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Development of an AP-DBD plasma assisted CVD process with submillimetre resolution: Experimental and Simulation approach

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Additive Manufacturing patterning technique is beneficial for a wide range of applications such as manufacturing of memory device, sensors and lab-on chip devices. Inkjet printing has emerged as a major patterning process in additive manufacturing. Whereas it has some limitations in terms of homogeneity and printing resolution because of coffee ring effect and its dependence on surface energy of substrate. Atmospheric Pressure Plasma Enhanced Chemical Vapour Deposition (AP-PECVD) has been a promising technique in printing as it is a solvent free technique and it is driven by cold plasma. In this work, we focus on how we can obtain the micro-resolution plasma polymer coatings by using AP-PECVD.

The developed deposition process relies on a co-axial AP-DBD plasma torch. The precursor is injected through a hollow inner capillary, whose diameter defines the plasma polymerised dot resolution, in the plasma post-discharge region. Methyl methacrylate (MMA) and Vinyltrimethylsilane (VTMS) are used as model precursors. X-ray Photoelectron Spectroscopy (XPS), Fourier transform Infrared Spectroscopy (FTIR) and Mass Spectroscopy (MS) analysis were achieved to characterize the atomic and molecular composition of the microdot coatings. A series of micro-plasma polymerised MMA coatings ranging from 200 (+- 10%) µm to 1 mm in diameter has been obtained with the precursor injector nozzle of 500 µm. In addition, thanks to the low substrate temperature increase (<40°C), plasma-polymerised microdots can be deposited on a wide range of substrates like polymer and paper.

Through a comprehensive study combining experimental and computational approaches, the mechanisms controlling the deposition are explored. In particular, correlation in between the diameter of precursor injector nozzle and thus coated plasma polymer has been studied. Hence, the nozzle diameter, gas flow ratios and the distance between the nozzle and substrate has been experimentally verified to be of vital important. A fluid dynamic plus mass transport simulation approach has been taken in account to understand correlation of gas dynamics, geometrical design of the reactor and coating resolution.

Keywords
Plasma Printing