# Recording Media Technologies for Plateless Digital Offset Printing

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Abstract: Exciting evolutions are taking place in offset printing. Digital printing form preparation is moving into the pressroom, and onto the press. Direct imaging, computer-to-press, is adopted by major press manufacturers to differentiate them from their competition and to answer the changing needs of their customers. But already new concepts are being developed, in which re-usable substrates are being used, and for which new recording media technologies are required. This presentation reviews the different recording media technologies that presently are being developed. Three generations of technologies are described : a first generation uses a lithographic substrate on which an active layer is image-wise applied or image-wise removed; a second generation uses a non-lithographic substrate on which a switchable (but non-reversible) active layer is coated; a third generation uses a reusable reversible active layer. It is explained that all three technology generations have their merits but also impose technical and scientific challenges to Research and Development Groups. Finally a new type of coating sensitive to infrared laser recording and suitable for plateless digital offset applications, called LiteSpeed$^{TM}$, is introduced and subsequently its performance is discussed

## Introduction

In this era of digitization, ever-increasing productivity and shorter turnaround times, offset printing is confronted with challenges and opportunities at the same time. Challenges are presented by new communication media technologies and by new printing technologies. Opportunities are offered by radical changes in printing plate technologies and plate preparation. Digitization is radically changing the offset environment. Still, offset as a printing technology remains extremely flexible and versatile in terms of quality, run length, substrate to be printed, inks, ...

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This paper takes a closer look at a technological evolution that impacts the nature of the printing press and of the printing process in a very significant way : printing form preparation on press. The focus will be on media technologies beyond the horizon : plateless digital press technologies. An overview of the landscape will be given and more specifically, one technology will be highlighted and explained in detail : Agfa LiteSpeed™.

## What is Digital Offset Printing ?

In digital offset printing systems, the imaging process is integrated in the press. This implies that the printing form is mounted prior to imaging, and that it needs no or only a very simple treatment after imaging, as opposed to the traditional chemical processing of conventional plates. Examples of such plate-based digital presses are: Heidelberg Quickmaster 46-4 DI, Heidelberg Speedmaster 74 DI, Omni-Adast Dominant 705C DI, Komori Project D and Sakurai Oliver 474 DPII DI.

The major advantages of digital offset (as compared to computer-to-plate) are in set-up time (job cycle time) - mainly because registration corrections are eliminated - and in overall workflow organization and control. This makes digital presses interesting especially in environments with high job change frequency and short run lengths.

The latest technological evolutions in digital offset printing go one step further and are called “plateless systems”. Plateless does not necessarily mean that no metal sheet substrate is used. It does imply however, that the substrate is not changed between jobs, but rather re-used for a substantial number of jobs. One of the earliest examples of such a plate-less digital offset press is the MAN Roland DICOweb.

## Why Plateless Digital Offset ?

The obvious answers to this are cost reduction and productivity increase. We believe it is realistic to expect that there will be a cost benefit from consumable related savings. Another attractive element may be productivity. It is believed that plateless digital presses can offer very short job changeover times, and thus very high productivity.

On the other hand, it remains to be seen to what extent plate quality, flexibility, versatility can be matched, and it seems likely that plate-based and plateless digital presses will co-exist in the future. Applications that focus on productivity may be best served by plateless solutions, applications that focus on highest quality and flexibility may be better served by plate-based solutions.

## Overview of the Recording Media Technologies

In this paper an overview will be given of the recording media for plateless digital offset printing. Three generations of technologies are described. The scope of this paper is limited to high quality laser imaging.

### First Generation Technology

The first generation plateless technology uses a substrate on which an active layer is imagewise applied or imagewise removed. In these systems the ink-receptive (oleophilic) layer is formed on the hydrophilic substrate of the plate cylinder. In these systems the plate cylinder is characterized by its good lithographic properties.

Man Roland's DICO (Digital Change-Over) concept has been exploring this plateless technology since the late 1980's (US 5,816,161 – EP 693 371) and presented it in a technology demonstration at Drupa '95. The web offset system, called DICOweb is based on the laser ablation transfer (LAT) technology. A thermal transfer ribbon, carrying an ink-receptive polymer is placed in contact with the metal plate cylinder. As a result of the IR-laser exposure the polymer is transferred to the plate cylinder. After this the formed image is fused by heat to obtain a higher run length. The image life is expected to be up to 30,000 impressions. After the job is finished, the press automatically washes off the ink and image from the plate cylinder and the press is ready for the next job. The DICOweb system drew a lot of attention during its successful demonstration at Drupa 2000.

