Anisotropic Porous Substrates for High Resolution Digital Imaging

Dieter Reichel and Willy Heinzelmann
Folex/Celfa AG
Seewen, Switzerland

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Market Situation and Current Technology

World wide growth rates for high definition inkjet printers are somewhere arround 53%, overall growth of inkjet printers = 18% annually.

Digital photography is rapidly expanding with growth rates of digital cameras of 48% and digital camera exposures expected to reach almost 10 billion this year (Lyra / Photofinishing News 10/99)

Worldwide demand for inkjet photopaper is forecasted to grow more than 3-fold over the next 4-5 years to reach over 1.6 billion sheets by 2004 (Lyra's Supplies Advisory Service 2000).

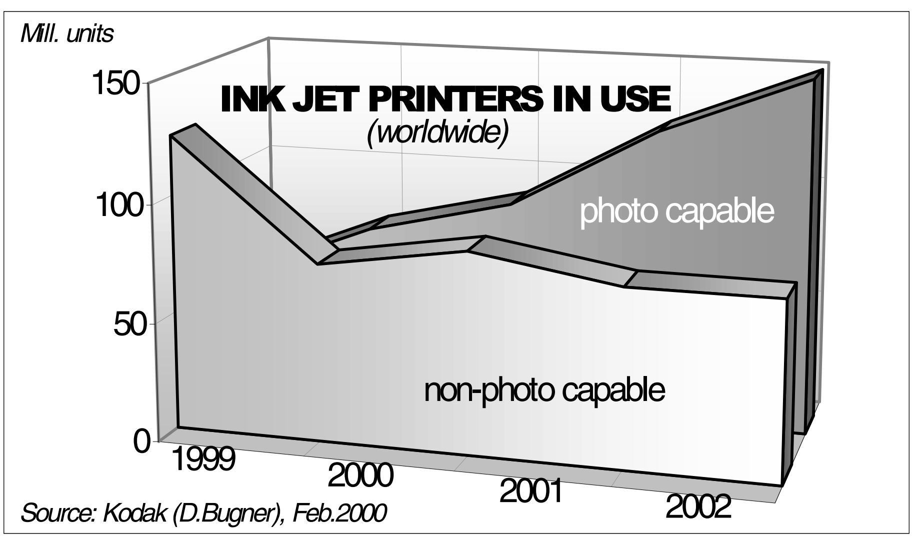
The impact of digital photography on printer and ink technology has been impressive

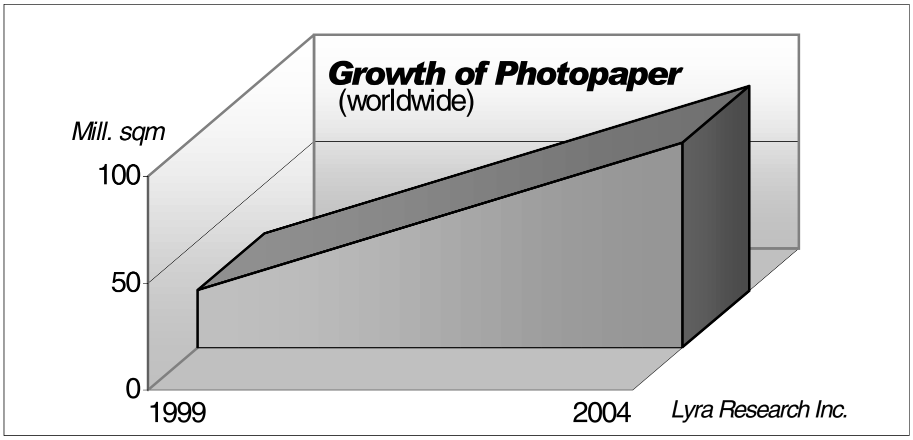
- dpi increased from 300 in the early 90ties to 1440 today
- ink drops came down to a few picoliter per drop
- no. of colors/cartridges increased to 6, sometimes 8 colors
- pigment inks & piezo heads are now established technology
- particle size of pigments dropped from 10 to 0,1 micrometer
- color gammut has widened extensively

With the expected market penetration of digital cameras, this trend is going to continue and will probably increase with new demands for real continuos tones, archival stability etc.

Can substrate technology keep up with those advancements?

Current technology is mainly based on paper coatings, where ink droplets are wetting the surface and dyes are adsorbed by swelling and diffusion into the coating layer, a certain ammount of dot gain thus is unavoidable.



