Doping silicon dielectrics with silicon, cerium and oxygen via ion implantation

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Abstract

Silicon nanocrystal (Si-NC) based photonic materials continue to receive a great deal of attention as candidates for silicon-based luminescence and multi-carrier generation [1,2]. Further, when doped with RE ions it is found that luminescence from the dopant is often significantly enhanced [3].

In this work we describe the formation of silicon nanocrystals in SiO_2 or Si_3N_4 and their subsequent co-doping with RE ions via ion implantation and annealing.

The implantation was performed using the McMaster University Universal Ion implanter with annealing taking place via a JetFirst RTP system.While it remains more expensive to produce doped thin films through ion implantation it is perhaps a better fabrication technology for the exploration of changes in film constituency on properties such as luminescence intensity.

Silicon nanocrystals were formed in fused silica via ion implantation at energies in the range 15-30keV and doses ranging from 1.5-4.0x$10^{16}$$cm^{-2}$. Subsequent annealing took place at temperatures in excess of 1000^{o}C. The most efficient sample exhibited an IQE close to 1%, measured using an integrating sphere set-up, pumped using a HeCd laser. An example of typical spectra from Si-nanocrystal samples is shown in figure 1.

Both SiO_2 and Si_3N_4 (the latter formed via LPCVD and thought to be close to stoichiomteric in composition) were doped with cerium at an energy and dose of 25keV and 5x$10^{15}$$cm^{-2}$ respectively. The subsequent luminescence was found to be strongly dependent on oxygen co-doping with the maximum luminescence found for an oxygen/cerium ratio of 7:5. The IQE of this film was found to be close to 20%.

We will conclude this presentation with a discussion of the possible integration of these films with electroluminescent structures.

[1] Timmerman *et al*, 'Space-separated quantum cutting with silicon nanocrystals for photovoltaic applications', Nature Photonics, **2**, 105-109 (2008)

[2] Lee *et al*, 'White light emitting silicon nanocrystals as nanophosphor', phys. stat. sol. (b) **241**, No. 12, 2767 – 2770 (2004)

[3] V. Y. Timoshenko, M. G. Lisachenko, B. V. Kamenev, O. A. Shalygina, P. K. Kashkarov, J. Heitmann, M. Schmidt, and M. Zacharias, Applied Physics Letters **84,** 2512-2514 (2004)

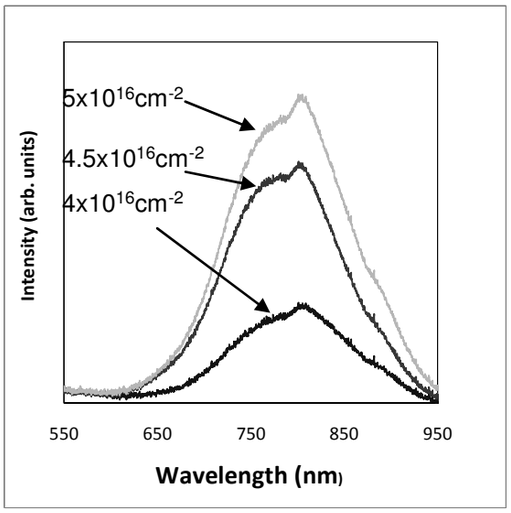

Figure 1 – Luminescence obtained from silicon implanted SiO_2 (25keV energy) subsequently annealed at 1100^{o}C for 10 minutes. Implantation doses are indicated on the figure.