Ultra-Thin Layers for use with Direct Imaging Thermal Ablative Plates

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Abstract:
A microscopic investigation of a novel lithographic surface, based upon ultra-thin layers of polymers and ceramics coated on a polymer-ceramic composite, yields insights into the behavior of a new DI™ product from Presstek. High magnification scanning electron microscope photographs reveal the intricate micro-features that result in a thermal ablative lithographic plate that can be imaged directly on-press without the need to process and requires no gumming step. By simplifying the imaging and registration processes, this structure provides a more reliable printing process. Although coated upon a standard polyester base, this plate uses the surface chemistry of these unique polymer and ceramic layers as the actual printing surfaces. These ultra-thin layers allow for extremely high resolution and long run capability over 100,000 impressions. These novel lithographic surfaces are formed using advanced vacuum coating techniques. The link of plate morphology and more repeatable press performance is described.

INTRODUCTION

Industry experts have admonished printers to become more cost effective in order to become more competitive with non-print media alternatives. One way for this to happen is to streamline the pre-press and on-press printing processes. This requires the elimination of materials, processing steps, processing time, equipment, and waste, along with the associated reductions in cost.

Such significant improvements often require significant changes in materials technology. One such materials technology change involves the use of "ultra-thin" ceramics for computer-to plate or Direct Imaging on-press.

Presstek Inc., Media Research & Development

PROBLEM DESCRIPTION

Today, the majority of the lithographic plates in use are "subtractive plates". Such plates are imaged and processed in such a manner as to remove ["subtract"] unwanted portions of the coating layers previously applied to a substrate, usually aluminum. This leads to the "Subtractive Plate Axiom": "The more you put on, the more you have to take off." Thick coatings have the potential for higher emission and higher effluent levels than thinner coatings. In addition to lower pollution potential, thinner coatings also increase the resolution capability of plates. However, as coatings get thinner, the possibility that run length will decrease becomes more assured. This is the "Subtractive Plate Dilemma" that must be overcome. A solution to this problem would be to have a subtractive plate that has an "ultra-thin" coating of which the minimum area is removed during imaging. This plate should also have coatings that are sufficiently hard and strongly adherent as to maintain the desired run length. Improved oleophilicity of the image would also be desirable to minimize roll-up and maintain density stability throughout the run, thereby minimizing paper waste. These thin coatings should also be scratch resistant.

PROBLEM SOLUTION

One such solution is the use of Ultra-Thin Ceramic Technology in the new APPLAUSE™ plate from PRESSTEK. This plate will be offered in spool format for DI™ press applications, and in sheet format for CtP or "hybrid" Direct Imaging on-press applications. The ultra-thin coatings allow for a plate that needs no air management during imaging, and no chemical processing or processing equipment after imaging. This plate technology has exhibited run lengths in excess of 100,000 impressions for single pixel images of 10-15μ diameter. Its resolving power is well below 5μ pixels.

PROCESS COMPARISONS

In order to quantify the improved efficiency allowed by ultra-thin ceramic technology, it is necessary to revisit the description of the subtractive plate process [Figure 1]. In general, subtractive plates fall into two main categories: Positive and Negative

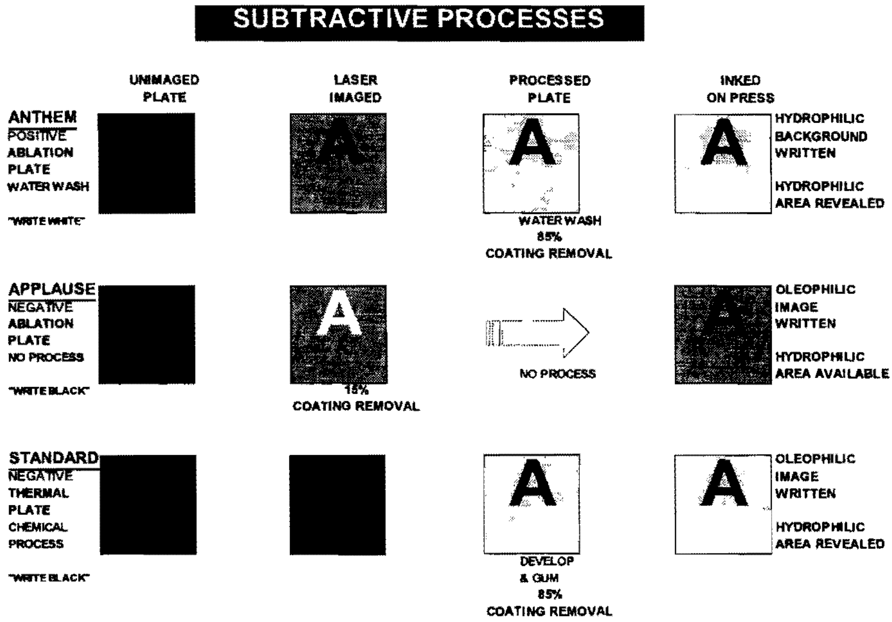


Figure 1

In the standard Negative plate, the image area is exposed via laser and cross-linked to prevent dissolution in the plate developer. During the chemical development, approximately 85% of the coatings are removed to reveal the non-printing area in an average "standard" image. [Obviously, the intended ink coverage of the subject matter, the amount of text, and the color to be printed, determine the individual area that is exposed for each plate.] The plate is then gummed and sent to press. The remaining imaged area gets inked on press. This can be termed a "write black process".