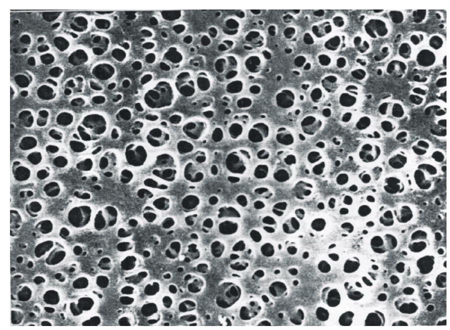


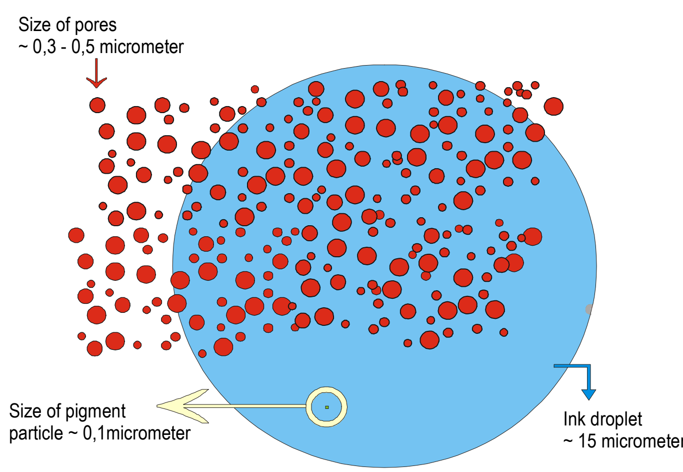
What are the Alternatives?

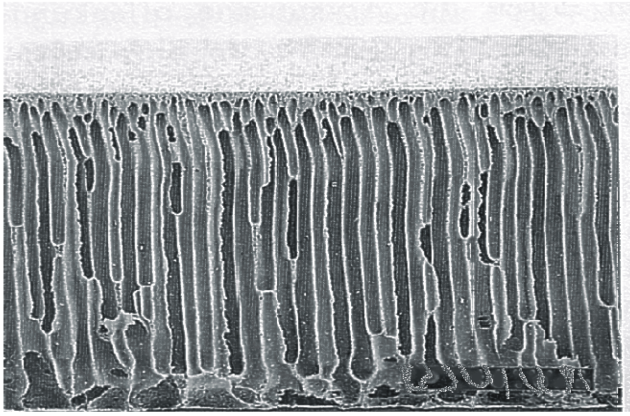
One way of overcoming dot gain and achieving real high resolution coatings are **anisotropic porous substrates**, designed with unique properties, such as:

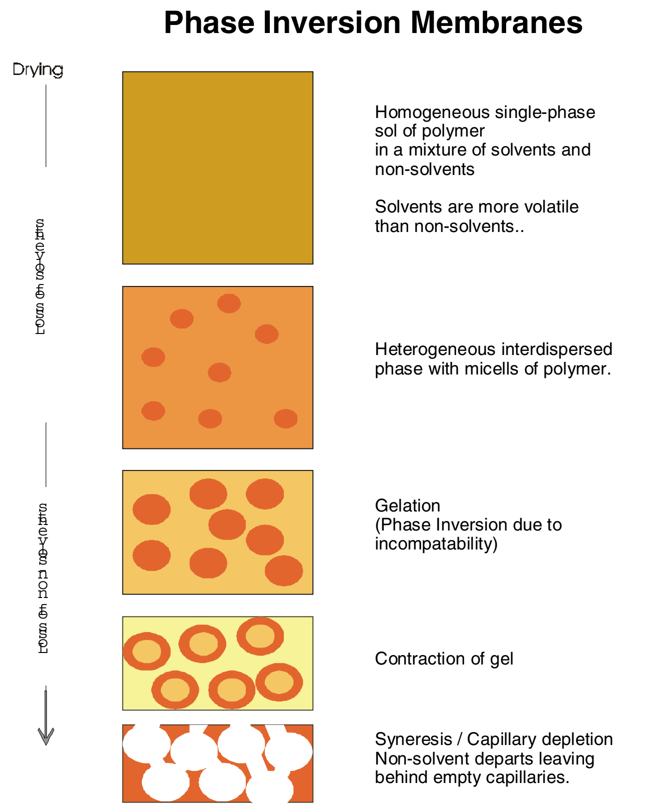
- inert polymer composition, i.e. no interaction with inks
- tubes vertical to surface (anisotropic structure)
- pore diameter must exceed pigment particle size
- number of pores/area must be higher than required dpi
- sufficient intake capacity, i.e. pore volume exceeds ink volume.

