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Argon-water DBD pretreatment and vapor-phase silanization of silica – Plasma-chemical model and experimental data

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A dielectric-barrier discharge (DBD) in an Ar/H_2O mixture is an efficient tool to generate simultaneously H atoms and strongly oxidizing OH radicals, species which are able to remove organic contaminants from the surface (OH) and to catalyze the gas-phase rehydroxylation of high-temperature annealed silica (H). DBD pretreatment with 0.3 % water vapor, combined with an immediately subsequent vapor-phase silanization in a flowing gas stream of Ar, saturated with (3-aminopropyl)trimethoxysilane at 80 °C, was applied for the amino-silanization of U-bent silica fiber optic sensors. In an immunoassay-based comparison, virtually the same results are achieved with the new vapor-phase procedure on the one hand, and the wet-chemical method on the other, although about 30 % less reactive amino groups were still generated on the surface by the dry procedure. More important for biochemical applications appears to be, instead of the maximum reactive amino group density, its standard deviation, which is found to be three times smaller than for wet-chemical silanization. In a study of the impact of a reduced water fraction on the attainable density of amino groups it was found that the density could be increased by a factor of 1.4 at 0.075 % water vapor. This observation is in qualitative agreement with results from a chemical-kinetic model of the gas-phase reactions in an Ar/H_2O DBD, based on the simplifying assumption that the dissociation of water (and of molecular reaction products) in the DBD is only due to energy transfer from excited argon species ($Ar^* + H_2O \rightarrow Ar + OH + H$) where Ar* represents, as a “lumped species”, the four excited Ar 1s states as well as an excimer Ar_2^*. Aside from better reproducibility the new procedure has the advantage, compared with the wet-chemical procedure, that no hazardous chemical wastes are generated.

Keywords
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