In a standard Positive plate the exposure results in the non-printing area being soluble in the developer. Again, the average "standard" image area results in the removal of approximately 85% of the unwanted coatings to reveal the hydrophilic areas of the plate. After gumming, the plate is sent to press and the remaining oleophilic coatings pick up ink. This can be termed a "write white process".

The ANTHEM™ plate is also a positive or "write white" plate. However, because it is imaged using laser ablation technology, part of the unwanted coatings are removed in the imaging step, and the remaining residuals are washed off with water. Once again, around 85% of the area is removed. No gumming is needed before going to press. The portions of the plate that were not ablated accept ink and those that were revealed during imaging accept water.

The APPLAUSE™ plate is different. Although it is a negative or "write black" plate, only 15% of the coating area is removed during laser ablative imaging. This step reveals the ink receptive area and leaves behind a water receptive area. Because there is such a thin layer of material being removed, no further processing is required. No developer or gum is needed. Therefore, imaging can be done off-press or on-press.

This is possible because the construction of this plate is "turned upside down" compared to the typical negative plates [Figure 2].

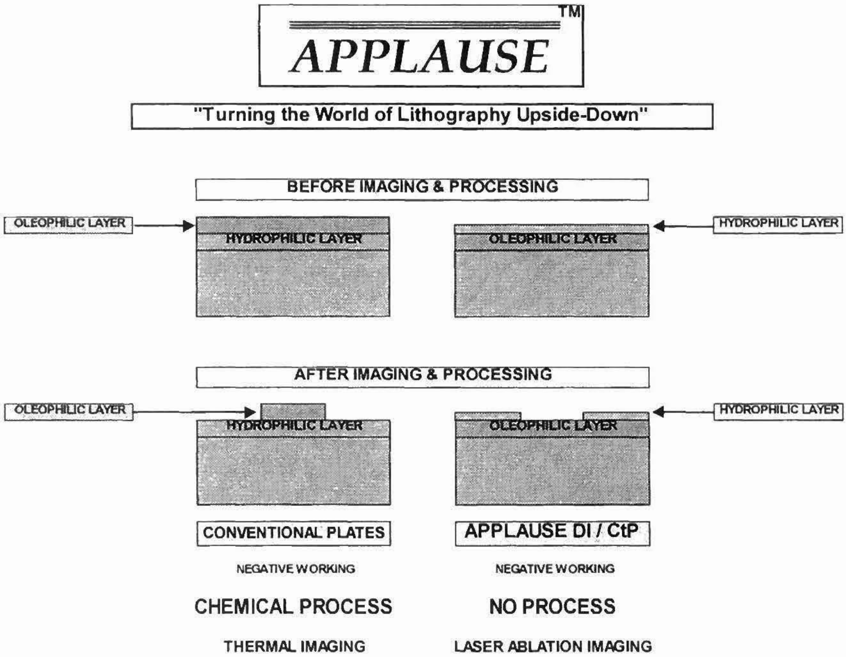


Figure 2

In conventional plates, the hydrophilic layer is on the bottom and the oleophilic polymer layer is on the top. This is because the usual hydrophilic layer is a specially treated anodized layer on an aluminum substrate. With APPLAUSE, the oleophilic layer is on the bottom and is a specially treated polymer-ceramic layer coated on polyester. [This may then be laminated to aluminum if desired.] The hydrophilic layer on the top is a ceramic material.

As a result of this construction, the imaging process is similar to a "laser engraving process" and therefore only a small area needs to be removed to reveal the ink receptive image area. This type of process yields the minimum amount of materials removal and therefore is more efficient than standard negative plate processes used in other systems.

"ULTRA-THIN" DEFINITION

Before going into a discussion of process efficiency, it is important to define what is meant by "Ultra-Thin". In Figure 3, "thin" is defined as a coating in the 1μ regime. This can be compared to the diameter of a human hair at 75-100μ, or a piece of 4-mil film at 100μ in thickness.

Something "very thin" can be defined as a coating in the order of ¼μ, whereas coatings of 0.05μ [50 nanometers] or less can be considered "ultra-thin".

