Unconventional Printing Plate
Exposed by IR. (830 NM) Laser Diodes

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ABSTRACT: The trend toward direct-to-plate technology has been seen to be a viable alternative to contact exposure with film. What only a few years ago was seen as nothing more than a curiosity has become a realistic approach to an improved printing process. Over the past several years the required technologies of electronic hardware, data manipulation, software, imagesetters and plates are in the position to offer to a printer the means to go from computer to plate. Two general technologies are seen as the present choices for plates: 1.) photopolymer, and 2.) silver. Both are effective in providing high speed systems responding in the visible portion of the electromagnetic spectrum. This paper describes the results of investigations aimed at realizing an alternative technology leading to a printing plate useful for a direct-to-plate application, but imaged in response to heat indirectly obtained from an infrared energy source. The status of direct imaging using a laser diode operating at 830 nm and the associated plate will be reviewed.

Introduction

For more than fifteen years there has been a series of developments leading to the ability of exposing a plate electronically. The initial efforts focused on making the existing technologies faster. Specifically, diazo and photopolymer based coatings sensitive in the ultraviolet region were increased in photospeed. Plates requiring 200 mJ/cm^2 were reduced to 100 mJ/cm^2 and then to 20 mJ/cm^2. Eventually some were even pushed to as little as 1-2 mJ/cm^2. This appeared to be reaching the limits of the then conventional photochemistry. Although remarkable improvements were realized in photospeed, the power efficiency of the lasers was very low. The poor efficiency and cost of operation quickly signaled that if direct-to-plate was to be a reality, it wouldn't be with existing diazo and photopolymer technologies operating in the ultraviolet region of the electromagnetic spectrum.

The shift in technology was towards the visible region where a higher percentage of the argon ion laser output was realized. Additionally, other energy sources were available in this range. (See Diagram 1.) Also, the use of silver enabled speeds approximating that of film. Companies such as DuPont-Howson, Hoechst and Fuji developed high speed systems with energy requirements of 0.1 $\mu J/cm^2$ and less. More recently Agfa, 3M, Horsell and Polychrome have produced high speed products with respectable performance for direct-to-plate applications.

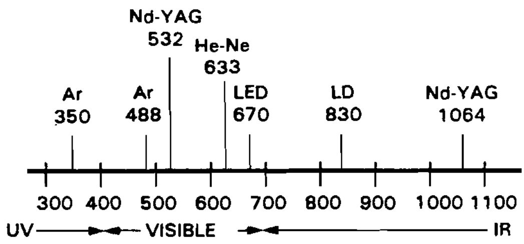

Diagram 1. Wave lengths of common energy sources

In surveying the various technologies and how Kodak might participate in the direct-to-plate market, it was realized that infrared, although used in other imaging applications, was never used for imaging a plate. Some plates in existence can respond to the red region and near infrared portion of the electromagnetic spectrum but more in the classical photochemical sense. The concept of the approach undertaken, and soon to be described, was to form images through solely a thermal mechanism. The chemical mechanism is not fully understood and certain patent applications remain to be filed, but to the extent possible the product referred to as the thermal or laser diode plate will be described.

Description of the Plate

The concept held before work began on the formulation of the plate was to arrive at a product that would be indistinguishable from more conventional plates. It would be ideal if a pressman would not be able to recognized a thermal plate as being different from a diazo or photopolymer plate in terms of handling, printability, compatibility with inks and fountain solutions, and general ability to work with pressroom chemicals. It was further desired to use as many commercially available chemical components as possible. Finally, and most importantly, it was necessary not only to formulate a plate, but to drive the design and creation of an imagesetter since none existed for plate usage heretofore.

A prototype unit, which will be described later, was used for the initial development work. The plate uses an electrochemically grained, sulfuric acid anodized, hydrophilized aluminum substrate. It is the same type of support used for most positive and negative printing plates. The coating consists of a binder polymer, laser dye, cross linking agents and an acid generator.

The binder polymer may be selected from a variety of candidates. Generally, if a plate is desired to process in a negative aqueous developer, the polymer used in the conventional negative plate is employed. Conversely, if it would be advantageous to process the plate in a positive developer, the polymer system used in a positive plate may be incorporated. The selection of the correct polymer is not a trivial matter but it is not crucial for the successful performance of the plate.

The laser dye is the key element for the successful performance of the coating. A suitable dye is one that has its maximum absorption (λ max) at or near the output of the laser source. Further it must be compatible with the other components and have the proper absorption and effective heat release for maximum chemical amplification and image formation. It is also possible for the laser dye to act as the colorant for the plate.

The acid generator is a material which when activated liberates a strong inorganic acid. The cross-linking agents are multifunctional monomers that react with the binder polymer to create a highly cross-linked matrix in the image. The formed image is durable and capable of extended press performance.

