramic tiles, direct-to-shape packaging printing, and the application of inkjet to deposit functional fluids as an advanced manufacturing process in areas such as display, pcb, semicon, solar and glass. In other words, they are focusing on designing and supplying products that integrate electronics, paper and conductive inks to create unconventional and entertaining products for point of sale, out of home, packaging, direct mail, newspapers and books, as well as the musical, medical and toy sectors. The segments that can benefit from novel and amusing electronics-led applications are potentially endless. Interactive books and toys, multi-sensorial posters and switchboards, that result from the mix between touch technologies and advanced ink capabilities.

It's undeniable that print technology and product effectiveness are the leading drivers of the functional printing sector. Nevertheless, the experiential element and a more consumer-orientated perspective shouldn't be overlooked. System integration and functionality are after all pursued to reach marketing and business objectives where customer experience and satisfaction are key measurements of the success of a product.

Press Ready Technology

Process free plates are becoming more and more popular among printers. Besides its ecological aspects and chemistry-free application, such plate-making is time saving and does not require any additional equipment. Kodak recently introduced press ready technology by launching its new Sonora XP plates.

Plates are negative-working and can be imaged in thermal platesetters. During the imaging of the plate, the thermal laser writes the image, cross-linking the polymer resin to create a hardened, robust image area.

During the startup of the press, the absorption of the fountain solution prepares the unimaged coating to be physiccally removed by the tack and shear of the ink. This enables a successful transfer of the coating from the plate to the blanket, and the coating is then carried out of the press, in almost all cases within the first several make-ready sheets or newspaper copies

Plates, in almost all cases, a printer's current press setups, sequences, inks, fountain solutions, and blankets can be used successfully. Press ready technology also works with integrated and non integrated, conventional and continuous dampening systems and for printers with automatic startup sequences.

Two types of process free plates are available: for commercial and for offset packaging applications and for newspaper applications.

White ink label press

The UK manufacturer Domino realized it would require a white ink for the label market but has spent time developing a higher-resolution head. Now it is applied to their N610i label press. The new design uses two printheads for the white, to create higher opacity, although each will have a smaller drop-size to ensure the same amount of ink is used compared to other colors.

Domino uses 600 dpi Kyocera heads in the press. The press uses vibrant UV curable inks designed for a range of materials normally without the need to prime. Key applications include Industrial, security, health and safety, chemical and pharmaceutical labels.

New specifications for digital photography

The Ghent Workgroup released new specifications for digital photography. GWG recommends using these guidelines with digital photography projects for print production. Doing so will insure correct implementation of ICC color management and standards, which are essential to maintaining maximum quality from original capture through to the final, printed result.

Recent developments in digital photography made an update of specifications necessary. In addition to improving processing and production guidelines to align more smoothly with the latest digital imaging applications, they also include the best practices for professionals whose everyday work relies on outstanding production quality.Two versions are available: "News Photography", for newspaper production and "Shootings", for magazine and studio-quality production.

Specifications include, but are not limited to:

- 'How-to' screenshots compatible with the latest version of Adobe Photoshop.
- "Shoot-Optimize-Save" function reorganized to better match photographer set-up process when using Adobe Photoshop.
- Image delivery now directed to recipients' online portals.
- By user request, more detailed IPTC information/fields have been added.

The Ghent Workgroup is an international organization made up of graphic arts users, associations & developers building best practices for publishing and packaging workflows

A new compact press

Combining proven technologies and print quality with important agility features, the Magnum Compact press introduces powerful benefits for single-width newspaper production and for new short-run, multi-product business models. Extremely fast changeovers, maximum versatility and simplified operation provide the keys to expanded uptime and low-cost production of newspapers, books and semi-commercial products.

Some of the advanced features:
Single-level compact design
Three-part printing units
Autoplate™ fully automatic plate changing
Shaftless servo drives
Automated presetting and start-up sequences
Slot-gap plate lock-up
Reel rod blanket lock-up
Blanket cylinder bearers
Double-row pre loaded roller bearings
Motorized ink fountain rollers
Motorized Goss® remote control ink keys
Automatic ink leveling
Automatic grease lubrication
Motorized register control
Spraybar dampening
Automatic web-up

The 3D revolution is spreading

Almost unnoticed, revolutionary production technologies have emerged without any meaningful input from big players. Instead, the initiatives came from researchers, small start-ups and tinkerers in their garages who experimented with printing three-dimensional stuff. As is common with all technical revolutions, the "movement" thrives on its early protagonists' enthusiasm, which in this case happens to be mostly made up of middle-aged, male tech aficionados working in tandem with a complementary open-source community. These so-called "makers" espouse the trend toward personal production and the networking of things. The elation of a new age, together with goldrush-like optimism is palpable, notwithstanding that many young businesses soon will join the corporate world, fairly quickly abandoning their open-source ideals en route.

Still, 3D printing is not without history. Long before the internet changed the world, laser-based processes for industrial applications had been developed, e.g. for the manufacture of prototypes and models to be used in the production of limited numbers of work pieces and building components. Other than is the case with standard injection moulding processes, 3D printing bypasses the labour-intensive set-up of jigs, together with the various processes of cutting, lathing and drilling.

