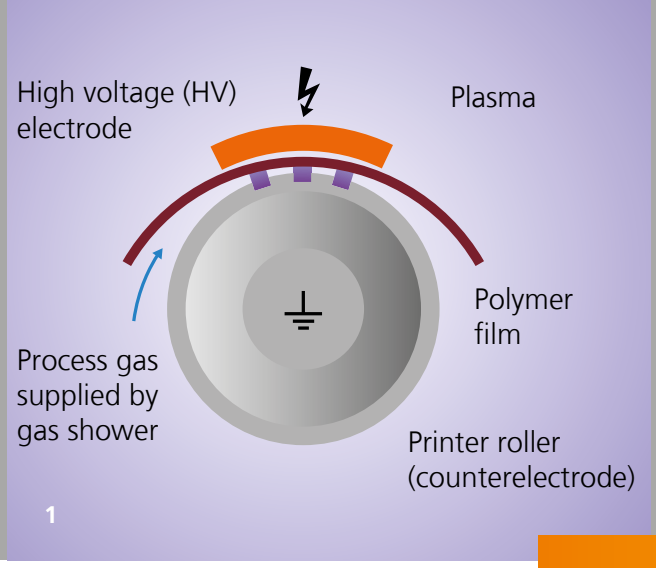


Extract from the annual report 2016
To the website: www.ist.fraunhofer.de/en.html

STRUCTURED PLASMA TREATMENT FOR GRAVURE PRINTING

The aim of the BMBF project »Basic principles of location-selective wetting of nano inks« is to conduct research into new kinds of micro plasma sources for the location-selective pretreatment of film surfaces. With these new plasma sources a wetting contrast is to be created on films which will exert a local influence on the dispersion of printing inks and at the same time improve the adhesion of conductive nano inks. With the aid of various functional models from the fields of electronics and security printing, the performance of plasma printing in combination with the gravure printing of nano inks is to be investigated at the Fraunhofer IST in collaboration with our partners from industry, GRT GmbH & Co. KG and Schwarz Druck GmbH.

Influence of functionalization on wetting behavior

The location-selective structured plasma treatment of polymers at atmospheric pressure at the Fraunhofer IST is carried out by a reel-to-reel process (see Figure 1). For applications in the field of electronics or security printing, such as the forgery-proof printing of bank notes, conductive structures consisting of nano inks are to be deposited, combined with a gravure printing process. The plasma treatment hydrophilizes the surface of the polymers locally, after which the nano ink is printed into these structures. The differences in surface energy between the plasma-treated and the untreated areas makes it possible to achieve a greater contour accuracy when the nano inks are applied.

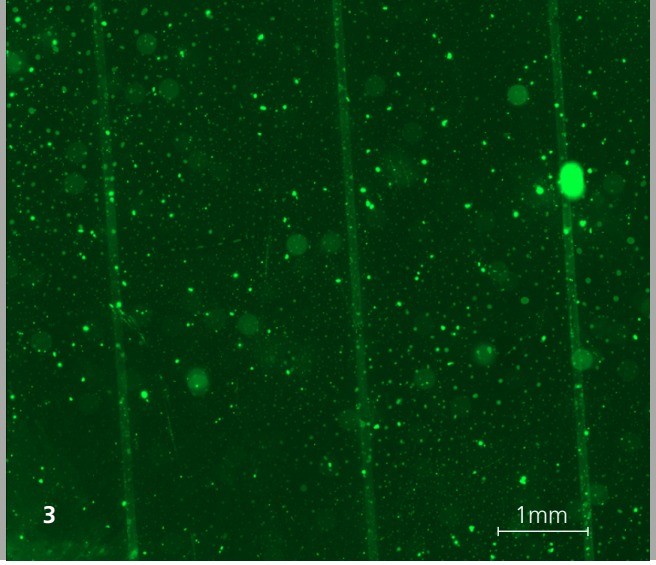
Analysis of plasma-treated films

After the plasma treatment, various investigations were carried out at the Fraunhofer IST with regard to confirm the successful structuring of the film. Here, the chemical changes on the surface, resulting from the generation of chemically reactive groups, were the main focus of analysis, but also the accuracy of reproduction and the edge sharpness of the contours created.

One way of indirectly revealing the chemical changes occurring at the surface after plasma treatment is to determine the free surface energy by contact angle measurements. Investigations showed that with a power input of at least 100 Wmin/m^2 the surface energy of the film could already be increased up to 40 % and in addition the long-term stability of surface activation improved to five days.

Another important aspect of the work conducted at the Fraunhofer IST is the high-definition transfer of the structure from the press roller to the film as a wetting pattern. To achieve this, selective film types were treated location-selectively with a structure width of 188 µm. The subsequent evaluation using a laser scanning microscope (LSM) revealed a deviation from the engraved structure of only 0.9 µm, which is equivalent to about 0.5 %.

In addition, an analysis of the films was carried out by means of the fluorescent marker Fluorescein isothiocyanate (FITC). Reactive nitrogenous groups, such as amines, imines or amides, were detected in the plasma-activated areas. Furthermore, the uniformity of the fluorescence signal over the labeled area



showed that the homogeneity of the plasma treatment within the structures could be demonstrated, as well as the sharpness of the boundary between the individual treated areas and the background. Figure 3 shows for instance the fluorescence of an activated line structure of 200 µm width.

Outlook

Results so far show that the wetting contrast of the films is already very high. Future research conducted in collaboration with Schwarz Druck GmbH will examine the adhesion of the nano inks for further treatments. In addition, one focus of work at the Fraunhofer IST is on further increasing the speed of the plasma treatment process.

1 *Schematic illustration of the reel-to-reel plasma printing process.*

2 *Wetting of BoPET film with steam after local plasma treatment; structure width 1000 µm.*

3 *Fluorescence of FITC-labeled film after an activation by plasma printing, width of line structures: 200 µm.*

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