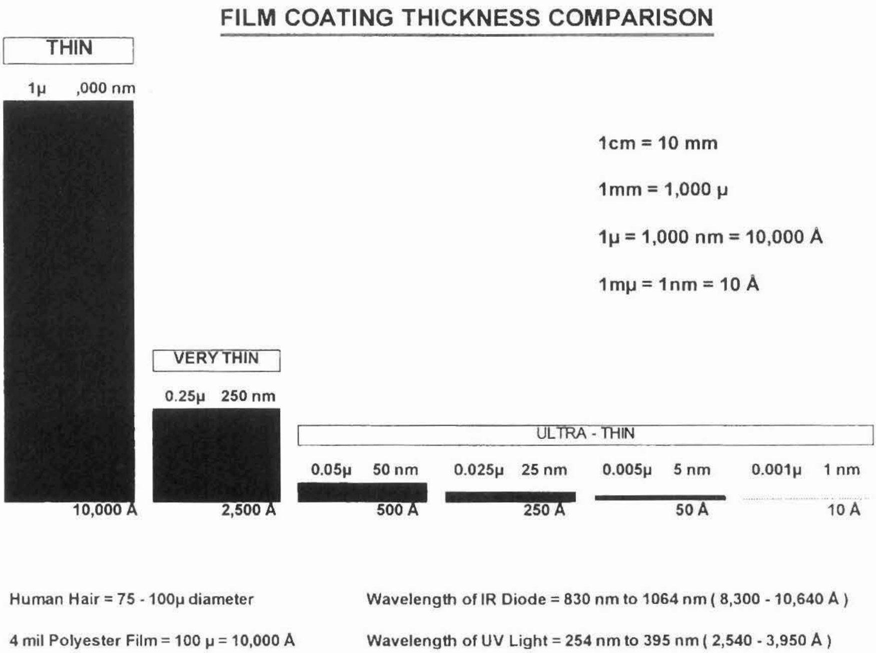


Figure 3

Having made these definitions allows a comparison to plate coatings. Typical negative and positive lithographic plates have oleophilic layers in the range of 1-2μ and are therefore considered "thin" coatings. [Figure 4]

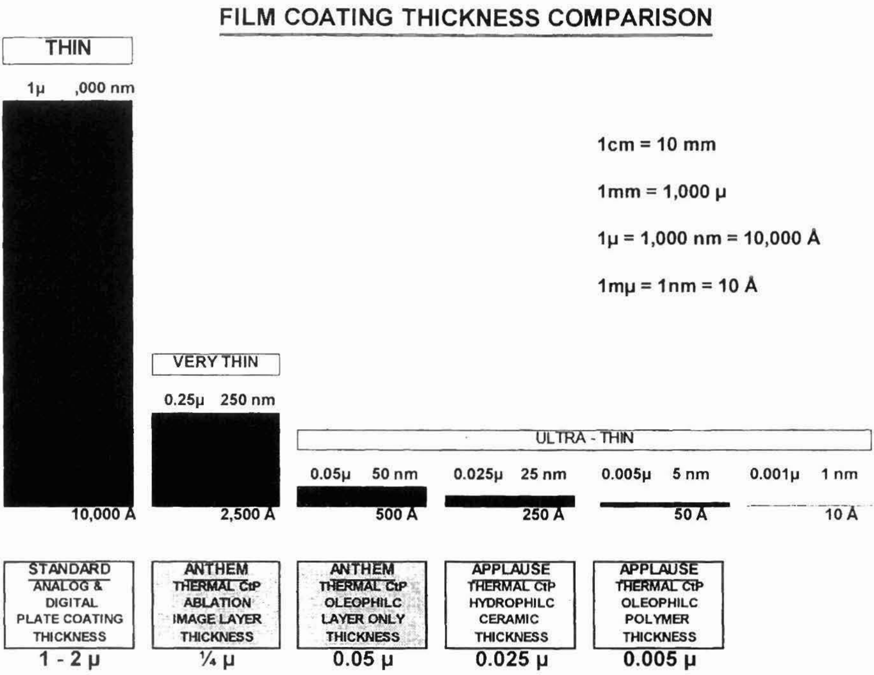


Figure 4

In ANTHEM, the total thickness of the carbon and oleophilic polymer layer is 250 nm, so the combination is "very thin", but the polymer layer by itself is only 50 nanometers. That layer would be considered "ultra-thin". The ceramic layer for APPLAUSE, at 25 nm, is also "ultra-thin". The 5 nm oleophilic polymer layer under that ceramic coating is even thinner, but is not removed in the process of making an APPLAUSE plate.

MATERIALS EFFICIENCY COMPARISON

By comparing the thickness of the layers that are removed on the various plates shown in Figure 5, as well as the area removed during imaging and processing, a "materials efficiency" rating can be derived.

Materials Removal Efficiency

	THICKNESS		COVERAGE	% REMOVAL	PLATE AREA (790X1030mm)	MATERIAL REMOVED WEIGHT (GRAMS)	MATERIAL REMOVED VOLUME	NUMBER of TIMES LESS VOLUME REMOVED
STANDARD NEGATIVE PLATE THERMAL	1.5µ	1,500 nm	1.5gram / M²	85%	0.8M² Dens = 1.0	1.02	1.02	0
ANTHEM POSITIVE PLATE ABLATIVE	0.25µ	250 nm	0.25gram / M²	85%	0.8M² Dens = 1.0	0.17	0.17	6
APPLAUSE NEGATIVE PLATE ABLATIVE	0.025µ	25 nm	0.12gram / M²	15%	0.8M² Dens = 4.93	0.014	0.003	340

Compared to STANDARD LithoPlates

Figure 5

Clearly the coatings on ANTHEM are 6 times thinner than conventional products and therefore more efficient. However, the coatings on APPLAUSE are 60 times thinner than standard plates. [Figure 6]