As stated, the exact mechanism isn't fully understood. It is believed the method of image formation is a three step energy transfer mechanism. The laser dye is seen as absorbing the energy from the laser diode and emitting the energy as heat. The heat activates the acid generator to release a molecule of acid which in turn catalyzes the cross-linking agents to react with the active sites on the polymer. (See Diagram 2.)

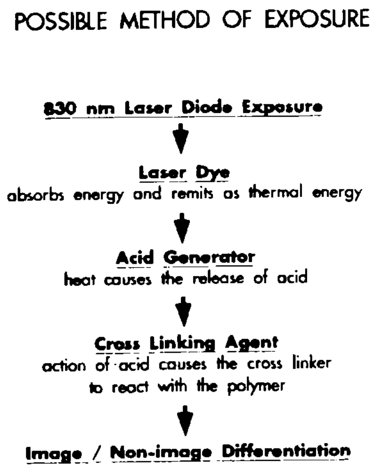

Diagram 2. Possible mechanism by which the thermal plate functions

Most research to date has centered on the use of laser diodes emitting at 830 nm. Effective image formation is achieved with approximately 150 mJ/cm^2. The threshold of image formation is about 75 mJ/cm^2. It appears that over exposure is not possible. Energies up to 525 mJ/cm^2 have been used with no adverse or beneficial effects. It is suspected that at some point image loss or degradation may occur but it is not possible to speculate at what level of energy this would begin.

The exposed plate may be processed immediately after exposure. In this instance the coating responds in a manner analogous to a positive plate. The coating exposed with the laser diode will be removed in the development step and the unexposed portion becomes the image. Alternatively, the exposed plate may be heat-treated prior to development to create image reversal. The coating exposed now becomes the image and the unexposed area is removed during development to become the background. The heating requirement for creating the image reversal is moderate. On the average, heating at 100°C for 90 seconds is adequate. Whether the image is formed with or without the reversal method, the developed plate may be run on press as is or post-baked for extended press performance. (See Diagram 3.)

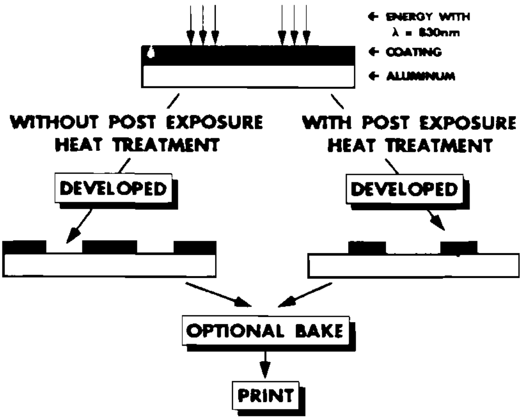

Diagram 3. Response of the thermal plate to imaging with and without an intermediate heat step

The original version of the plate evaluated was fully insensitive to all visible and ultraviolet light. This iteration was abandoned in favor of a plate that performed equally well with laser exposure but could also be contact exposed in a conventional vacuum frame. This variation requires a yellow lighted environment similar to any conventional plate. Input obtained from a survey of printers suggests the bimodel feature to be more preferred than the 830 nm only type.

Description of the Image-Setter

The imagesetter for laser diode imaging is required to be an external drum device. Due to the short focal length of the laser diode, it is the most practical method to insure uniformity and consistency of exposure. The plate is mounted on a rotating drum and as the plate spins, the laser diode traverses the length of the plate. The exposure path is a 0.004" helical pattern around the plate.

A prototype unit was obtained which uses an array of eight laser diodes. The output of each diode is connected with fiber optics to an alignment block where the output of the array is focused through optics for final correction. The energy from each diode reaches the plate as a 14μ spot. Each diode is rated at 0.3W. At the plate the power from each diode is 0.2W.

The plates are imaged at 1800 dpi. The drum rotates at about 900 r.p.m. A more important parameter is surface speed. Initial speeds of 7.5 m/sec proved satisfactory. When a larger drum was tested at a surface speed of 12 m/sec, the image quality was observed to still be acceptable. Higher powered laser diodes are becoming economically available. It is expected that a larger array of 1.0 W laser diodes will provide the means to realize large formats exposed effectively and in a timely manner.

Within the past year a collaborative effort was begun with Ektron to build a fully featured imagesetter. The unit they offer has a 23" (58.4 cm) drum. The width is 44" (111.8 cm) and has a circumference of 72" (182.9 cm).

At a rotational speed of 450 rpm, the surface speed is 14 m / sec. The image head is equipped with an array of 20 laser diodes. The imaging time for a full size plate is 8 minutes. (See Diagram 4.)

