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Intermediate phases of pyrolytic carbon observed by atomic force microscopy

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Pyrolytic carbon layers were deposited on planar cordierite substrates from methane in a hot-wall reactor. The influence of the surface area / volume ratio (0.79 mm^{-1}, 1.56 mm^{-1}, 3.22 mm^{-1}), methane pressure (4 kPa – 50 kPa) and residence time (up to 1 s) on the surface morphology was studied by polarized light microscopy, atomic force microscopy and friction force microscopy (FFM).

The pyrolytic carbon layers consist of growth cones nucleated at the cordierite surface. These growth cones appear at the surface of the pyrocarbon layer as hillocks with typical diameters between 5 µm and 50 µm and typical heights between 1 µm and 3 µm. At a smaller length scale the surface of these hillocks shows a granular structure with a typical grain size of 100 nm.

Under appropriate deposition conditions, i.e. at sufficiently high methane pressures, further structures at typical length scales between 100 nm and 5 µm were found additionally on top of the hillocks. From investigations of the deposition kinetics [1] it is known that at these deposition conditions adsorption saturation is reached. The observation of these structures which are clearly distinguishable by FFM from the rest of the pyrocarbon surface is the first direct experimental evidence for the existence of an intermediate phase of carbon. Such an intermediate phase which results from the deposition of large planar molecules expected according to the nucleation mechanism postulated by Hüttinger et al [2].

[1] Z.J. Hu, W.G. Zhang, K.J. Hüttinger, B. Reznik, D. Gerthsen. Carbon **41** (2003), 749-758.

[2] Z.J. Hu, K.J. Hüttinger. Carbon **40** (2002), 617-636.