A completely different technological approach was developed by Goss Graphic Systems (partly in conjunction with Rockwell International), and used in its Adopt/CP (Advanced Digital Offset Printing Technologies Concept Press) concept (US 5,129,321 – EP 724 967 – US 5,333,548). An erasable copper image is generated from a solution onto a nickel-crystal coated cylinder, as a result of a laser exposure. The copper forms the printing image, the nickel-crystal coated cylinder is the hydrophilic surface. The image is very durable and can last for millions of impressions. When the job is finished, the copper image is removed and the plate cylinder can be reused. It is unclear whether this development work is still ongoing at present.

Both the Man Roland and the Goss system are based on a laser-induced imagewise application of an ink-receptive layer onto a reusable lithographic substrate. Besides the laser imaging technology several attempts have been made to use ink-jet as application technology in direct-to-press applications (Fuji – US 6,152,037 ; Dataproducts Corp. – US 4,833,486 ; Scitex Corp. – EP 965 444). However up to now none of these attempts seems to have lead to a product ready for commercialization. The ink-jet technology will not be further reviewed in this paper. A second sub-group of the first generation plateless technology is based on the imagewise removal of a coating ,which is applied on-press.

A important representative in this subgroup is Agfa's LiteSpeed™ digital press consumable technology, which was first announced at Drupa 2000, and then demonstrated live during GraphExpo 2000 together with CreoScitex on their SP™ technology demonstration

The LiteSpeed™ liquid, which is sprayed onto a lithographic substrate, forms a thermofusable coating that is imaged using state-of-the-art 830 nm laser diode technology (Agfa - EP 770 496 – EP 802 457 – EP 1 084 862). As a result of the IR-laser exposure the hydrophobic latex particles are thermally fused onto the lithographic substrate. After imaging the plate is imagewise cleaned during press start-up. After the printing job is finished, the inked-up image parts of the coating are removed, after which the substrate is ready for a new job cycle. The nature of Agfa's LiteSpeed™ comes close to that of a conventional printing plate, in which a hydrophobic image is formed onto a highly hydrophilic substrate. This is one of the main features of the technology, which gives the printing form its outstanding press latitude. LiteSpeed™ is strongly related to Agfa's Thermolite processless plate (Van Damme, 2000). In the second part of this paper the LiteSpeed™ technology and performance will be explained more in detail. Agfa LiteSpeed™ was developed in cooperation with CreoScitex, and it is fully compatible with the CreoScitex SP™ process (US 5,713,287 – US 5,996,499).

The LiteSpeed™ technology is based on an IR-laser induced physical insolubilization mechanism. The insolubilization process can also be based on a chemical process. Many patents have been published dealing with such chemical concepts.

An early example of negative working plate concept which can be used in a plateless digital offset press is described in the Xerox patent (US 4,081,572) and is based on the thermal cylodehydration of polyamic acids with hydrazide groups. Agfa described the IR-laser induced crosslinking of azosulphonates which are characterized by a large change in polarity upon crosslinking (Agfa – EP 771 645). This results in a high on-press processing latitude. Eastman Kodak (EP 987 104) described other interesting classes of heat sensitive polymers, which can also be processed on the press. A first class is based on hydrophilic polymers which have heat-activatable thiosulfate groups (also known as Bunte salts) pendant to the backbone. Upon exposure these functional groups are believed to provide crosslinking sites. At the same time a large shift in polarity is observed. Due to the crosslinking during imaging a high run length is expected. A third example of negative working heat sensitive polymers is described in the Fuji patent EP 1 048 457. The hydrophilic polymers have hydrophilic functional groups in the side chain capable of becoming hydrophobic by heat (i.e. $-SO_3^-$, . $-CO_2^-$ , $-P(OR1)O_2^-$ , $-PO_3^{2-}$ , $-N^+R_1R_2R_3$) and can be used in an on-press development, were the non-image areas are removed by using the fountain solution in the printing machine.