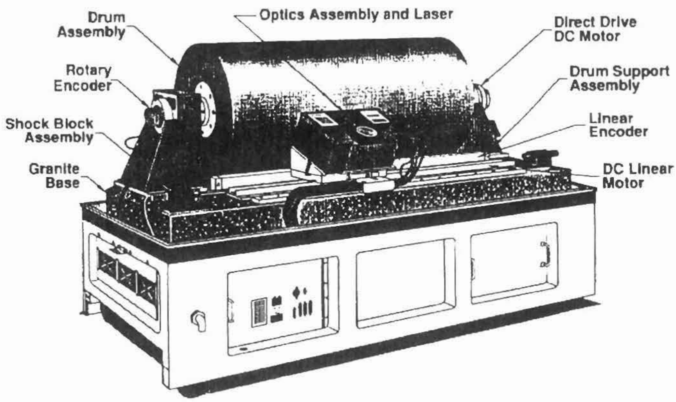

Diagram 4. Ektron 6447 Laser Imagesetter

This unit is manual for loading and unloading. The average throughput for a full size plate is 5 - 6 plates per hour. Smaller formats could have a throughput of 8 - 10 plates per hour.

Plate Performance

As stated, the plate requires a yellow light environment. The white light tolerance is not significantly different than any currently used diazo or photopolymer plate. In terms of handling, there are no special precautions. Scratching and scuff sensitivity are similar to any commercially available presensitized plate. Storage at ambient conditions [70°F (21°C); 50% R.H.] will provide acceptable usage for at least two years.

Further, the exposure required for acceptable imaging at 830 nm is about 150 mJ/cm^2. It is possible to underexpose the plate but to date it hasn't been observed that overexposure is possible. An appropriately exposed plate will produce on the average 75,000 impressions if the plate is not baked after development. When baked, approximately 400,000 impressions are obtained. When the plate is contact exposed at 368 nm, the energy requirement is 60 mJ/cm^2 for acceptable exposure (solid step 4; Δd / step = 0.15). Such a plate will produce 250,000 impressions. The effect of baking on the image formed with ultraviolet exposure is minimal. Also, there is no influence by an intermediate heating step. All images are formed using a negative flat.

The plate has an olive green color before exposure and a reddish-brown color where exposed. The contrast is ≅ 0.08 and the dmax is 0.95 with a dmin 0.30. Upon processing, the image reverts to green. The resolution of a properly exposed and processed plate is 0.5 - 99% at 175 LPI. Since the screening may be increased or decreased electronically, dot gain, and therefore dot gain curves, are not of importance for a plate exposed thermally. A properly contact exposed plate has an average dot gain on the plate of 2.5% on a 50% dot.

The below images show the image quality of a 50% dot using two screening methods on the thermal plate. Both are magnified 275 X.

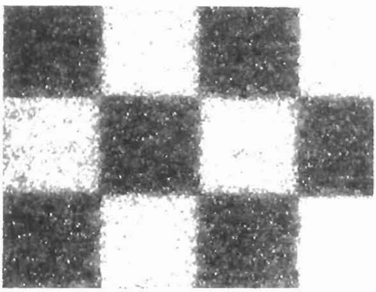

Image I

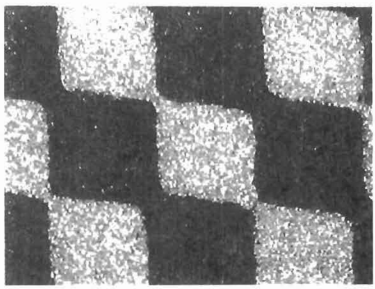

Image II

Plate corrections are not unlike any other plate. Additions are accomplished with the use of pens, needling, stippling solutions and set in solutions. If the coating processable with positive developer is used, positive deletions gels are effective for removing unwanted images.

Conversely, the negatively processed version has deletions made with any commercially available deletion fluids.

When the plate is thermally imaged, it has been determined there is no time requirement before processing. Plates have been imaged and permitted to be stored up to four months before processing. No visual or performance differences were observed between the stored and freshly processed plate. An extension of this concept was tested on a plate that was heated after exposure. After heating, the plate was stored four months and then developed. Here again no differences were observed between the stored plate and one freshly processed.

Conclusion

There are open issues around the imagesetters, the utility of the plate with frequency modulated screening, and performance when imaging at other wave lengths and sources such as 1064 nm with Nd - YAG and other laser diodes. There are also improvement opportunities around improved thermal response, run length and the elimination of baking for extended press performance. Although there are topics to be addressed, it is believed thermal imaging has been demonstrated to be a viable alternative to existing technologies for direct-to-plate applications. There are advantages related to using yellow lights. The evolution of laser diodes has the potential for providing more powerful imaging heads at a lower cost, improved longevity, and increased plate throughput.

Acknowledgment

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