As an undeniable fact, the 3D revolution's social and economic repercussions are making themselves felt. In times where the life cycle of products continues to compress while the number and variety of products inexorably expands, the tirelessly working printing robots producing complex objects at precision levels unmatched by mere mortals, are just what the doctor ordered.

Consequences of the 3D revolution

3D printing not only supplants, reconfigures and leverages traditional processes, but accelerates innovation by virtue of the fact that an instant creation of solid prototypes and tangible templates has numerous benefits. In the consumer space, unit costs of mass-produced articles will always stay below those of customized manufacture, yet at the very margins, some share of the manufacturing process may well be taken over by the consuming public itself. It would hardly be a detriment to the economy, since these unaffiliated manufacturers still need 3D technology besides materials and support, at the same time creating brand new lines of business, e.g. printing services for those who are reluctant to invest in a 3D printer themselves. We all recall the unreal rates a square foot of digital printing on fabrics commanded back in its early years.

Market survey

Getting your feet wet in 3D printing is relatively easy. Building sets and apparatuses for beginners can be had for around 300 Euro. Professional machines sell for 3 000 Euro and up. But these machines, being used in industrial applications, are under a great deal of pricing pressure. Analogous to 2D printing equipment, three categories of machinery have also emerged in the 3D sector: for home use, for professionals, and for Industrial application. Two dozen manufacturers from all over the world are currently offering solutions for the press floor. Most of them were inspired by the RepRap project, originally conceived by Adrian Bowyer, a professor for evolutionary research at Bath university, England.

RepRap stands for **Rep**licating **Rap**id-Prototyper and is a 3D printing press, the blueprint of which Bowyer had published under a GNU general public licence with the goal to achieve rapid proliferation. The best-known American maker of 3Dprinters, Makerbot in NewYork used to be a non-profit or-

Efficient color label printer

EPSON
EXCEED YOUR VISION

Demand for reliable label printers is increasing. Epson launched ColorWorks™ C3500 inkjet label printer, which can dramatically reduce label costs, increase operational efficiencies and print high-quality, durable labels on demand in four colors (CMYK) at speeds of up to 10 cm/second.

The printer has robust, compact and is ideal for high-mix, low-volume applications. It has individual ink cartridges for efficient use of pigment ink, using MicroPiezo method and automatic nozzle checking. High speed USB and Ethernet connections are provided.

The printer supports all major label applications and has rear-feed capability for fanfold and large rolls. ColorWorks™ C3500 Color Label Printer is equipped with an automatic cutter, capable of operating 88 thousand hours.

Inkjet platemaking

Inkjet printing is not so extensively widespread in the production of printing plates. However, it can have many competitive advantages: it is simple, low cost, chemistry-free, high speed run and finest print quality.

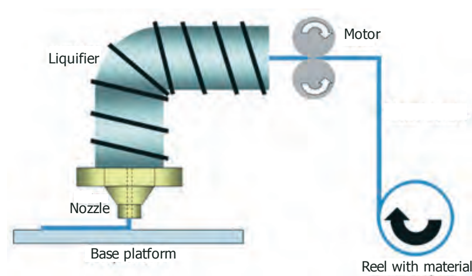
Canadian manufacturer TechNova offered a truly versatile system, the Smart Jet platesetter, which can image not only the chem-free metal plates, but also no-process polyester CtP plates. This technology is intended for offset printers aspiring to enter the business at lowest investments and high efficiency. This innovation is the result of Tech Nova's intention to help extend the life cycle of small and medium printers facing competitive pressure from digital and electronic media, providing an affordable and sustainable option.

organization. Since 2013, it is a subsidiary of Stratasys and the current 3D printer model Replicator 2, unlike previous models, no longer bears any resemblance to the open source matrix.

The English manufacturer Bits from Bytes was also bought out. The company started with the 3D printer RapMan, a commercial version of the open source hardware RepRap Darwin. In October 2010, the enterprise was taken over by the leader in the consumer sector, the American company 3D Systems. Resources for research and production at their main plant in Waterford Business Park of Rock Hill are at the limit of their capacities; for those reasons, 3D Systems plans an additional site.

In the professional sector, Stratasys is the undisputed worldwide leader. They have two head offices and six branch offices, one of them in Stratasys' product range extends from popular-priced desktop 3D printers all the way to large state-of-the-art 3D production systems. With 150 photopolymers and thermo plastics, it also features the largest assortment of special materials.

World leader for industrial applications in the sector Laser Sintering is EOS in Krailling near Munich (Bavaria), founded in 1989. It supplies customers like MTU, EADS, Daimler and BMW with 3D-printers for their production sites. China supports its 3D printer industry through TierTime Technology Co. Ltd., founded 2003 in Peking. Their devices are marketed under the name Inspire. In short: whether high-end products, one of a kind, or small-scale series - the capabilities of 3D printers are advanced enough right now to perform many conceivable and as yet inconceivable tasks.