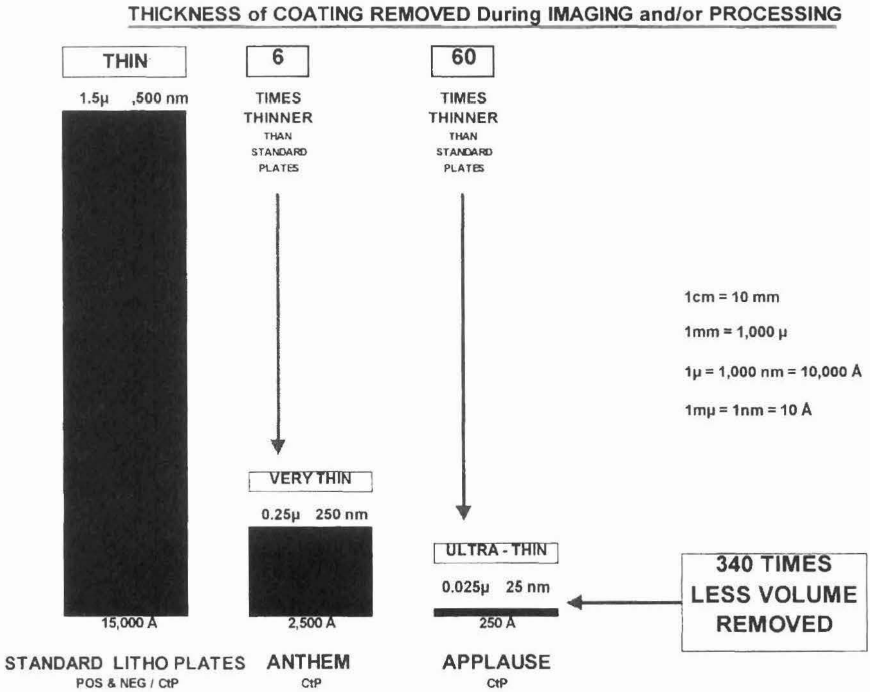


Figure 6

Taking the reduced area removal into account for the laser engraving process in addition to the "ultra-thin ceramic technology" results in 340 time less volume of material removed with APPLAUSE. This results in a "materials removal efficiency rating" of 340 to 1 versus other subtractive plates. [Figure 7]

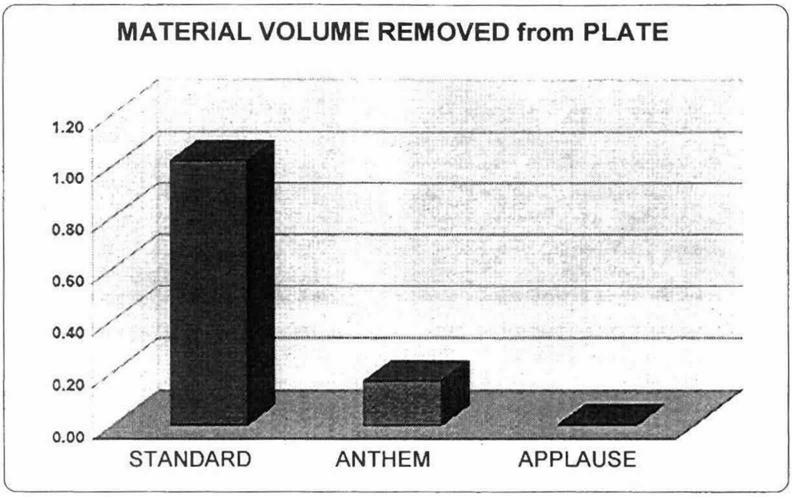
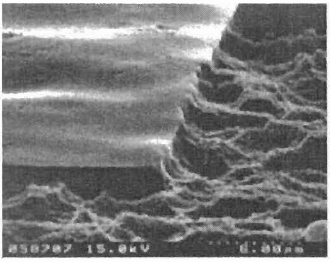


Figure 7

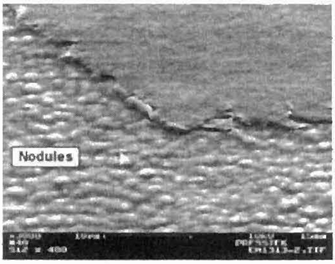
The relative thickness differences for these plate types can be seen in the SEM micro-photographic comparison in Figure 8. Clearly the thickness of the coating on the conventional thermal CtP sample is significantly greater than the layer thickness for the ANTHEM plate. [The surface roughness is also higher for the standard plate.] The ceramic layer is so thin on APPLAUSE it is difficult to see the edge of the coating even at 3,000X magnification viewed at an angle similar to the other plates. [Figure 9]

