Design and Fabrication of Novel Barrier Discharge Reactors with Gas Permeable Electrodes

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In this work the design and fabrication of a novel dielectric barrier discharge with a gas permeable electrode for plasma printing applications is presented. Atmospheric pressure area-selective surface modification of polymers via microplasmas has been a major research topic of a cooperation between the *Institut für Oberflächentechnik (IOT)* and the *Institut für Mikrotechnik (IMT)* of the *Technische Universität Braunschweig* for the past several years and strides have been made to continually improve upon the designs of "plasma stamps". One major aspect of improvement is the introduction of gas permeable electrodes by IOT which allow constant access of process gas to the reactor microcavities, enabling ever thicker layers to be deposited. These electrodes are produced from a melt-extraction process and allow for porosities exceeding 80 %.

An optimization of the reactor flow chamber surrounding the electrode used to guide the process gases, as well as the layout of the microcavities for the actual plasma generation was conducted. This reactor is capable of working with more than one inlet to enable mixing and dynamic deposition procedures, the flow chamber design was therefore extremely important and was simulated using Fluent™ CFD modeling. A flow spreader inlet was developed to introduce homogeneous velocity flow to the entire permeable electrode and therefore allow an exact diffusion of gases through the electrode volume. The microcavities were laid out to establish a high density pattern of spots equidistant from one another, i.e. hexagonally patterned. These cavities were designed based on the limitations of polydimethylsiloxane (PDMS) in which the cavities were relief molded. Due to the low tensile strength of the PDMS, and the fact that the cavities must be complete through holes, the offset and diameter of the cavities is limited.

Fabrication of the microcavities was initially accomplished using a type of compression molding process, but as the size and density of the structures continued to increase the required compressive force also increased to unacceptable limits for the mold. Using a spin coater various thickness of PDMS were able to be cast onto a master mold. A correlation of spin speed to thickness was developed and through hole structures were able to be generated from masters up to the mechanical limits of the PDMS.

Keywords: microplasma, dielectric barrier discharge, polydimethylsiloxane, gas permeable electrodes, plasma printing