One principle, many processes

3D printing, also known as "Rapid Prototyping" or "Additive Manufacturing", is based on the layering principle, an additive process by which the objects to be printed are built layer upon layer from several liquid or powder-like substances. In its course, chemical and/or physical processes precipitating curing and/or melting take place. For those reasons, the typical materials used are artificial resins, plastics, metals, ceramics and paper. Manufacturers currently use a number of 3D print processes, which in their application are fundamentally alike except for a few patented variations. Among the most notable processes employed are selective laser melting, electron beam melting for metals, selective laser sintering for plastics, stereo lithography, digital light processing, polyjet modeling for photopolymers, and fused deposition modeling for thermo-plastics. Most 3D printers at this time process only a single type of material or some kind of blend. There have been tests, though, to use plastics with different degrees of hardness and colour in a combined printing process. The FDM (fused deposition modeling) process melts delicate, semi-liquid strands of the thermoplastic acrylnitril-butadiene-styrol (ABS) with a spray nozzle, piling layer upon layer to eventually assume the final object's shape. The PolyJet technology deploys photopolymers which are instantly cured under UV light.

Excerpts from a professional article published by Messe Düsseldorf

Low migration inks

The target application of so-called indirect food packaging mostly requires the use of Low Migration (LM) inks. Moreover, also other applications, especially pharmaceutical packaging, require the use of LM inks.

Today, Low Migration inks are readily available for traditional analogue printing techniques, including LM UV-curable inks for flexo printing. Now, market demand for digital printing on food packaging is rising strongly, driven by short/variable run length, just-in-time, low waste, marketing opportunities and other types of versioning and VDP.

Food packaging increasingly requires the use of UV-curable inks. The LM UV-curable inkjet inks from Agfa Graphics are specifically targeted at these applications in single pass printing systems with all common industrial piezo printheads, for curing with LED and/or with mercury arc lamps.

Thanks to extensive chemical and ink formulation knowledge, Agfa's new digital UV-curable ink formulation technology results in superior crosslinking of the ink monomers by curing (Agfa CCT is for Complete Crosslinking Technology) compared with standard inks. The correct use of the CCT technology results in inkjet inks capable of being used as LM inks as part of a complete solution which incorporates the printing system and the total production process flow according to local legislations.

The Agfa LM ink sets are not only designed for optimal performance in a wide variety of printing systems, comprising different print heads and curing systems. They are also proven to deliver 'food safe' prints having passed stringent levels of ink migration testing both through the substrate and/or set-off.

Bookshelf

Handbook of Paper and Board

Papermaking is a fascinating art and technology, dating back to early ages. The second edition of this successful handbook provides a comprehensive view on the technical, economic, ecologic and social background of paper and board. It has been updated, revised and largely extended in depth and width including the further use of paper and board in converting and printing. A wide knowledge basis is a prerequisite in evaluating and optimizing the whole process chain to ensure efficient paper and board production. The same is true in their application and end use for a variety of products.

The two volume set of handbook covers a wide range of topics:

- Raw materials required for paper and board manufacturing such as fibers, chemical additives and fillers
- Processes and machinery applied to prepare the stock and to produce the various paper and board grades including automation and trouble shooting
- Paper converting and printing processes, book preservation
- The different paper and board grades as well as testing and analysing fiber suspensions, paper and board products, and converted or printed matters
- Environmental and energy factors as well as safety aspects

The handbook provides professionals in the field, e. g. papermakers as well as converters and printers, laymen, students, politicians and other interested people with the most up-to-date and comprehensive information on the state-of-the-art techniques and aspects involved in paper making, converting and printing.

Handbook of Paper and Board
Two volume set - 2nd edition
Editor: Herbert Holik
Publisher: Wiley, 2013
ISBN: 978-3-527-33184-0
992 pages
Hard cover

Environmentally Friendly Production of Pulp and Paper

Implementing Cleaner Production in the pulp and paper industry

The large - and still growing - pulp and paper production is a capital and resource-intensive industry that contributes to many environmental problems, including global warming, human toxicity, ecotoxicity, photochemical oxidation, acidification, nutriafication, and solid wastes. This important reference for professionals in the pulp and paper industry details how to improve manufacturing processes that not only cut down on the emission of pollutants and costs, but also increase productivity.

Environmentally Friendly Production of Pulp and Paper guides professionals in the pulp and paper industry to implement the internationally recognized process of Cleaner Production (CP). It provides updated information on CP measures in:

- Raw material storage and preparation
- Pulping processes (Kraft, Sulphite, and Mechanical)
- Bleaching, recovery, and papermaking
- Emission treatment and recycled fiber processing

The Art of the Book in the Twentieth Century

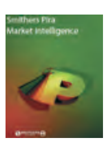
Author: Jerry Kelly

Publisher: RIT Cary Graphic Arts Press (March, 2011)
ISBN-13: 978-1-933360-46-1
200 pages
230 x 305 cm
Hardcover

Throughout the twentieth century, modern design theories in combination with newer printing technologies offered book designers far more options than were previously available. Utilizing these resources, designers produced stunning designs in period style, arranging modern re-cuttings of early type designs with historical decoration that resulted in the creation of truly beautiful books; while others preferred a more contemporary aesthetic, building upon earlier principles in a novel manner.

Through the selection of eleven expert artisans, a wide range of styles is shown: from classically inspired design and historical revival, to novel and modern layouts. The care is described with which of them combined typographic elements in their own way. It is only a small sampling of the practitioners that the twentieth century produced, but they are indicative of the wide range of book design styles achieved during this dynamic century. With a commentary and carefully selected illustrations, this edition introduces the reader to exquisite examples of quality book design of the twentieth century and the principles behind them.

