A Novel Si/SiO_2 Nanocomposite By CVD Infiltration

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In order to achieve high photoluminescence (PL) yield from Silicon, several different systems have been proposed. One of these systems is based on nanostructured Si (nanocrystalline and porous Si), where quantum confined effects and exciton localization play a major role in the light emission process.

As a light source, silicon nanocrystals have an additional advantage over bulk silicon in that the electrical carriers are confined in a region in which no defects are present. This is due to the fact that the host material (normally SiO_2) provides efficient passivation of defects and recombination centres. For this reason, different systems based on Si and SiO_2 have been recently investigated, like Si/SiO_2 superlattices (1), SiO_2 films doped with Si nanocrystals (2), or oxidized porous Si (3).

However, the insulating effect of SiO_2 makes it difficult to inject electrical charges into Si nanocrystals, and thus efficient light-emitting diodes are troublesome to make. Also, when large currents are passed through an oxide film it will eventually fail, resulting in a short circuit.

The present work deals with a completely different approach to produce Si/ SiO_2 nanocomposites. We investigated the possibility of infiltrating Si into completely oxidized porous Si (Porous Silicon Oxide, PSO). PSO is obtained by simple oxidation in dry O_2 of porous Si, at 1000 °C. Then, the samples are inserted into a LPCVD (Low Pressure Chemical Vapor Deposition) reactor, modified with the purpose of reaching very low growth rates (GR), a condition necessary to have a coverage of the whole internal surface followed by the pore filling. On the other hand, at high GR, Si deposition takes place mainly on the top surface of the PSO layer because of the pore mouth bridging by Si.

A similar infiltration technique (for Ge and Si) has been proposed in the past (4), but applied directly to porous Si. In that case, no PL had been observed due to the light absorption of the host material. According to early reports, we demonstrate that weight measurements is a useful and easy-to-manage technique for the investigation of infiltration CVD techniques. In this way it is possible to estimate both the GR of Si inside the pores and the thickness of the deposited film. Values up to 5 nm have been obtained, resulting in complete pore filling. Optical techniques are also used to characterize the infiltration process. In fact, Si infiltration in PSO gives rise to an increase for the refractive index that can be easily detected. PL characterization is underway. It has to be stressed, however, that complete pore filling can give rise to a percolated Si network inside PSO. This, in principle, can solve the electrical injection problems mentioned above for systems composed by isolated nanocrystals.

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