All these negative working heat induced chemical insolubilization reactions are characterized by a rather low IR-sensitivity ($\geq$ 500 mJ/cm$^2$) and the high run length still needs to be proven. This makes them less suitable in comparison with the heat induced physical insolubilization process as used in Agfa's LiteSpeed$^{TM}$ concept.

Ablative recording layers can also be used in the 1st generation technology. During exposure the ablated dust must be collected by an air-filter system in order to protect the environment and to keep it from clouding the lenses and mirrors. Besides this ecological issue, the ablative recording media exhibit a rather low IR-sensitivity at pixel dwell times used for on-press imaging. Both limitations prevent a fast implementation of ablative media in plateless digital press applications. Therefor the focus of this paper will be on non-ablative recording media.

## Second Generation Technology

In the second generation of plateless technologies it is expected that switchable (but non-reversible) active layers will become availabe which will be coated on the substrate of the plate cylinder. A more generic and more precise denomination is "(non-reversible) switchable surface technologies". With these technologies, the transition from hydrophilic to oleophilic or vice versa is made at the surface of the coated layer. No material is ablated during imaging, no material is removed as in a cleaning cycle. There is an immediate and irreversible conversion by thermal (laser) energy. An attractive concept because it offers truly processless printing form preparation and the lithographic properties do not depend on the substrate of the plate cylinder.

Several companies are believed to be working on so called "switchable polymer technologies". Both positive and negative working concepts are described.

A classic example of a positive working switchable polymer coating is the IR dye sensitized acid generation and subsequent acid catalyzed cleavage of acid labile group pendant from a polymer backbone as described in 3M patents (WO 92/09934 and EP 652 483). This reaction is characterized by a high IR-sensitivity (app. 200 mJ/cm$^2$), however the lithographic latitude is unacceptably low.

Various examples of negative working switchable polymers have been published in the literature (Fuji – EP 1 052 113 and EP 1 046 496). They can be based on a heat induced chemical change, a physical change or a combination of both. Crosslinked compositions comprising heat-sensitive ionomers are well described polymers that are able to switch chemically from a hydrophilic to a hydrophobic state (KPG – EP 990 517 and WO 00/6325 ). A preferred class of such ionomers are vinyl polymers comprising positively charged pendant N-alkylated aromatic heterocyclic groups. Many examples are also described of heat switchable compositions based on a physical change. Usually these compositions comprise hydrophobic polymer particles which are dispersed in a crosslinked hydrophilic matrix (KPG – US 6,014,930 ; Vermeersch, 1992 ; Agfa - EP 1 065 049 ; EP 976 549 ; Fuji – EP 1 057 622 ).

A nice example of a physical change combined with a chemical reaction is the thermally induced rupture of microcapsules and the subsequent reaction of the microencapsulated oleophilic material (isocyantes) with the functional (hydroxyl-) groups of the crosslinked hydrophilic binder. Based on this technology Asahi developed the Asahi Thermal CTP Plate which was demonstrated at DRUPA 2000 (US 5,569,573 – EP 646 476 – WO 94/2395 – WO 98/29258 – WO 00/63026).

The switchable polymer coatings are attractive concepts because they offer the possibility for truly processless printing form generation and their lithographic properties do not depend on the substrate of the plate cylinder. However there are also serious challenges to overcome. To obtain a significant enough lithographic differentiation to enable offset printing is one, to keep a strong enough differentiation for practicle run lengths is another. It is expected that the time for a commercial application will be substantially longer compared to the 1st generation technology.

## Third Generation Technologies

The third generation technology consists of reversible switchable surface technologies. The ultimate goal in digital offset is to eliminate the need to replace the printing form with every job. Reversible switchable surface technologies reuse the same form by erasing the previous image and replacing it with a new one. Here, no coating is applied for every new job. The printing form consists of a high number of individually selectable and switchable micro-elements. These are “switched” to obtain the necessary lithographic differentiation. When the job is finished, the micro-elements are reset to their original state, after which the process can be repeated with a new image.