The Future of Specialty Printing Papers to 2017



Publisher: Smithers Pira
Printed and Digital Edition, 2012
226 pages

This edition is based on an in-depth combination of primary and secondary research, to generate an up-to-date and accurate picture of the specialty papers market. Furthermore, research was based on extensive literature analysis of published data and trends collected from key players. This report provides an unparalleled level of data, analysis and conclusion. The specialty printing paper market produces specialty paper grades, such as thermal, photographic security, synthetic and fine art papers. The report provides detailed strategic forecasts and quantifies the market for specialty printing papers, identifies key drivers and trends with analysis of cutting-edge technology and developmet.

The book is divided in six sections, each provided with an extensive list of references and covering specific topics like Emissions from Pulp and Papermaking, Cleaner Production Measures in Pulp and Paper Making, etc.

In addition, the book includes a discussion on recent cleaner technologies and their implementation status and benefits in the pulp and paper industry.

Covering every aspect of pulping and papermaking essential to the subject of reducing pollution, this book essential for paper and bioprocess engineers, environmental engineers, and corporations in the forest products industry.

Environmentally Friendly Production of Pulp and Paper
Author: Pratima Bajpai
ISBN: 978-0-470-52810-5
Publisher: Wiley, 2010
365 pages

Advances in Printing and Media Technology

The latest volume of the series Advances in Printing and Media technology was published in late November 2013. The book reports on scientific studies that that will help improve print and media products, on technologically based innovations, and on new ways to support media communication and interact with media services. It contains the scientific and technical papers presented at the 40th International Research Conference of the International Association of Research Organizations for the Information, Media and Graphic Arts Industries, held in Chemnitz, Germany, in September 2013.

All the papers are, in various ways, concerned with technology based innovation in the print and media field. Many of them are offering an insight into the new fields of research and application This book is divided into four sections, reflecting the different research foci and the diverse approaches to innovation for and in the industry.

The section on *printed functionality* investigates innovative ways of using printing technology for totally new purposes. The section on *printing processes and products* is concerned with the improvement of industrial processes and product development for traditional paper based information products. The section on *quality in print* looks carefully at new methods for improving and maintaining the technical and perceived quality of printed products. And, finally, in the section on *media development and the consumer*, scientists explore the problems and opportunities of satisfying consumer demands in a multi-media world.

Much inspiration as well as concrete foundations for business development and further research can be found within these pages. iarigai is committed to provide the print and media industry as well as the research community with topical research information.

Advances in Printing and Media Technology, Vol. 40
Editors: Nils Enlund and Mladen Lovreček
ISBN: 978-3-9812704-4-0, ISSN: 225-6067
Publisher: IARIGAI, Darmstadt 2013
392 pages
285 x 190 mm
Hard cover

Packaging technology: Fundamentals, materials and processes

Packaging is a complex and wide-ranging subject. Comprehensive in scope and authoritative in its coverage, *Packaging technology* provides the ideal introduction and reference for both students and experienced packaging professionals - provides the ideal introduction and reference for both students and experienced packaging professionals - examines fundamental issues relating to packaging, such as its role in society, its diverse functions, the packaging supply chain and legislative, environmental and marketing issues - reviews the principal packaging materials such as glass, metal, plastics, paper and paper board - discusses packaging processes, from design and printing to packaging machinery and line operations, as well as hazard and risk management in packaging. The book is designed both to meet the needs of those studying for the a degree in Packaging Technology and to act as a comprehensive reference for packaging professionals.

Part one provides a context for the book, discussing fundamental issues relating to packaging such as its role in society and its diverse functions, the packaging supply chain and legislative, environmental and marketing issues. Part two reviews the principal packaging materials such as glass, metal, plastics, paper and paper board. It also discusses closures, adhesives and labels. The final part of the book discusses packaging processes, from design and printing to packaging machinery and line operations, as well as hazard and risk management in packaging.

Edititors: Anne and Henry Emblem
Published by: Woodhead Publishing in association with the Packaging Society
ISBN: 1-84569-665-4; ISBN-13: 978 1 84569 665 8
October 2012
600 pages
244 x 172 mm
Hard cover

Color: A Workshop for Artists and Designers

This book demystifies its subject for professionals and students alike. It inspires confidence in color's application to graphic design, illustration, painting, textile art, and textile design. In addition to covering the fundamentals of colour theory, the author provides assignments that guide the student through a variety of colour experiences, moving logically from basic structural concepts to experiments with colour applications. Concepts and terminology are always linked with supporting visuals. The book is generously illustrated with examples drawn from the rich, multicultural history of art and design. Color charts and studies, created by students themselves, round out the range of illustrations. The book also includes an extensive, fully illustrated glossary of color terms. Students encountering these color principles and ideas for the first time will feel empowered by a new set of tools. More experienced readers will refresh and increase their knowledge and perception while gaining valuable strategies for color exploration and use.

Author: David Hornung
Publisher: Laurence King Publishing
Second edition, August 2012
ISBN: 978-18566-9878-8
343 color illustrations
168 pages
280 x 216 mm
Paperback

Nanoimprint Technology:

Nanotransfer for Thermoplastic and Photocurable Polymers

Editors: Jun Taniguchi, Hiroshi Ito, Jun Mizuno and Takushi Saito

Publisher: Wiley, 2013
ISBN: 978-1-118-35983-9
238 pages
Hardcover

Nanoscale pattern transfer technology using molds is a rapidly advancing area and one that has seen much recent attention due to its potential for use in nanotechnology industries and applications. However, because of these rapid advances, it can be difficult to keep up with the technological trends and the latest cutting-edge methods. In order to fully understand these pioneering technologies, a comprehensive understanding of the basic science and an overview of the techniques are required.

