

Technology Overview on Computer-to-Waterless Plates (CTWP)

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Abstract

Waterless printing represents a specialized printing technology, which offers many economic and environmental benefits for high quality printing. Waterless printing plates reside in the core of this unique printing technology. Recent advancement in computer-to-plate technologies spurred a series of research and development activities in the computer-to-waterless plate (CTWP) area. This paper is intended to review various technical approaches to CTWP. The reviewed CTWP approaches include thermal ablation of silicone covered composite coatings, thermally sensitive contact masks on photosensitive waterless plates, and recently developed non-ablative techniques.

Introduction

Traditional wet offset printing involves competitive spreading of ink and fountain on a plate surface. Inks can be transferred from ink form rollers to receiving stock in areas where ink spreading on the plate surface is more favorable than fountain spreading. No ink will be transferred if fountain spreading is more favorable than ink spreading. In other words, a wet offset printing plate is not required to repel ink in the non-image area. As a matter of fact, all commercial wet offset printing plates accept inks well in the non-image area when no fountain is present.

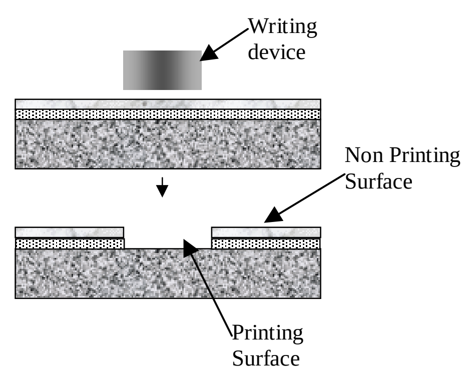
To be useful for waterless printing where ink is applied in the absence of fountain, a printing plate has to be able to repel inks in the non-image area. Two types of materials have been found to exhibit ink-repelling behaviors: one is silicone elastomer and the other is fluorinated polymer coating. Of the two, only silicone elastomers have achieved commercial success.

Thus, the essence of waterless plate technology comes down to the method of creating a pattern of ink-receptive image areas and complimentary ink-repellant non-image areas. For computer-to-waterless plate (CTWP) applications, many methods of such pattern creation have been developed. These methods involve various modern writing devices such as laser beams, inkjet print heads, LED arrays, and resistor heads. Among these devices, high power solid-state infrared lasers are target devices for most of the computer-to-waterless plate designs.

CTWP by Infrared Lasers

Laser Ablation

Nowadays, high power solid-state infrared lasers are relatively inexpensive for computer-to-plate applications. These lasers are powerful enough to ablate coatings that contain suitable IR absorbers. Thus, to make a waterless plate, one adds silicone elastomer coating on top of a laser ablatable layer. The following figure illustrates a typical design of laser-ablation waterless plates.



The laser ablatable layer is usually made of materials that are susceptible to decomposition at high temperatures. Nitrocellulose is one of the most frequently tested materials for this application. High temperature for effecting thermal decomposition is achieved due to absorption of infrared light. Carbon black is a convenient source of IR absorbers. Many IR absorbing dyes are also readily available now. Thus, a typical composition of the laser ablatable layer contains thermally decomposable binders and IR absorbers. Crosslinkable ingredients are often added. Crosslinking is expected to enhance the durability of the plate on press, but higher laser energy is required. In early days when laser power was limited, crosslinking was effected only after the imaging step is completed,[1,2] but in recent patent literature, crosslinking is usually effected before laser ablation, probably as part of a plate manufacturing process.

In addition to nitrocellulose, other organic coating materials have been screened for this application. Among them are polyvinylidene chloride[3] and styrene-maleic anhydride copolymers.[4] Recently, it has been claimed that acrylic polymers with N-N side chains such as hydrazide is particularly sensitive to high heat generated by IR lasers.[5]

Choice of binder resins is usually made on the basis of efficiency of thermal decomposition at elevated temperature. However, adhesion to the silicone layer is another factor to consider. Such adhesion will affect the durability of a plate on press and scratch resistance during handling. When silicone elastomer is made from vinyl functional siloxane polymers and methyl hydrogen siloxane, acrylic or vinyl polymers with unsaturated side chains have been shown to have particular advantages as the binder for the heat-sensitive layer under silicone coating.[6] Epoxy crosslinking chemistry has also been explored as a means to create a chemical bond between silicone top coating and heat sensitive bottom coat.[7]

Instead of organic coatings as a laser ablatable anchorage for silicone coating, laser-absorbing metal or metal oxide thin films are also found effective.[8] One of the advantages of metal or metal oxide films is the absence of gaseous effluents, which are usually formed when an organic coating is decomposed at high temperature generated by absorption of laser energy.