COATING THICKNESS COMPARISON

SCANNING ELECTRON MICRO-PHOTO
3,000 X



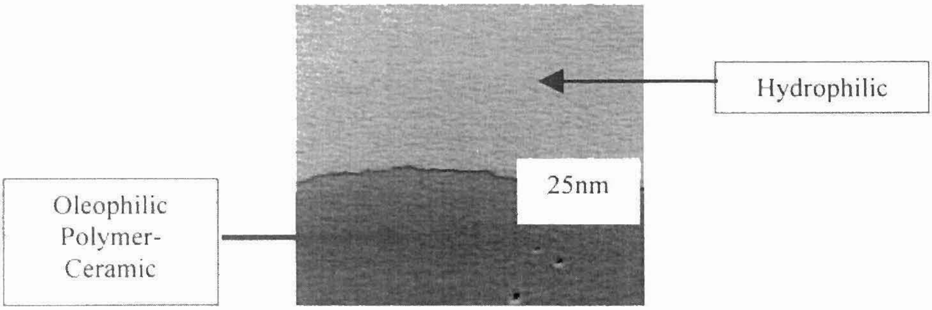
CONVENTIONAL THERMAL CtP



ANTHEM THERMAL ABLATION CtP

Figure 8

Ceramic Coating Thickness



Scanning Electron Micro-Photo
3,000X

Figure 9

TECHNOLOGY DESCRIPTION

These "ultra-thin" layers of ceramic materials are made possible by a coating technology known as ION SPUTTERING DEPOSITION. [Figure 10]

ION SPUTTERING DEPOSITION

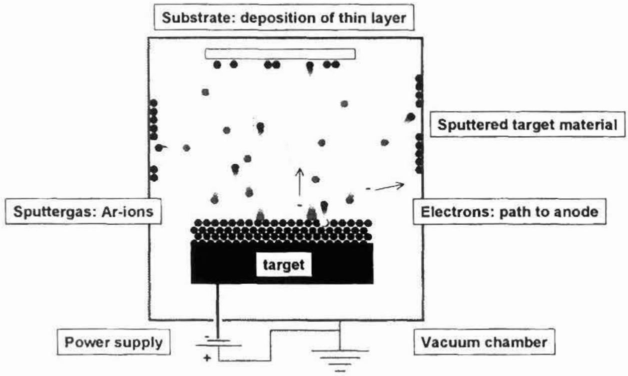


Figure 10

In this process, ions of inert gases such as Argon are accelerated in magnetic fields in order to bombard electrodes made from the material that is to be deposited. This bombardment results in the sputtering of atoms at high velocity in reduced atmospheric pressure. These high velocity materials will strike the target substrate and nucleate to begin building "ultra-thin" films. Extremely accurate film thickness levels in the order fractions of a nanometer can be maintained. To obtain ceramic compositions, reactive gases are often introduced into the vacuum chamber to obtain materials of precisely controlled stoichiometry and structure.

In the APPLAUSE plate structure, shown at 30,000X magnification of cross-sectional view in a scanning electron microscope, the ceramic of choice is Titanium Carbide. This TiCx layer is sputtered on top of a polymer-ceramic composite layer. The ceramic in this composite is an extremely fine grain size of high packing density. [Figure 11]

APPLAUSE™
Microscopic Side View

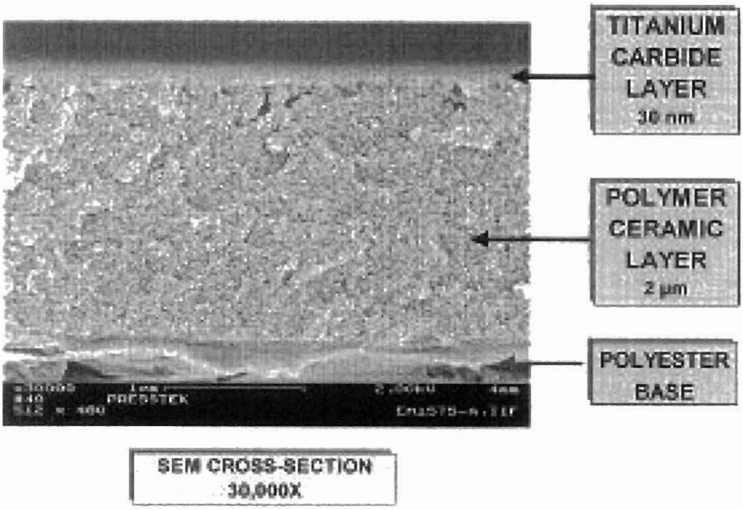


Figure 11

This layer serves in a similar capacity to the anodic layer on aluminum in that it toughens the surface of the polyester upon which it is coated. This layer doubles the hardness of the polyester and contributes to the increased run length of this plate. [Figure 12].

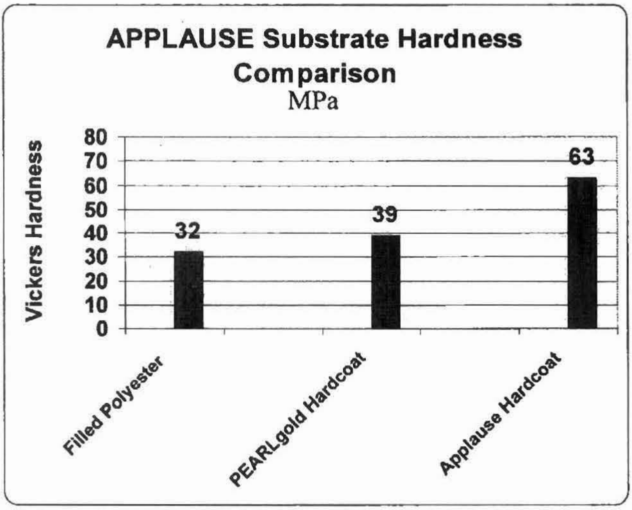
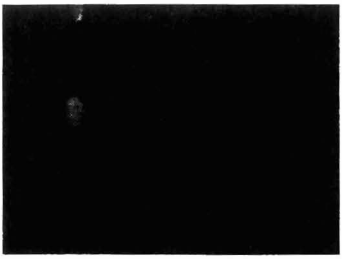