Nanoimprint Technology: Nanotransfer for Thermoplastic and Photocurable Polymers covers the latest nanotransfer science based on polymer behaviour. Polymer fluid dynamics are described in detail, and injection moulding, nanoimprint lithography and micro contact printing are also discussed. Cutting-edge nanotransfer technologies and applications are also considered and future trends in industry are examined. The book addresses the following key issues:

- Covers the fundamentals of nanoimprint technology
- Presents cutting-edge techniques and applications
- Provides industrial examples and describes the fabrication process
- Considers nanotransfer of thermoplastics by simulation
- Describes the design and evaluation of UV curable polymer

Nanoimprint Technology: Nanotransfer for Thermoplastic and Photocurable Polymers is a comprehensive reference for industry engineers as well as graduate and undergraduate students, and is a useful source of information for anyone looking to improve their under-standing of nanotransfer mechanisms and methods.

Bookshelf

Academic dissertations

Doctoral thesis - Summary

Author:
Branka Morić Kolarić

Speciality field:
Color science, Document protection

Supervisor:
Ivana Žiljak Stanimirović

Defended:
September 2013, at the Faculty of Graphic Arts, University of Zagreb, Croatia

Contact:
branka.moric@nn.hr

Development of document protection elements with the separation of colors for ultraviolet, visible and near infrared spectrum

The aim of this investigation is elaboration and introduction of the new methods in creating highly protected documents by ink management in three spectrally separated ranges. Security graphics for ultraviolet (UV), visible (V) and near infrared (NIR) spectra is developed with a new method of mixing the offset printing inks. Controlled and target planned security graphic carries three information in one reproduction. In contains two different images with three states of recognition.

By the separation for the ultraviolet spectrum, through properties of the F ink, the CMYKIR separation is extended to UV, V and NIR range. An experimental color set up is developed for CMYF separation, with the aim of concealing the graphic in the visible spectrum. Twin colors X_0 and X_{40} were defined by experimental methods, while the formulations were determined by the type of paper, type of ink and the printing technology. From the calculated and measured colorimetric values of process inks, cyan, magenta and yellow - which do not contain F ink - a color tone of X_0 ink was created, while twin ink X_{40} has in its composition a pre-defined value of the F ink, F=40 %. In the visual spectrum twin inks are completely covering one another, while the determined color difference ΔE is bellow 2.

The ultraviolet and the infrared properties were established on the same image element, with strictly determined values in the CIELab color space. By algorithmic mixing of the cyan, magenta and yellow process inks, a unique solution for the protective printing of the documents was achieved. A separate ink formulation was determined for each paper grade. Each print substrate with printed planned CMYF inks gives unambiguous results. A scale of new inks was created, with new characteristics for the protective printing. The F/Z graphic is designated facilitating three different information, intentionally created in one single image.

Doctoral thesis - Summary

Author:
Marion Sanglard

Speciality field:
Fluid Mechanics, Energy, Processes

Supervisor:
Christine Chirat

Co-supervisor:
Dominique Lachenal

Defended:
January 2013 at PAGORA-INP Grenoble, France

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Simultaneous production of bleached cellulose fibers and polyxylosides alkyl through a biorefinery paper

This project aims at converting a Kraft pulp mill into a biorefinery by removing hemicelluloses from Hardwood in order to convert them into surface-active agents, namely alkylpolyxylosides, while high quality bleached pulps must still be obtained. Industrial Eucalyptus globulus woodchips were submitted to different autohydrolysis conditions so as to extract a substantial amount of hemicelluloses, composed mainly of xylose. The prehydrolysis liquors were purified with activated charcoal and concentrated. Then the extracted saccharides were successfully used to synthesise alkylpolyglycosides. These surfactants have a saccharide as their hydrophilic part, while their lipophilic part is a fatty alcohol. Moreover, the impact on the glycolsylation reaction of the saccharides' concentration and of the other species found in the prehydrolysates was studied.

In parallel, the pretreated woodchips were much easier to delignify using Kraft cooking than the control ones. This allowed the use of soda-anthraquinone cooking at reduced alcali and temperature. The resulting pulps had lower lignin and hexenuronic acid content than the pulps from untreated wood, with higher DPv and brightness. The pulps from prehydrolysed wood reacted as well as the control pulps to oxygen delignification. All pulps were fully bleached to a 90 % ISO brightness through an ODEPD sequence.

The Journal of Print and Media Technology Research will publish summaries of high quality academic thesis within the scope of the journal. Short summaries should be sub-mitted to <journal@iarigai.org> by the thesis supervisor. Information on type and field of the thesis, author, supervisor, date and university of defense or presentation, as well as on how the full thesis can be obtained must be provided.

Events

IPEX

Mapping the future

London, UK
24 to 29 March 2014

After many years being hosted by NEC in Birmingham, Ipex, is returning to London, where it will be held at ExCeL, the international exhibition and convention centre. This largest printing, media and publishing event in 2014 will feature not only the traditional floor show, but will as well offer the tools, knowledge and inspiration to turn today's challenges into tomorrow's opportunities.

