Nanocomposites and nanomaterials

Carbon incorporated nanostructured silica as nanocomposite material for tunable white photoluminescence

A.V. Vasin[1], V.A.Tyortyh[2], Y.M. Bolbukh[2], A.N. Nazarov[1], V.S. Lysenko[1]

[1] Lashkaryov Institute of Semiconductor Physics, NAS of Ukraine, Kyiv, Ukraine
E-mail: andriyvasin@gmail.com

[2] Institute of Surface Chemistry. NAS of Ukraine, Kyiv, Ukraine

In present report we analyze structure and light emission properties of SiO_2:C nanocomposite powders. The SiO_2:C composite was fabricated by successive chemical modification of fumed silica powder (particle size about 10 nm, specific surface area of 300 m^2/g) by hydrocarbons or hydrocarbosiloxanes followed by calcinations at temperature up to 700 ^oC in inert ambient (pure nitrogen flow or vacuum). Correlations of fabrication conditions, local bonding structure and photo-luminescent (PL) properties have been studied. The main goal of the work was to identify physical mechanism of broad band PL in nanostructured SiO_2:C materials

It was demonstrated that light-emission properties of SiO_2:C are sensitive to amount of incorporated carbon and annealing temperature/duration. The less carbon incorporation in the powder the larger temperature it needs for PL activation. Vice-versa, the more carbon in the powder the easier it goes black (not emissive) due to graphitization of carbon. Such observation gives an idea that PL is originated from carbon nanoclusters.

The other important observation was the red spectral shift of PL maximum (from 450 nm to 530 nm) with increase of annealing temperature and/or number of carbon atoms in attached hydrocarbon radicals. One of the reasonable explanations of such shift is the effect of the size of carbon cluster (the smaller cluster size the larger gap between HOMO and LUMO electron states).

Tunable spectral properties of SiO_2:C makes possible “color engineering” of white PL. In some cases color rendering index was calculated to be very high (about 97%). Excellent spectral properties of white light emission along with lack of expensive heavy metal dopants make SiO_2:C material attractive as luminophor for artificial lighting applications.