carbon2004
July 11–16. Providence, Rhode Island. USA.

Early stages of the chemical vapor deposition of pyrolytic carbon investigated by atomic force microscopy

Andreas Pfrang[1, *], Yong-Zhong Wan[1], Virginie De Pauw[2], Winfried Send[2], Dagmar Gerthsen[2], Thomas Schimmel[1, 3]

[1]*Institute for Applied Physics, University of Karlsruhe, D-76128 Karlsruhe, Germany*
[2]*Laboratorium für Elektronenmikroskopie, Universität Karlsruhe, D-76128 Karlsruhe, Germany*
[3]*Institute of Nanotechnology, Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany*

Pyrolytic carbon was deposited on planar silicon substrates from methane in a hot-wall reactor at a temperature of 1100 °C. The substrate was oriented parallel to the gas flow. Methane / argon mixtures were used at a total pressure of 100 kPa (10 kPa or 20 kPa methane partial pressure). Short deposition times between 5 and 90 minutes were chosen to focus on the early stages of the deposition process. Samples grown with residence times up to 3.2 s were investigated.

At short residence times single pyrolytic carbon islands were found on the silicon substrate. Force modulation microscopy was applied to achieve a material contrast between silicon substrate and carbon islands. This allows the identification of the carbon islands. Three different nucleation mechanisms were found: random nucleation of single islands, nucleation of carbon islands along lines and secondary nucleation which corresponds to the nucleation of carbon islands at edges of already existing carbon islands.

The transition from individual carbon islands to a complete carbon film was observed with increasing residence time. This is in agreement with the observation that with increasing residence time, the pyrocarbon deposition rate is increasing. Similar sizes are observed for individual islands close to this transition from individual islands to a complete film and for the grain structure of thicker carbon films.