Silicone coating composition also affects sensitivity to laser ablation. It has been shown that addition cured silicone rubber with 10-20% of organohydrogen polysiloxane is particularly effective.[9]

In addition to the design of the laser ablatable coating composition, modification of layer structure has also been explored as a means to reduce the energy requirements. One of the approaches taken is to provide means to reflect laser beams at the inner surface of the light-absorbing coating.[10] A more recent advancement was made by utilizing interference fringes between two partially reflective layers.[11]

After laser ablation, the top silicone is usually loosened, but still attached to the plate. Loosened silicone can be removed by wiping the plate with a solvent such as isopropyl alcohol.[1] Other techniques of cleaning have been proposed. It has been claimed that surface tension of the cleaning liquids is very important and the preferred range is between 25 to 50 dyne/cm.[12] Dry rubbing has also been proposed to avoid use of solvent.[13] Another method of avoiding use of cleaning solvents is to press an adhesive sheet onto laser ablated plates followed by pealing off the adhesive sheet. The loosened silicone is thus removed from the original coating layer in the laser struck area.[14]

To avoid post-imaging altogether, a specialty silicone coating has been developed that incorporates hard segments between soft siloxane segments. These hard segments are susceptible to thermal decomposition. Waterless plates as such can be put in press operation right after laser ablation imaging.[15] The down-side of this design is the necessity for a vacuum suction system to be installed on the plate image setter.

Acid Catalyzed Decomposition

Despite various improvements made in laser ablation technologies, the energy requirement is still high. To reduce energy requirement and thereby increase imaging speed, more efficient thermal reactions have been explored. Among these reactions, acid catalyzed decompositions at elevated temperature have been studied extensively.

The layer structure of waterless plates based on acid catalyzed decomposition is similar to ablation type waterless plates. The top coat is usually silicone rubber applied over a heat sensitive composition. Laser energy can either be used to generate acid catalyst.[16] or provide heat necessary to complete decomposition reaction in the presence of an acid catalyst. In the latter case, the acid catalyst is often generated by another means such as UV flood exposure shortly before laser imaging.[17] This will ensure good shelf life of raw plates.

In the case of using laser energy for acid generation, an acid precursor is usually incorporated in the heat sensitive coating. It is known that many onium salts such as diazonium, iodonium, and sulfonium salts decompose at high temperature to yield strong acids.

After thermal decomposition is completed in the laser struck areas of a waterless plate, a development step is taken to remove decomposed coating and overlying silicone rubber, yielding a negative waterless plate.

Acid Catalyzed Crosslinking or Coupling Reactions

Strong acids generated during laser exposure can be used to effect crosslinking of a suitable composition such as a mixture of Novolac and resole resins. Once overcoated with silicone, such compositions can be used to generate laser-imageable positive waterless plates.[18] The process of imaging such plates will involve image-wise laser scanning, preheat, and development in a suitable liquid.

A related composition of a waterless plate is made of a fluoroalkyl silane, a binder resin and an acid generator. An IR laser beam generates strong acid in the image area. The acid will then catalyze a bonding reaction between the silane and the binder. The unreacted silane in the non-image can be washed out on press.[19]).

Heat Induced Enhancement of Dissolution Rate

Recently, we have discovered a coating composition that has enhanced dissolution rate in the laser struck area.[20] This composition consists essentially of a special polyurethane and an IR absorbing dye. The dissolution rate differential can be developed into a pattern in a silicone coating by a suitable solvent such as a glycol ether. It has been noticed that the dissolution rate enhancement is a transient phenomenon. In other words, the latent image is erased after the plate is heated in an oven. An erased plate can be imaged in the same way as a raw plate.

Heat Induced Phase Change

There have been inventions in patent literature that describe methods of modifying ink-receptivity of a coating without removing materials from either exposed or non-exposed areas, resulting in essentially planar waterless plates. One example of such inventions is a coating that comprises ink-repellant phase and an ink-receptive phase. Laser exposure causes rearrangement of these two phases in a coating, either making the surface more ink-repellant, or more ink-receptive.[21]

Another waterless plate is based on a special behavior of fluorinated polymer coatings. Such coatings are ink-repellant when heated in air, but become ink-receptive when heated in the presence of a liquid. This behavior allows one to write a planar image or background depending upon the sequence of point-heat and overall heat application.[22] X-ray data suggests that the ink-receptive and ink-repellant states have different molecular orientations on the surface[23]

CTWP by Electrostatic Printers

Toner images from an electrostatic laser printer may be converted into a waterless printing plate. One method of such conversion is to coat a silicone elastomer layer onto a substrate bearing fused toner images. The silicone onto the toner image is then removed by applying a suitable solvent. The solvent penetrates the silicone coating and dissolves the toner images.[24] To avoid use of solvents, it has been proposed to apply a non-tacky silicone onto unfused toner images followed by removal of loose toner images and the overlying silicone.[25] Another way of avoiding use of solvent is to apply an aqueous dispersion onto hydrophobic toner image.[26] Since the aqueous dispersion does not wet the toner image, silicone coating is only formed in the non-image area. A related method is to prime a substrate with a silicone curing catalyst.[27] A toner image is then applied onto the primed substrate followed by a coating of silicone gum without curing catalyst. Thus, silicone rubber formation on toner is not only prevented by poor wetting, but also by lack of curing catalyst, which is buried under the toner image.