Figure 12

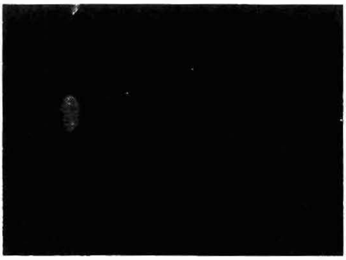
LASER ABLATION IMAGING

The APPLAUSE Laser Ablation Imaging Event is shown in Figure 13. In the microphotographs taken at 4,000X, the infrared laser beam coming from the right side is focused on a spot on the surface of the ceramic layer. The TiCx is an excellent IR absorber and rapidly heats.

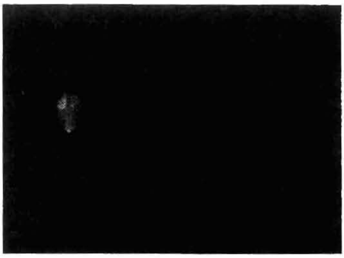
APPLAUSE --- LASER ABLATION IMAGING EVENT @ 4,000x



t = 30ns #1

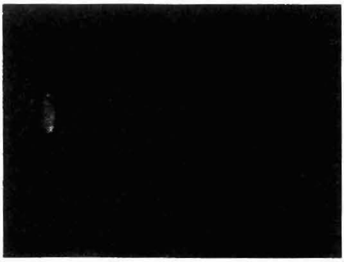


t = 68ns #2



t = 114ns #3

t = 156ns #4



t = 290ns #5

t – 480ns #6

Figure 13

In Frame #1 the initial glow of the heated spot can be seen at t=30 nanoseconds into the event. In frame #3 at 114 ns, the fine particulates can be seen clearly expanding away from the plate surface. By frame #6, the event is nearly over, and the particulates are seen to be redepositing on the surface of the plate due to the high density of the particles. The amount of ejecta in this event is miniscule compared to other laser ablation imaging processes because the coatings are "ultra-thin". The loose particulates on the surface are easily removed during roll-up and create no color change, thus enabling Direct Imaging on press with no processing needed. The sensitivity is approximately 350mJ/cm^2.

The result of the laser imaging can be seen in Figure 14 at 3,000X under the SEM. At 20,000X slight differences in the topography are visible. However, it is not until the surfaces are viewed under 100,000X magnification that the differences in surface features and porosity can be easily distinguished in Figure 15. The granular morphology of the TiCx layer is important for two reasons. First, the increase in surface area increases the water holding capability; second, the granularity allows the "ultra-thin" but very hard layer to resist cracking.

ULTRA-THIN CERAMIC

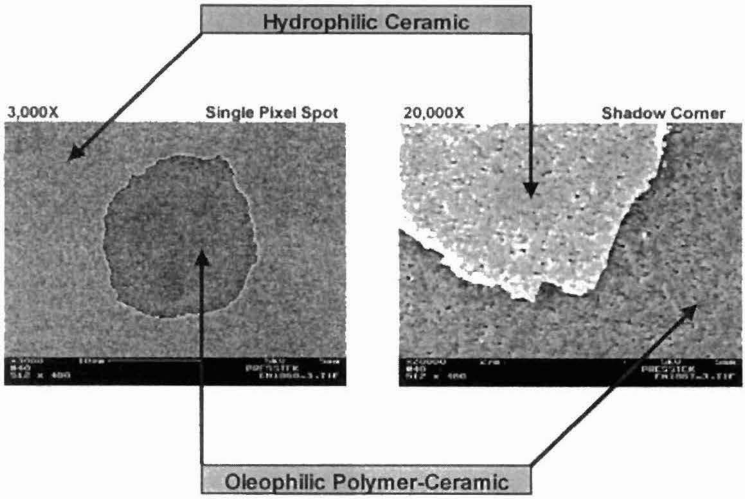
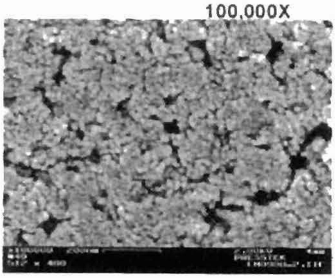
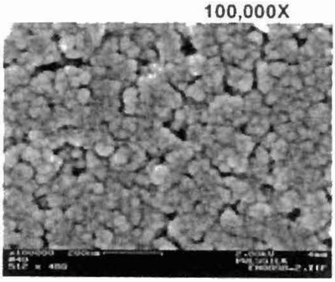


