Template-assisted fabrication and study of 2D and 3D ordered porous nanodiamond films

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Two-dimensional (2D) and three-dimensional (3D) porous nanodiamond (ND) films are known to be unique versatile materials for applications in sensing, photonic crystal devices, fuel cells, energy harvesting, chromatography, and biomedicine due to their superior physical, chemical, and mechanical properties. We hereby, describe a novel method of nanocasting fabrication of 2D and 3D ordered porous ND films.

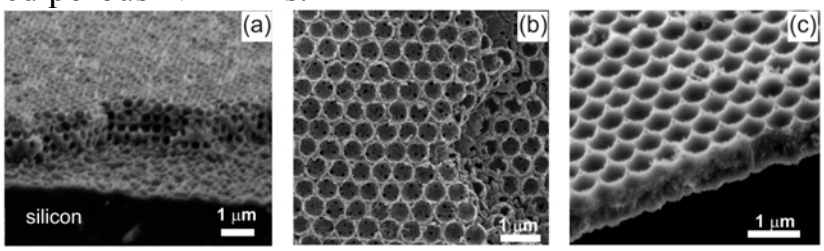

Figure 1: SEM images. (a) Cross section and (b) surface of 3D porous opal-based nanodiamond film. (c) Surface of free-standing 2D ND film.

We used self-assembled silica fcc colloidal crystal films (opals) as templates for the fabrication of the nanostructured diamond films. First, we synthesized highly ordered opal films on Si substrates from 500 nm diameter amorphous SiO_2 spheres. Then we filled the interstitial space within an opal film with detonation nanodiamond (DND) particles, using a specially designed evaporation-driven infiltration technique. This technique allowed us to uniformly fill the porous of opal film with DND to the given depth variable by controlling the parameters inside the evaporation chamber. Further growth of ND inside the opal pores was performed by MPCVD technique. DND particles, previously seeded inside the pores, provide a densely arranged nucleation centres for CVD diamond growth. Using a set of opal films filled with DND to different depths we could control the level of infiltration of opal with CVD nanodiamond. To fabricate porous ND the silica template was subsequently etched away in HF aqueous solution.

The finally made samples were either connected to the Si substrate (Fig. 1a,b) or free-standing (Fig. 1c) 2D and 3D ordered porous ND films of various thicknesses. The morphology of fabricated films replicated the pore structure of opal template. Raman spectra of the samples confirmed nanocrystalline structure of diamond in the synthesized films. Comprehensive studies of luminescent defects were carried out.