CTWP by Inkjet Printers

Inkjet machines can be used to deliver a catalyst to an uncured silicone coating. After silicone is cured in the area with inkjet images, the remaining uncured silicone can be removed by a developing step.[28]

Inkjet technology may also be used to deliver an ink-receptive image on an ink-repellant surface. Of course, special inks have to be designed to achieve adequate adhesion to silicone coating. The adhesion problem may also be partially solved by leaving silicone not fully cured before inkjet imaging.[28]

Another method of using inkjet printers to make waterless plates is to apply an adhesive liquid such as cyanoacrylate to a soluble layer positioned on top of a silicone coating.[29] In this case, cyanoacrylate insolublizes the soluble layer and create a bond to silicone layer in the image area.

Other Methods of CTWP

Due to abhesive nature of silicone rubber, it is usually difficult to add ink-receptive coating on top of silicone. Therefore, a special surface treatment such as corona discharge is necessary. To maintain ink-repelling characteristics in the background, the surface treatment has to be conducted in an image-wise fashion. After imaging, a special coating consisting non-volatiles may be applied. This coating only adheres to the treated area, and serves as image area on press.[30]

Contact Masks

Analog waterless plates can be converted into a digital waterless plate by applying a digital contact mask layer. The contact mask layer can be designed using various approaches discussed earlier as long as the layer has adequate UV absorption for masking. A convenient example is to ablate a black coating on an analog silicone plate by an IR laser.[31] A digital contact mask on waterless plates can also be generated by heating a coating with uncoalesced latex particles using an IR laser.[32] Heat-developable silver halide technology may also be used to generate a contact mask on an analog waterless plate.[33] This will allow the use of low power lasers to write the image. The latent image can be developed into a contact mask of opaque and transparent patterns by a simple heating step. To facilitate removal of contact mask, an intermediate layer is inserted between the mask and silicone layers. After developing mask image and flood-exposing the light sensitive coating underneath, both mask and intermediate layer can be peeled off before the analog waterless plate is developed.

Closing Remarks

Due to inertia at both printers and major plate suppliers, growth of waterless market has been slow. However, research and development in the area of computer-to-waterless plates seems to be very active. As a result, there have been significant technology advancements made in this area. Some of them may help to overcome the market inertia and turn waterless printing into a workhorse in future graphic arts industry.

References

1. Eames, A. C. *GB 1, 489, 308* (1977).
2. Lewis, T. . *US 5161465* (1992)
3. Leenders, L. *EP 573092* (1993).
4. Ellis, R. . *EP 652483* (1995).
5. Ichikawa M; Fujimaru K. *EP 897795* (1999).
6. Hirano, T. *US 5871883* (1999)
7. Nguyen, M. .; Laksin, M. *EP 764522* (1997)
8. Lewis, T. E. *US 5632204* (1997).
9. Hirano, T. et al *US 5888696* (1999).
10. Lewis, T. E. et al *US 5487338* (1996).
11. Ellis, E. W. Lewis, T. E. *EP 825021* (1998).
12. Yokoya, et al *US 5849464* (1998)
13. Leenders, L. US 5378580 (1995).
14. Yokoya, H. US 5721087 (1998).
15. Harris M. A; Burberry M. S. *EP 847853* (1998).
16. Herrmann, H. *US 4842990* (1989).

17. Yokoya, H. *EP 794055* (1997).
18. Tsuchiya, M. et al US 5786125 (1996).
19. Bennett P. A.; Bayes S.; Smith C., *EP 888576* (1999).
20. Huang, J. *US 5919600* (1999)
21. Van Rompuy L; Et Al *EP 882583* (1998).
22. Katano, Y. *US 5177506* (1993).
23. Takano, Y. *Macromolecules* **27** (8), 2342 (1994).
24. Dankert, F. *US 5370906* 91994)
25. Kato, E. et al *US 5731115* (1998).
26. Crystal, R. *US 3907562* (1975).
27. Wells, J. B. *US 3961947* (1976)
28. Gunthers, W. *US 4003312* (1977)
29. Fromson, H. A. *US 5750314* (1998)
30. Takahashi, H. et al *US 4590148* (1986).
31. Nguyen, M. T. *WO 9700777* (1997).
32. Zhong, X. et al *WO 9853994* (1998).
33. Kagami, K. *JP 222841* (1984)

Biography

Dr. Jianbing Huang holds a position of Director of Corporate Research in Kodak Polychrome Graphics LLC. He received his Ph. D. Degree in 1993 from North Dakota State University. He joined Polychrome in July 1992 and has since been working on ink-plate interactions, development of new photosensitive coatings, synthesis of proprietary materials, and thermal/waterless printing plate designs.