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Design, realization and testing of a 2D-gradient DBD reactor for combinatorial plasmachemical surface treatment

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Combinatorial methods can be used to reduce experimental effort and cost of determining optimum conditions for surface-technological processes. While such methods are well-established in chemistry and biochemistry, systematic studies in plasma-based surface science and technology are relatively rare.
The present contribution reports on design and testing of a new kind of reactor for plasmachemical surface modification based on dielectric barrier discharges (DBD). The reactor allows a two-dimensional gradient of process parameters: a concentration gradient of a reactive gas i, dc_i/dy in a corresponding negative gradient of a carrier gas g, dc_g/dy, so that $c_i + c_g$ = constant, transverse to the gas flow direction, and a gradient of power density in flow (x) direction. To constitute the concentration gradient, a so called “gradient mixer” is used. The gradient mixer consists of two halves, each providing manifolds with outlets of adjusted cross sections, allowing a controlled mixing of defined volume flows of two gases. A power density gradient is established by spatially varying capacitive voltage division of the applied external AC voltage. This is achieved by using a sequence of glass plates with varying thicknesses as a dielectric. With this setup, a two-dimensional variety of major process parameters can be realized at once, greatly increasing the sample throughput and reducing costs for materials.
The new reactor is tested using DBDs in Ar with small admixtures of H_2, N_2, or O_2 to modify the surfaces of polymers or inorganic materials such as ZnMgAl-coated steel sheets. The aim of the studies on the metal surfaces is to analyze how the properties of the modified native oxide films correlate with the plasma parameters and what the plasma-induced changes in the surface chemistry and composition of the oxide are.

Keywords
Combinatorial surface technology
Plasma-assisted surface modification
Gradient surfaces
High throughput experimentation