Figure 14

APPLAUSE^{TM}
Microscopic Top View



POLYMER CERAMIC INK RECEPTIVE LAYER

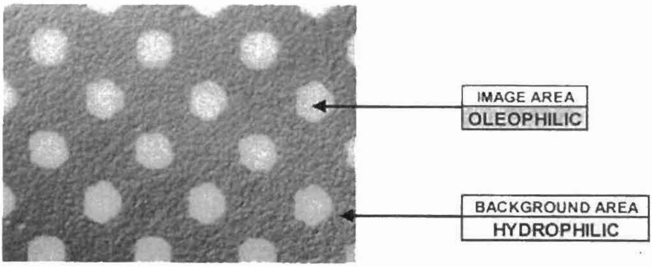


TITANIUM CARBIDE WATER RECEPTIVE LAYER

Figure 15

Looking at the imaged plate at the more normal magnification of 200X, the resultant half-tone dots at 175 lpi appear sharp and well defined in polarized light. A surface texture is also apparent. This comes from the polymer-ceramic composite layer. [Figure 16]

HALF-TONE DOTS on *APPLAUSE*^{TM}



Imaged on DIMENSION 400 @ 175 Line @ 2540

25% DOTS 350mJ/cm² 200X

NEGATIVE WORKING PLATE

Figure 16

For other plate technologies, the imaging process would be followed by chemical processing steps carried out in a variety of equipment and taking up space. How much space would depend on the need for additional processing requirements such as pre-heating or post-baking steps. A popular CtP process is compared to the much-reduced process for ANTHEM in Figure 17. APPLAUSE needs no processing at all and therefore needs no process equipment, chemicals, or space. Thus, it is even more efficient.

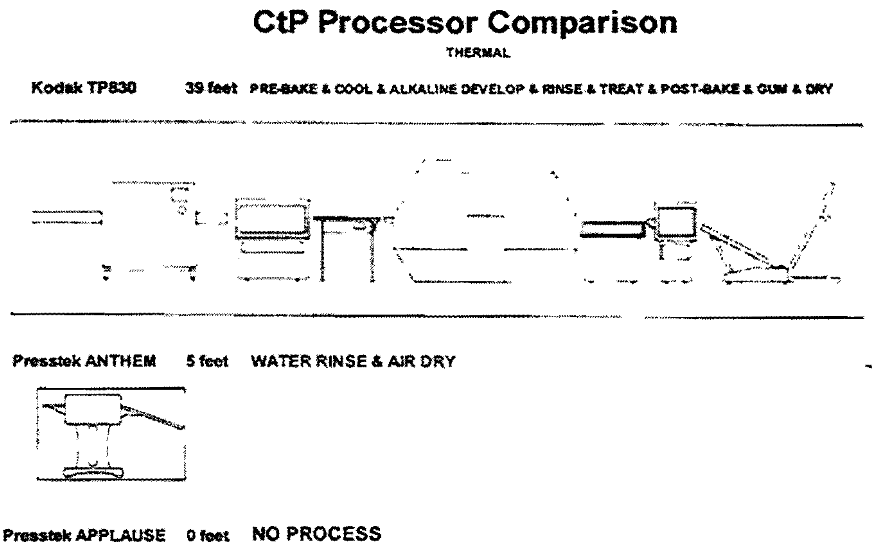


Figure 17

PRESS PERFORMANCE

After imaging, press roll-up occurs immediately in the DI™ mode, or after a time delay in the CtP mode, without the need for gumming. Roll-up to ink density can be extremely efficient and take place in less than 10 impressions. [Figure 18] The stability of ink density can be maintained over the entire run length as shown during a three-day run of 100,000 impressions. This plate was stopped and started multiple times. [Figure 19]