Visitors from around the globe will have an opportunity to witness the latest global technologies and solutions to produce quality print applications from the entire print production workflow.

The advantage of this year's IPEX are numerous side programs, comprising free events and seminars which will offer practical business workshops such as writing business plans and winning new business.

World Print Summit

Ipex will bring together some of the world's most visionary and ambitious leaders from the international print supply chain, who will discuss; debate and share insights and solutions surrounding the evolving role and power of print in this new digital age.

Masterclasses Program

A perfect complement to the exhibits on the show floor and the World Print Summit, the Ipex Masterclasses will provide visitors with information, inspiration, tools and techniques to run their businesses better. The Ipex Masterclasses will focus on sales and marketing, operations, production and technology, with the aim of equipping attendees with ideas and insight to enable them to produce and promote print and related products and services in a compelling, cost-effective, and sustainable manner.

Youth in Print

The new feature 'Youth Day', taking place at Ipex 2014, is the perfect place for the super-connected generation to be blown away by what print can and is doing today. From 3D to Augmented Reality; from saving lives through printed electronic sensors to becoming a DJ using printed electronics; from fashion design and screen printing to car wrapping; from journalism and design to innovative print on packaging, etc.

Participants will have an opportunity to hear from students themselves already experienced with print and printed media and from the educators and advisors, who can guide students and young entrepreneurs through all the possibilities and opportunities. In the afternoon, students will also have the option of going on a walking tour to see some of the key exhibitors.

Cross Media Production

London, UK
25 to 27 March 2014

Cross Media Productions will be located alongside Ipex 2014, the world's largest English-speaking event for print, publishing and media.

With both shows taking place at the ExCeL, London in March, this is the ideal opportunity for businesses and customers to come together and discover all their marketing, publishing and printing solutions in the one place.

Intended for publishers, brands, reprographics, print & marketing service providers, Cross Media Production will allow participants to look beyond campaign planning and get under the hood of building, managing and delivering your communications across multiple platforms, discovering which innovative solutions exist to tie the campaigns together and how these processes can be automated, reacting instantly to the demands of the target audience.

Taipei International Book Exhibition

Taipei, Taiwan
5 to10 February 2014

The 2014 Taipei International Book Exhibition (TIBE), will host around 650 publishers, expecting to attract a total attendance of 500 000 people this year. The main objectives of the book fair range from cultural interaction and copyright exchange to reading promotion. With the exceptional performance of Taiwan's printing industry, independent booksellers and university publishers at this year's TIBE, it can be seen that small publishers can still find their own place in a market crowded with large corporations. TIBE will also include around 60 professional forums.

APN Research Meeting

Swansea, Wales UK
11th March 2014

The Advancing Printing and Coating Network (APN) is an industrial research group supported by the Welsh Centre for Printing and Coating (WCPC). The APN provides an opportunity for Industry to be involved and gain benefit from the latest research being carried out at the WCPC. The APN has a number of on-going activities in areas such as printed electronics, bio sensors, commercial printing and packaging across all of the print processes.

As part of the program of events for 2014, the research meeting will consist of a series of 30 minute presentations to explain specific aspects of the work in detail and 10 minute overview presentations designed as project updates. The format has been calculated to ensure that delegates have the ability to gain benefit from a one off attendance or allow APN Members to keep up with on-going work. Time has also been set aside to provide opportunities for peer to peer networking as well as interaction with the research staff.

Printex 2014

Mumbai, India
14 to 16 March 2014

Printex 2014 is the largest, most comprehensive trade show in the West an South India for commercial, printing, publishing, and converting technology.

It will play host to a projected 20 000 industry professionals from throughout the South East Asia. It will be the biggest, most comprehensive graphic communications exposition of its type in the West & South India in 2014. Printex is the representatives of the large companies in the world, covering all stages of the technological print process including pre-press, press, post press and consumables. It is the venue where businessmen interested in new acquisitions in the field can find consultants and financial solutions in this respect. Established itself as one the comprehensive print industry exhibition, Printex explored emerging opportunities of printing industry.

Annual Technical Conference of TAGA

Forth Worth, Texas, USA
23 to 26 March 2014

TAGA is the global association for individuals researching, developing, and studying graphic arts technology. It serves the interests of three groups:

- Print professionals investigating and utilizing leading-edge technology for their companies.
- Scientists and researchers developing technology for industry suppliers.
- University professors and students conducting basic and applied research.

TAGA maintains the industry's permanent set of technical papers and abstracts that have been published and maintained by TAGA since its founding. TAGA papers focus on emerging technology in imaging methods, workflow and production systems, while continuing to examine changes in overall technology. The Harvard Business Review describes technology fusion as "nonlinear, complimentary and cooperative. It blends incremental technical improvements from previously separate fields of technology to create product. Relying on breakthroughs alone fails because it focuses the R&D effort too narrowly, ignoring the possibilities of combining technologies." A basic principle for technology fusion is that there is a high level of intelligence gathering to keep tabs on technology developments both inside and outside the industry.