Eastman Kodak discovered a direct laser writeable and eraseble printing form consisting of a zirconia ceramic (EP 769 372 – US 5,855,173 – US 5,893,328). However very powerful lasers are required to make the system work. A practicle implementation does not seem to be possible in the near future. Another interesting reversible switchable surface technology was developed by Mitsubishi Heavy Industries and is based on the photocatalytic activity of $TiO_2$ (WO 00/6037).

The reversible switchable surface technology is the ultimate goal for a plateless digital press application. However its commercial application still seems to be far away since not only lithographic aspects (run length and lithographic latitude) need to be fulfilled but also the re-usability.

## Agfa's LiteSpeed™

Agfa' LiteSpeed™ is a thermally fusable lithographic coating. It is patented by Agfa (EP 770 496 - EP 802 457 – EP 1 084 862). It is strongly related to Agfa's processless Thermolite plate, from which its formulation is derived (EP 770 494 – EP 770 495 – EP 770 497 – EP 849 091).

### LiteSpeed™ Working Principle

LiteSpeed™ comes in a press-ready liquid form. It is sprayed onto a highly hydrophilic substrate (Figure 1 – 1.) and dries almost instantly (Figure 1 – 2.). It thus forms a sub-micron thermo-fusable layer that can be imaged using state-of-the-art 830 nm laser diode technology. The coating can also be applied by other than spraying technologies i.e. roller coating or ink jet printing.

Upon IR-exposure the fine thermoplastic particles, present in a polymer binder, are melted together and at the same time thermally fused onto the lithographic support (Figure 1 – 3.). This IR-laser induced thermal process is non-ablative, and there is no need for a vacuum extraction system during imaging.

After imaging the plate is cleaned during press start-up using a procedure which guarantees a reliable on-press processing. First the dampening rollers are applied for a few revolutions (Figure 1 – 4.), exactly as with any lithographic plate, so that the plate is wetted. The fountain solution does not dissolve the non-image areas, but it only causes a swelling of these areas. As a consequence of the latex coalescence the fountain does not interact with the image-bearing areas. Next the ink rollers are applied (Figure 1 – 5.), and the tack of the ink shreds the latex and removes the coating in the non-image areas thereby exposing the underlying hydrophilic lithographic support. At the start of the printing the non-image coating is transferred to and removed by the first few press sheets. No contamination of the press dampening and inking systems occurs.

After the printing job is finished, the inked-up image parts of the coating are removed, after which the substrate is ready for a new job cycle. The LiteSpeed™ formulation is fully aqueous, operator and environmentally safe, most suitable for use in a press environment.

After coating the LiteSpeed™ liquid, the active layer consists essentially of hydrophobic (thermoplastic polymer) particles dispersed in a hydrophilic binder, along with an IR absorbing dye (830 nm sensitized). The composition is designed to allow a fast and reliable processing on-press during the start-up procedure as will be further explained in more detail.

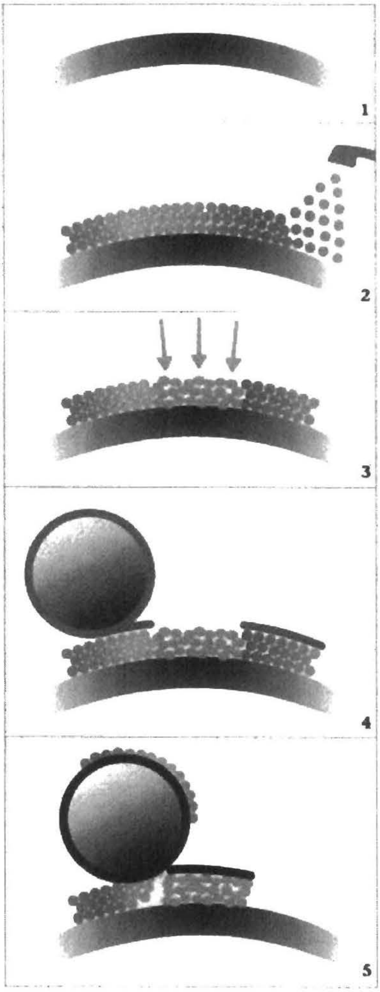

Figure 1: Working pinciple of the LiteSpeed$^{TM}$ coating

LiteSpeed$^{TM}$ Image Formation

The working principle of the LiteSpeed$^{TM}$ technology is based on the thermally induced coalescence of these hydrophobic (thermoplastic polymer) particles. Upon absorption of the IR laser light by the IR absorbing dye, the infrared light is converted into heat. As a result of this heat pulse the hydrophobic latex particles are melted together and are thermally fused onto the lithographic support

