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## Synthesis of carbon nano/micro-structures using extreme plasma fluxes

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We demonstrate the synthesis of carbon nanowalls decorated microparticles by exposing highly oriented pyrolytic graphite (HOPG) to a high-flux plasma. The synthesis method is a one-step processing route, and does not require surface pre-treatment or additional precursor injection. The effective surface area of the modified surface with nanowalls/microparticles is extremely large, i.e., ~4000 $m^2/g$. These micro/nanostructures are considered as potential candidates for energy applications. The HOPG samples are exposed to a hydrogen plasma in linear plasma generator Pilot-PSI with an average ion flux of ~$10^{24}$ $m^{-2}s^{-1}$. In order to optimize the growth of these microparticles, insights into the conditions in which these particles occur, as well as their growth mechanisms are required. Experiments were performed as functions of the ion energy, plasma flux and surface temperature. The samples are post-mortem analyzed by Raman spectroscopy, SEM, BSE, EDAX and XPS. The results show that the growth occurs significantly at peak surface temperatures of about 1200 °C. The microparticles are composed of a agglomeration of wavy graphene sheets. The spherical shape of the core and surrounding elongated layers, indicate initial growth in the gas phase and further growth by surface accretion after deposition (up to 0.6 μm/s). The surface surrounding the particles remained smooth and no traces of flaking were found, suggesting that initial nucleation occurred by either polymerization or agglomeration of (hydro)carbon. At temperatures above 1600 °C, no microparticles were observed, possibly due to heavy radiative enhanced sublimation and flaking. At temperatures below 600 °C only few particles were observed (<1 % of the surface area). The particles have a hemispherical shape and are grown on metal impurities. In conclusion, the surface temperature strongly influences the growth mechanisms. Future work will investigate the plasma chemistry of hydrocarbons in high-density plasma and application of these particles in Li-ion batteries.

**Keywords**
carbon nanostructures