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Mesostructured Silica Films With Metal Oxide Doped Pore Walls

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Since the development of periodically arranged mesoporous silica materials by Kresge and Beck in 1992, the investigation of this new class of materials found an enormous improvement with respect to the variability of the pore size and pore structure. The great research effort in this field resulted in a large variety of different compositions and morphologies, ranging from silica to mixed metal oxides and from powders to monoliths and thin films. A wide field of possible applications, which range from chromatography, catalysis, sensors to optics, is of interest for these materials.

The main goal of this work is the preparation of mixed-metal oxide mesostructured films by a combination of evaporation-induced self-assembly and ligand-assisted templating applying the spin-coating technique. The focus lies on Ge-, Ti-, Fe-, Al-oxide modified silica, with M to Si ratios of 1 : 10 and higher. The ligand-assisted templating allows a selective positioning of the metal species in the silica wall which is advantageous for many catalytic applications with respect to activity and efficiency.

For the synthesis of these metal doped silica films, a non-ionic polyether-based surfactant (Brij56) was simultaneously used as the structure-directing agent and ligand for the respective metal-alkoxide, such as titanium isopropoxide, germanium isopropoxide, iron ethoxide and aluminum isopropoxide. These modified surfactants were mixed with a prehydrolyzed silica-solution based on tetraethoxysilane and ethanol. To get different pore arrangements the concentration of the surfactant was varied as well as the spin-coating rotation speed as the main control for the film thickness.

To characterize the metal-surfactant-complexes, NMR and UV/vis-spectroscopy were used. The final films were characterized by XRD, XPS, nitrogen porosimetry and TEM.