From experience in separation membrane technology it is well known, that highly porous layers can be accomplished through a process known as „phase inversion". By tightly controlling conditions during the manufacturing process it is possible to create anisotropic, tube-shaped porous membranes with pore densities exceeding 100.000 pores per sqmm (> 60 million pores per sqinch), which constitutes an enormous theoretical resolution power, limited only by the capability of the inkjet printer to produce verysmal picoliter-droplets.









The picture shows the anisotropic pore structure vertical to the surface of the carrier.

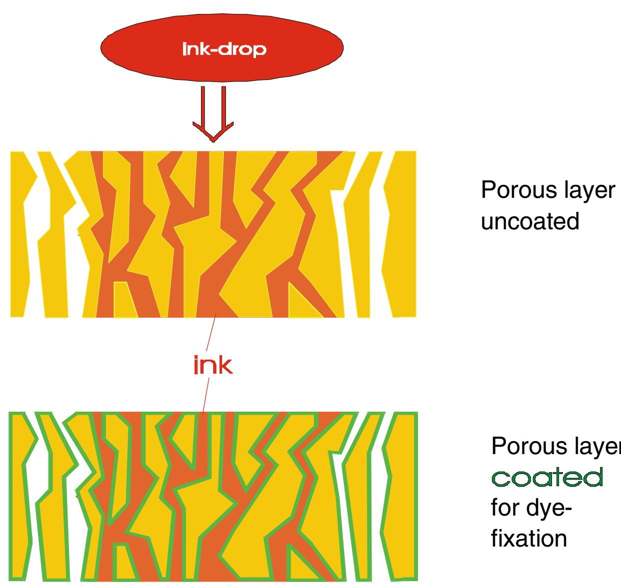
Compared with the structure of paper it is obvious, that aniso-tropic pores hold the ink droplets to their size, while with paper, ink is spreading along the horizontal oriented paper fibers.

Phase inversion with the aim to achieve highly porous layers with tight characteristics starts with a homogenious sol of suitable polymer – for instance a cellulose derivate – in a volatile solvent mixed with a less volatile non-solvent for the polymer.

The single-phase sol is casted on a substrate (paper, film etc.) and subsequently dried. At first the volatile solvent evaporates, leaving behind a heterogeneous interdispersed phase with micells of polymer.

Upon continuous drying *gelation* sets in and the polymer is building a solid structure within an enriched enviroment of non-solvents. This constitutes phase inversion due to incompatability of the components.

Further loss of liquids causes the contraction of the gel, formation of tubes filled with non-solvents and ultimately capillary depletion, where at last the non-solvents departs, leaving behind empty capillaries – the desired final product.



The inner surface of the anisotropic pores may be coated with functional ingredients (added to the sol), to enhance wetting characteristics or to improve water fastness by bonding the dyestuff chemically to the wall of the pores.

Advantages of Porous Layers Used For Inkjet Substrates:

- ☛ Instant absorption into the tubes by capillary forces, enabeling high printing speed.
- ☛ No bleeding of dots, high resolution, no dot gain.
- ☛ Polymer does not swell, consequently no sticky surface, no dye-diffusion within the layer.
- ☛ Capillary action prevents pigment separation, no cracking.
- ☛ Almost universal ink acceptance.
- ☛ Dyes can be chemically bonded to the walls of the pores.
- ☛ High and pure whiteness of the layer created by diffused light within the pores and not by reflection of pigments as with coated paper.
- ☛ Low glare due to diffused light.
- ☛ Stability during climatic changes, no humidity absorption.

And the Constrains?

- ☹ Up to now those layers do not allow a glossy surface because of the light diffusing effect.
- ☹ Highly porous layers are succeptible to scratching and physical damage.
- ☹ They do not allow transparent coatings.

We are just at the beginning of a promising new technology for high resolution substrates, which may prove not only valuable for ink jet but also for other types of printing such as waterless offset on non absorbing media like plastics.

Correctly designed porous layers may also be used for backlit displays on film, where the ink is guided toward the surface of the actual carrier and provides a brilliant high resolution image viewed through the backside. The highly diffusing layer smoothes any contours of light sources and the colors of the image may be stabilised by inner coatings of the pores.

There is still a lot to be done to overcome the current drawbacks and deficiencies of the sensitive coatings, to achieve a glossy surface for digital photos and ultimately a layer, which can be made transparent if requested. Our research department has taken on this challenge to create new media for high resolution recording of digital images based on this challenging new technology.

Biography

Dieter Reichel studied chemistry and received his Ph.D. at the University of Graz, Austria. He started his professional career with Ciba-Geigy in dyestuff research. For more than 30 years he has been with Folex/Celfa as a board member and VP for corporate projects, mainly in digital printing and imaging applications.