Luminescence of Silicon nanocrystals treated by High-pressure Water Vapor Annealing

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Silicon nanocrystals (SiNCs) have been fabricated with good reproducibility using a high-frequency non-thermal plasma reactor [1]. These SiNCs have been considered for application in photovoltaics [2] and thermoelectric devices [3]. SiNCs are also considered in electroluminescence and phosphors. Indeed, SiNCs can emit visible light when they are small enough to exhibit quantum confinement (size < ~ 4.9 nm) and when their surface is well-passivated. Here, we report a study of the luminescence of SiNCs fabricated by the non-thermal plasma technique. The SiNCs are spherical and exhibit an average size of about 6 nm, with very good uniformity, as shown by TEM studies. The SiNCs were not luminescent in as-prepared state as they were too large. In order to reduce their sizes as well as to provide a good oxide surface passivation, they were treated by high-pressure water vapor annealing (HWA). HWA creates a thin layer of about 1 nm of oxide at the surface of the SiNCs, confirmed by TEM studies. It was previously proven very efficient in providing high luminescence efficiency and stability when applied to nanocrystalline porous silicon [4]. Figure 1 shows the photoluminescence (PL) of HWA-treated SiNCs powder. The peak position is at about 900 nm, reflecting an average size of about 4-4.5 nm according to literature. This is in agreement with the formation of an about 1 nm-thick surface oxide layer. The PL is rather broad, suggesting a distribution of oxide thicknesses at the surface of the SiNCs. After removing the oxide layer in HF and letting the SiNCs in air for several days, the PL blue-shifted considerably and became brightly visible due to the growth of a new native oxide layer further reducing the SiNCs sizes. Various properties of the SiNCs will be presented.

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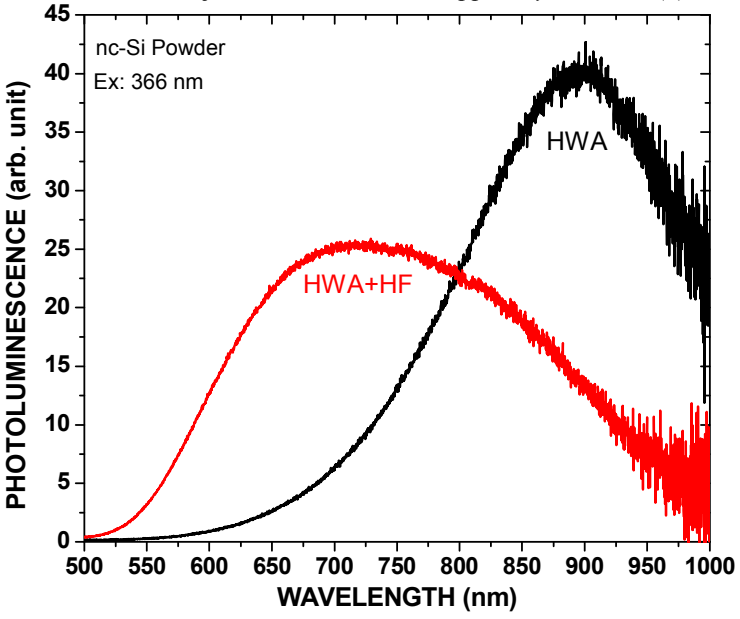

Figure 1: PL of SiNCs powder after high-pressure water vapor annealing at 3.9 MPa for 4 h (black curve). The surface oxide of this sample was then etched in HF and the PL measured again (red curve). Excitation was a LED emitting at 366 nm.