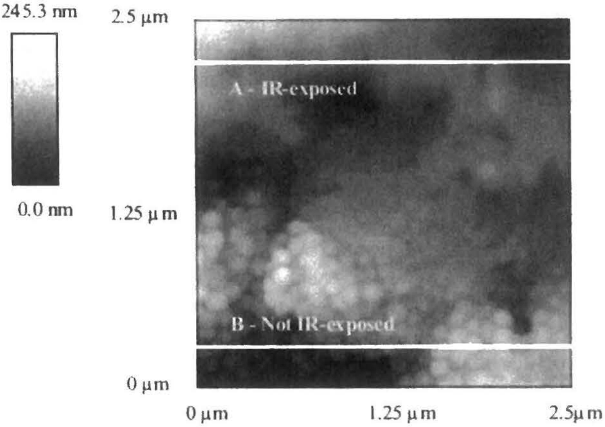

Figure 2: AFM-image of the surface topography. The upper part is an IR-exposed area (350mJ/cm²) ; the lower part of the image is not exposed by the IR-laser.

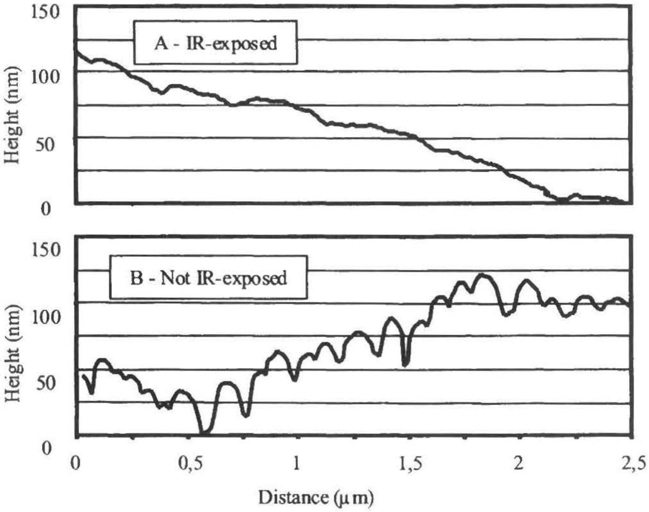

Figure 3: Line analysis of the surface topography: A. IR-exposed area; B. Not-IR-exposed area.

Via AFM the coalescence process can be visualized. In figure 2 the topography of an IR-exposed LiteSpeed™ surface is given. In the non IR-exposed areas, the latex fine structure can be identified (upper half of photograph). A topography line analysis (Figure 3) clearly shows the contours of the individual latex particles at the surface, meaning that there is no latex film formation of the latex particles upon coating the LiteSpeed™ liquid. In the IR-exposed areas the individual latex particles can no longer be identified. A line analysis demonstrates that the surface has become much smoother on a nanometer scale. This result confirms the latex coalescence process.

As a result of the heat induced latex coalescence process not only the cohesive strength of the active layer is increased (melting of the latex particles), but also the adhesive strength towards the aluminum substrate is increased (fusing into the pores of the aluminum substrate). These changes in physical properties of the active layer result in excellent latitude during on-press processing.

Another advantage of the latex coalescence process is the big change in polarity that is obtained. Upon coalescence the layer characteristics change from hydrophilic to hydrophobic (ink-accepting). This results in a fast roll-up on press. AFM in the Pulsed Force Mode allows visualizing these changes. In the Pulsed Force Mode the interaction between the surface and the analyzing $Si_3N_4$ tip is measured. Figure 4(a) shows the topography image of an IR-exposed LiteSpeed™ layer (1-pixel line pattern on a Creo Trendsetter at 350 mJ/cm²). In figure 4(b) the corresponding adhesion image is given. The gray-value is a relative measure for the interaction between tip and surface. The adhesion image reproduces the IR-imaged line pattern. The exposed areas show an increased interaction (white areas). This can only be explained by the change in surface polarity of the exposed areas towards a more hydrophobic state.

