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Plasma Printing: Area-selective functionalization of surfaces at atmospheric pressure – Plasma sources and applications

Michael Thomas, Kristina Lachmann, Marko Eichler, Antje Dohse, Claus-Peter Klages

Fraunhofer IST, Braunschweig, Germany

michael.thomas@ist.fraunhofer.de

The paper will give an overview on area-selective surface treatment using microplasmas at atmospheric pressure. In this so-called plasma printing process dielectric barrier discharges (DBD) are ignited inside microcavities, which are formed temporarily during the treatment by the contact of a suitably designed »plasma stamp« with the substrate surface. In the last two decades different plasma sources have been developed and patented in order to modify or coat different types of substrates for various applications. For semiconductor applications a localized plasma treatment of wafers was optimized so that wafer bonding can be performed at temperatures as low as 200 °C rather than at 1000 °C necessary in today's standard processes. In the field of biomedical applications area-selective deposition of different coatings with specific chemical functionalities have been applied to control the adhesion of biomolecules like proteins, cells, or anti-bodies.
In recent years the stamp technology was transferred to a reel-to-reel system allowing now line speeds up to 10 m/min. One of the most promising applications is the additive electroless metallization after area-selective surface treatment of polymers. By using N_2/H_2 gas mixtures more than 10 nitrogen-containing functional groups per nm^2 can be grafted to the surface, forming a seed layer for the subsequent electroless processes. Flexible printed circuits and biosensors were produced using copper and palladium, respectively, with resolutions down to 25 µm. The latest development is a combined process of plasma printing and gravure printing of security products such as Guilloches or color shift devices. The wettability of different nano inks was adapted to the treated surfaces. Graphene-containing nano inks were optimized so that they contract to the plasma-treated regions on BOPP. The sharp border between plasma treated and untreated areas leads to a high-resolution gravure-printing process with resolutions below 10 µm.

Keywords
microplasmas
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surface functionalization