The TAGA Annual Technical Conference provides an opportunity for its members to learn about the latest industry advances and those of related fields, as well as brainstorm with other experts about solving problems and road blocks in order to move our industry forward. Members come to the Annual Technical Conference from all over the world, from all facets of the graphic arts industry.

- Technology - providers of hardware, software and consumables
- Applications - providers of printing and related products and services
- Education - providers of education and training for the graphic arts industry

TAGA provides guidance and support to its university chapters throughout the world. The Annual Technical Conference provides a unique opportunity for students to compete in several competitions, share their research activities and learn from industry professionals.

Papers are invited on emerging science, technology, and applications of all forms of graphic technology and printing processes, including offset, flexo, gravure, digital, inkjet, pad, and screen. The scope of the conference encompasses topics such as color management, materials, packaging, curing, process control, data management, workflow, security, nanotechnology, MEMS, electronics, and fundamental science. Papers that include the innovative application or evaluation of technology in the graphic arts are also encouraged. Papers accepted and presented will be published in the *TAGA Proceedings.*

Paper2014

New York City, NY, USA
6 to 8 April 2014
23 to 25 March 2014

Paper2014, the paper industry's premier event, will be held March 23-25 in New York City. Co-hosted by the American Forest & Paper Association and the National Paper Trade Association It will feature an impressive and diverse line-up of speakers, whose presentations will bring new insights and spark discussions.

Paper2014, will provide executives from across the industry with timely sessions on emerging issues and unparalleled networking opportunities to enhance business partnerships and make new connections.

At Paper2014, industry leaders will meet to exchange ideas, expand their knowledge about market place issues and find new business opportunities.

PrintPack Alger

4th International Printing and Packaging Technology Exhibition
Algiers, Algeria
6 to 8 April 2014

The 4th printpack alger already attracted record attendance of 145 technology leaders from 23 countries have already signed in and there are still more to come. Like this, the event is as big and as international as ever before.

The exhibitors are coming from Algeria, Austria, China, Cyprus, Egypt, Germany, Greece, France, India, Iran, Italy, Portugal, Qatar, Saudi Arabia, Serbia, South Korea, Spain, Switzerland, Taiwan, Tunisia, Turkey, the United Arab Emirates and the United Kingdom.

The decision of the to increase the exhibition space by moving to the bigger hall was a logical consequence of the growing demand of the Algerian plast, print & pack industry and the great success of the 2012 edition.

printpack alger 2014 takes place on the background of sharply rising imports. According to VDMA, Algerian imports of printing and paper processing machinery and equipment rose for around 38 % in only one year.

FESPA Global Summit

Munich, Germany
6 and 7 March 2014

The Fourth FESPA Global Summit will build on the success and content of previous events and will take place at The Sofitel Bayerpost Hotel, Munich on the 6th and 7th March, 2014.

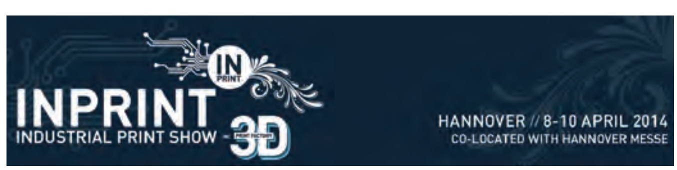
FESPA are delighted to bring this 5 star signature event for the first time to Munich. The FESPA Global Summit is a two day event comprising of traditional conference sessions, interactive workshops, panel discussions and quality networking opportunities with the objective of agreeing a route to success as the economy and the sector re-builds.

The FESPA Global Summit 2014 event invites industry leaders of the digital wide format community to address the key issues, challenges, opportunities and threats confronting the modern print service provider. The complete Global Summit 2014 program includes insightful presentations from and international list of top brands and agencies, as well as leading PSP's. Sessions will be focused on the following topics: Leadership, Sustainability, Successful Sales, Making the Most of Marketing, Digital Textile Printing, Shared capacity, Social Media for Business, Mergers and Acquisitions, New Technology in Print, Market Trends, as well as case studies from leading print companies and print buyers from all over the world.

InPrint 2014

Hannover, Germany
8 to 10 April 2014

InPrint is the first trade exhibition exclusively dedicated to print technology for industrial manufacturing. More than 100 companies from the decorative and functional printing sector will present the up-to-date printing equipment and solutions for manufacturers looking to improve capacity, flexibility and output within their production process.



InPrint features a comprehensive range of technologies and methods for printing on diverse materials such as metal, plastics, foils, textiles, glass, ceramics, wood and other substrates used within industrial manufacturing. As such, it provides a unique specialist platform for industry professsionals seeking new opportunities for the use of speciality, screen, digital, inkjet and 3D printing. The common objective of the show, is to flexibly fast-track the development process of industrial printing projects until they become market-ready and to offer support after the completion. InPrint offers a new perspective on the printing process within manufacturing. For companies ready to invest in advanced machines, tools and systems, this is the first stop to source the right equipment.

Call for papers

The Journal of Print and Media Technology Research is a peer-reviewed periodical, published quarterly by iarigai, the International Association of Research Organizations for the Information, Media and Graphic Arts Industries.

Authors are invited to prepare and submit complete, previously unpublished and original works, which are not under review in any other journals and/or conferences.