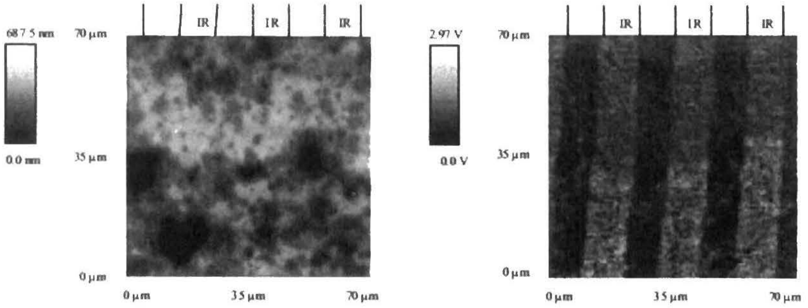

Figure 4: (a) AFM topography image of the LiteSpeed™ coating (left)
(b) AFM pulsed force mode – corresponding adhesion image

## LiteSpeed™ Performance Characteristics

### (1) Sensitivity and non-ablative nature of the LiteSpeed™ imaging technology

The LiteSpeed™ imaging requires on external drum architectures about 300 – 350 mJ/cm² (practical exposure). These energy densities may induce already ablative processes.

Ablation may comprise decomposition and vaporization of (a part of) the IR-sensitive layer, during which the physical and chemical nature of (this part of) the layer is changed. Usually this results in a clear change of topography of the surface of the active layer.

In order to prove the non-ablative nature of the LiteSpeed™ imaging technology the following experiment was performed. The LiteSpeed™ coating was sprayed onto a grained and anodized aluminum support. Next this plate was exposed on a Creo TrendSetter 3244 (2400 dpi) external drum platesetter with an energy density of 350 mJ/cm² with a 1-pixel line pattern. The surface of the imaged and non-imaged areas was analyzed with Atomic Force Microscopy. This analytical technique allows registering very small changes in topography (1-10 nm). In figure 4(a) the topography image of the surface is shown. The observed differences in topography (visualized as different gray levels) are attributed to the graining of the aluminum substrate. However an imagewise (line pattern) difference in topography is not observed indicating that the surface layer is not been effected upon exposure.

### (2) On-press processing latitude

The LiteSpeed™ coating is processed during press start-up using a procedure which guarantees a reliable on-press processing. First the dampening rollers are applied for a few revolutions, exactly as with any lithographic plate, so that the plate is wetted. The fountain solution does not dissolve the non-image areas, but it only causes a swelling of these areas. As a consequence of the latex coalescence and the increased hydrophobic character, the fountain does not interact with the image areas.

Next the ink rollers are applied, and the tack of the ink shreds the latex and removes the coating in the non-image areas thereby exposing the underlying grained and anodized aluminum support. At the start of the printing the non-image coating is transferred to and removed by the first few press sheets. No manual intervention, such as wiping with a cloth is required. As a result LiteSpeed™ offers extremely short make-ready times. Because the coating is removed by the ink, then transferred onto the press sheets there is no contamination of the press dampening system.

This was also verified in a test were the LiteSpeed$^{TM}$ coating was contacted with fountain solution during several revolutions. It was observed that even after a contact time of 25 revolutions, the non-image areas had not dissolved in the fountain but still remained fully on the substrate (see figure 5). As soon as the pre-wetted plate is contacted with fountain and ink, the LiteSpeed$^{TM}$ coating is easily cleaned after only 5 revolutions contact time.