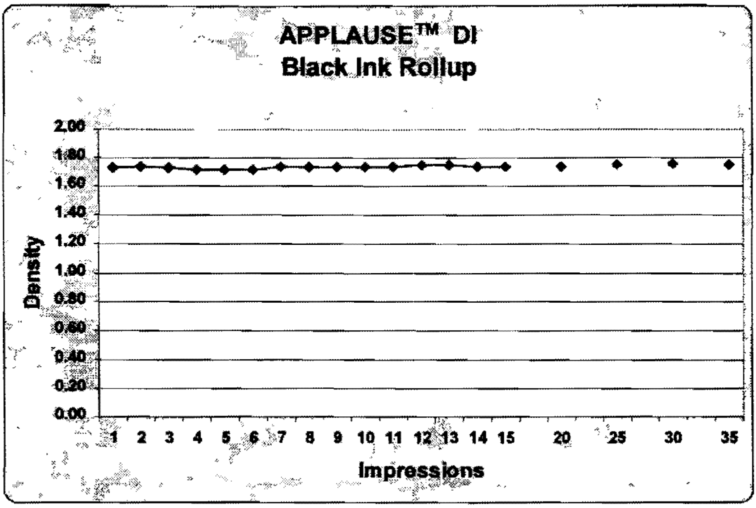


Figure 18

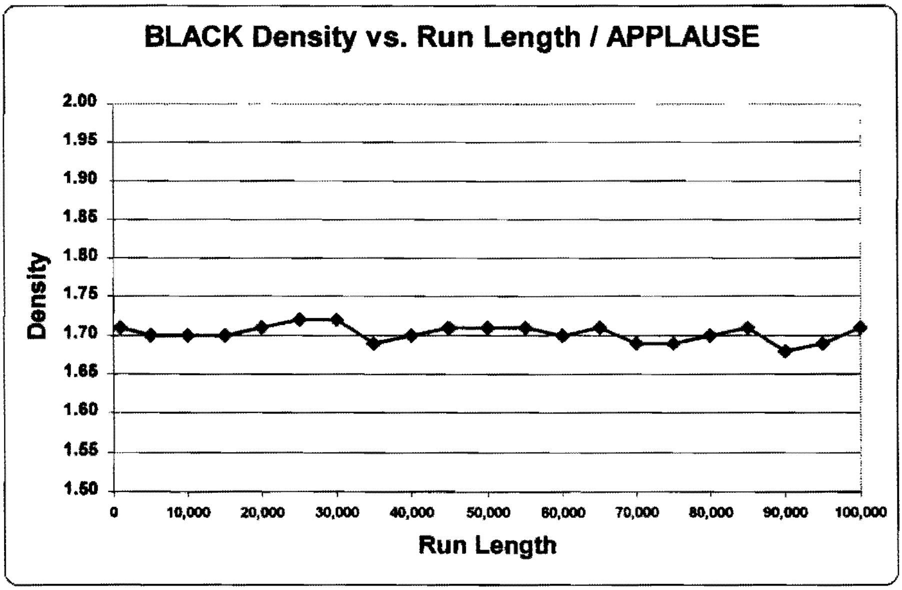


Figure 19

The excellent ink receptivity is due to the surface tension of the ink receptive polymer-ceramic layer. This layer is extremely non-polar, is readily wet by ink and resists being displaced by water or fountain solution. A typical contact angle for water is 98.8 degrees. [Figure 20]

APPLAUSE™

Ink Receptive Area

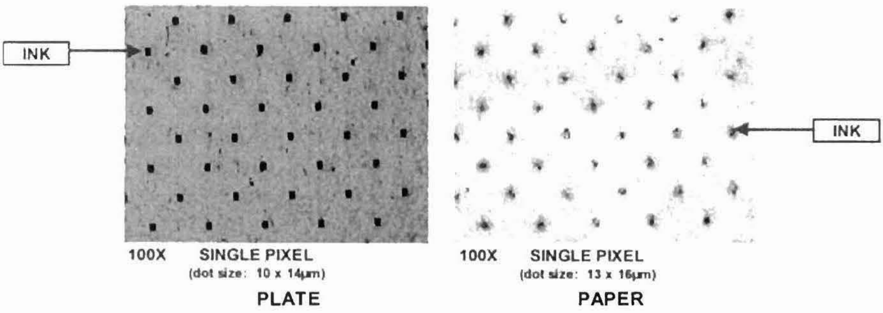
CONTACT ANGLE	
WATER	OIL
98.8	11.6

SURFACE TENSION (dyne/cm)		
POLAR	NONPOLAR	TOTAL
0.05	47.88	47.93

Figure 20

This high degree of ink receptivity helps to maintain the printability of even the finest images. Figure 21 shows a single pixel image of 10 X 14μ still intact and printing on paper after 100,000 impressions. In addition to the ink receptivity, an excellent interfacial adhesion is achieved for all layers. The hardness and abrasion resistance of the Titanium Carbide ceramic, even at a thickness of 25 nanometers, provides good press durability and run length. The hardness of the TiCx ceramic is even higher than the values for the Aluminum Oxide typically found in the anodic layers on standard plate technologies. [Figure 22]

APPLAUSE™ RUN LENGTH



100,000 IMPRESSIONS

Figure 21

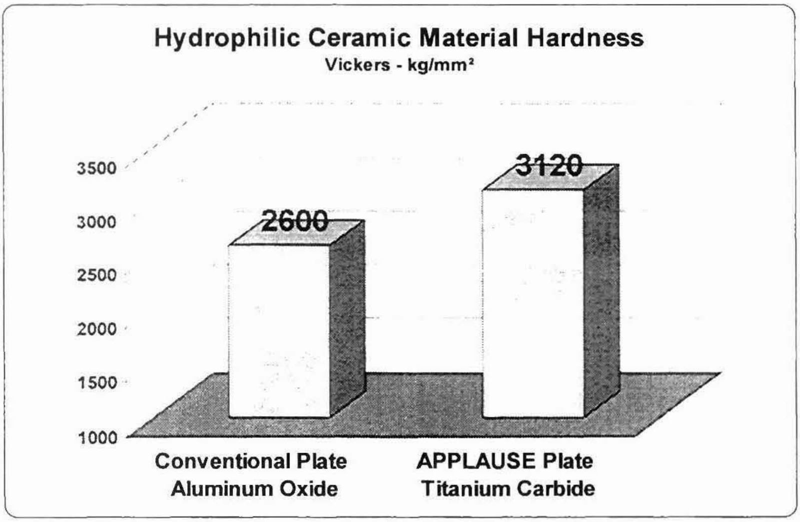


Figure 22

CONCLUSION

The "Ultra-Thin Ceramic Technology" used in the APPLAUSE™ plate provides a pragmatic solution to the "Subtractive Plate Dilemma". This "no-process" plate is highly efficient, long run, ultra-high resolution, low pollution, print stable, scratch resistant, and capable of being used in CtP or DI™ mode. Streamlined processes with high materials efficiency will be more cost effective for printers.