The journal will consider for publication papers on fundamental and applied aspects of at least, but not limited to, the following topics:

- Printing technology and related processes

  Conventional and special printing; Packaging, Fuel cells and other printed functionality; Printing on biomaterials; Textile and fabric printing; Printed decorations; Materials science; Process control

- Premedia technology and processes

  Color reproduction and color management; Image and reproduction quality; Image carriers (physical and virtual); Workflow and management

- Emerging media and future trends

  Media industry developments; Developing media communications value systems; Online and mobile media development; Cross-media publishing

- Social impacts

  Environmental issues and sustainability; Consumer perception and media use; Social trends and their impact on media

Submissions for the journal are accepted at any time. If meeting the general criteria and ethic standards of scientific publishing, they will be rapidly forwarded to peer-review by experts of high scientific competence, carefully evaluated, selected and edited. Once accepted and edited, the papers will be printed and published as soon as possible.

There is no entry or publishing fee for authors. Authors of accepted contributions will be asked to sign a copyright transfer agreement.

Authors are asked to strictly follow the guidelines for preparation of a paper (see the abbreviated version on inside back cover of the journal). Complete guidelines can be downloaded from:

http://www.iarigai.org/publications/

Papers not complying with the guidelines will be returned to authors for revision.

Submissions and queries should be directed to:

journal@iarigai.org or office@iarigai.org

Guidelines for authors

Authors are encouraged to submit complete, original and previously unpublished scientific or technical research works, which are not under review in any other journals and/or conferences. Significantly expanded and updated versions of conference presentations may also be considered for publication. In addition, the journal will publish reviews as well as opinions and reflections in a special section.

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A - General

The text should be cohesive, logically organized, and thus easy to follow by someone with common knowledge in the field . Do not include information that is not relevant to your research question(s) stated in the introduction.

Only contributions submitted in English will be considered for publication. If English is not your native language, please arrange for the text to be reviewed by a technical editor with skills in English and scientific communication. Maintain a consistent style with regard to spelling (either UK or US English, but never both), punctuation, nomenclature, symbols etc. Make sure that you are using proper English scientific terms.

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B - Structure of the manuscript

Title: Should be concise and unambiguous, and must reflect the contents of the article. Information given in the title does not need to be repeated in the abstract (as they are always published jointly).

List of authors: i.e. all persons who contributed substantially to study planning, experimental work, data collection or interpretation of results and wrote or critically revised the manuscript and approved its final version. Enter full names (first and last), followed by the present address, as well as the e-mail addresses.

Separately enter complete details of the corresponding author - full mailing address, telephone and fax numbers, and e-mail. Editors will communicate only with the corresponding author.

The title of the paper and the list of authors should be entered on a separate cover page (numbered as 0). Neither the title nor the names of authors can be mentioned on the first or any other following page.

Abstract: Should not exceed 500 words. Briefly explain why you conducted the research (background), what question(s) you answer (objectives), how you performed the research (methods), what you found (results: major data attained, relationships), and your interpretation and main consequences of your findings (discussion, conclusions). The abstract must reflect the content of the article, including all the keywords, as for most readers it will be the major source of information about your research. Make sure that all the information given in the abstract also appears in the main body of the article.

Keywords: Include three to seven relevant scientific terms that are not mentioned in the title. Keep the keywords specific. Avoid more general and/or descriptive terms, unless your research has strong interdisciplinary significance.

Abstract and keywords should be entered on a separate page, numbered as page 1. Do not continue with the main body of the text, regardless of the possible empty space left on this page.

Introduction and background: Explain why it was necessary to carry out the research and the specific research question(s) you will answer. Start from more general issues and gradually focus on your research question(s). Describe relevant earlier research in the area and how your work is related to this.

Methods: Describe in detail how the research was carried out (e. g. study area, data collection, criteria, origin of analyzed material, sample size, number of measurements, equipment, data analysis, statistical methods and software used). All factors that could have affected the results need to be considered. Make sure that you comply with the ethical standards, with respect to the environmental protection, other authors and their published works, etc.

Results: Present the new results of your research (previously published data should not be included). All tables and figures must be mentioned in the main body of the article, in the order in which they appear. Do not fabricate or distort any data, and do not exclude any important data; similarly, do not manipulate images to make a false impression on readers.

Discussion: Answer your research questions (stated at the end of the introduction) and compare your new results with the published data, as objectively as possible. Discuss their limitations and highlight your main findings. At the end of Discussion or in a separate section, emphasize your major conclusions, specifically pointing out scientific contribution and the practical significance of your study.

Conclusions: The main conclusions emerging from the study should be briefly presented or listed, with the reference to the aims of the research and/or questions mentioned in the Introduction and elaborated in the Discussion.

Introduction, Methods, Results, Discussion and Conclusions - as the scientific content of the paper - represent the main body of the text. Start numbering of these sections with page 2 and continue without interruption until the end of Conclusions. Number the sections titles consecutively as 1, 2, 3 ..., while subsections should be hierarchically numbered as 2.1, 2.3, 3.4 etc. Use Arabic numerals only.

Note*: Some papers might require different structure of the scientific content. In such cases, however, it is necessary to clearly name and mark the appropriate sections.*

Acknowledgments: Place any acknowledgments at the end of your manuscript, after conclusions and before the list of literature references.

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4-2013

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- Printing technology and related processes
- Premadia technology and processes
- Emerging media and future trends
- Social imapcts

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