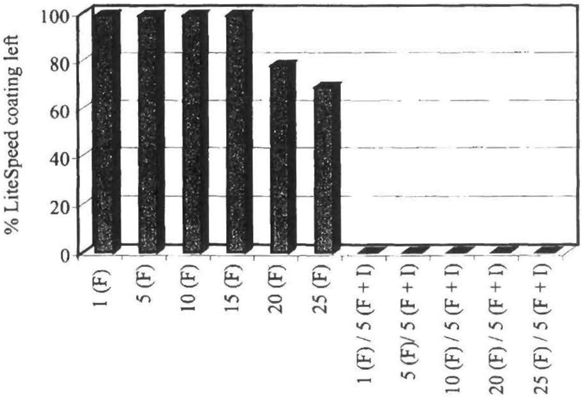

Figure 5 : Influence of the start-up procedure on the on-press processing.
# (F) = number of revolution of prewetting
# (F + I) = additional number of revolutions with fountain and ink

(3) Lithographic latitude, press dot gain and run length capability

After the short start-up procedure, LiteSpeed$^{TM}$ has the press behavior of a conventional plate. The lithographic latitude of LiteSpeed$^{TM}$ has proven to be excellent and this is no surprise since it prints from an electrochemically grained and anodized aluminum surface which is known for its excellent lithographic performance. The high oleophilic character of the LiteSpeed$^{TM}$ image, which is realized by the latex coalescence, guarantees a good ink-water balance on the press. As a result we have witnessed mid tone dot gain values on the press that are completely in agreement with what is to be expected for conventional negative plates (Figure 6).

Like other thermal plate systems the LiteSpeed$^{TM}$ system has a very high resolution. The typical tone rendered on the printed sheet at 200 lpi exceeds 2-95% (depending on the press and printing conditions). This level of quality (200 lpi) is appropriate for a wide range of commercial applications.

Run length testing were carried out with Thermolite, which is a plate using a similar coating. Under varying conditions (using various types of inks (low tack / high tack), fountain solutions (containing IPA or IPA-replacing agents), blankets (compressible / non-compressible)) a run length capability of up to 30,000 impressions was witnessed (on uncoated paper). To be on the safe side Agfa quotes the run length of the LiteSpeed™ at 20,000.

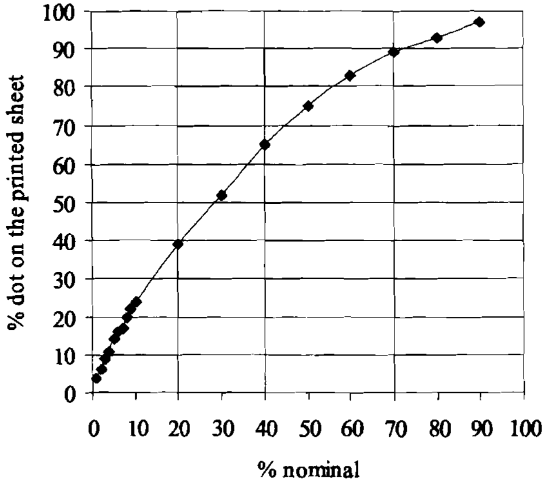

Figure 6: LiteSpeed™ coating tone rendering curve (200 lpi - printed sheet), exposed on a Creo TrendSetter 3244 (2400 dpi) and printed on a Sakurai Oliver 52 press.

## Conclusion

Plate-based digital offset presses are increasingly being accepted and adopted by the industry. It can be expected that next-generation plateless digital offset technologies will offer high productivity at attractive cost. Therefore, these technologies can complement plate-based systems, and offer a further possibility for offset to strengthen its position against non-impact printing and alternative media technologies. In this scenario, plate-based and plateless systems will each have their merits and limitations, and co-exist to address their specific areas of application.

All major press manufacturers and offset media suppliers are very active in this area and many new patents are being filed. It is believed that the first generation of plateless digital presses will be based on an imagewise application or removal of the active layer. Both the MAN Roland DICOweb and Agfa's LiteSpeed™ are two representatives from this first generation plateless technology.

Agfa LiteSpeed™ combines attractive coating and imaging characteristics with excellent lithographic performance - characteristics that are of great value especially in the targeted application areas. Implementation in actual digital press products is probably still a few years away.

It is expected that further generations of plateless digital presses will be based on switchable coatings. However serious challenges will have to be overcome. To obtain a significant enough lithographic differentiation to enable offset printing is one, to keep a strong enough differentiation for practical run lengths is another.

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Jo Vander Aa: holds an engineering degree in electronics. He has been involved in the development and market introduction of new digital printing plate products for over 10 years. His current position is in Strategic Marketing. His main field of activity is digital printing plates and digital offset technologies.

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