Photoluminescence features of defects in crystalline and amorphous SiO_2

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Point defects in crystalline and in amorphous SiO_2 represent physical systems of wide scientific and technological interest due to the diffuse application of these materials in several optical and electronic devices. Luminescence properties are widely investigated to elucidate the processes related to the electronic excitation and relaxation processes involving the energetic levels of the defects and clarify their electronic and microscopic structures. Our activity has been focussed to the study of native and ionizing radiation induced defects in crystalline materials of high purity and in pure and Ge-doped amorphous SiO_2.

Luminescence properties of crystalline α-quartz have evidenced that at low temperature two emission bands overlap at 2.7 eV. The first contribution is excited by band-to-band transition and is related to the radiative recombination of a self trapped exciton occurring in a time scale of a few ms, the second is associated with defects induced in quartz by γ- or β-ray irradiation, is excited at 7.6 eV, and its lifetime is 3.6 ns at T=10 K [1].

The study of the photoluminescence (PL) time decay of the Ge oxygen deficient centers (GeODC), characterized by two PL bands peaked at ~3.2 eV and ~4.2 eV, were carried out by excitation in UV and in vacuum-UV (VUV) in sol-gel Ge-doped a-SiO_2. By measurements in the temperature range from 8 K up to 300 K the effects of the intersystem-crossing (ISC) process linking the two emission bands have been isolated and a dependence of the PL decay lifetime on the spectral position inside the emission band at ~4.2 eV has been evidenced (Fig.1). These results are interpreted as fingerprint of the inhomogeneity of the point defects and suggest a direct tool to probe the environment effects on the optical properties of point defects [2].

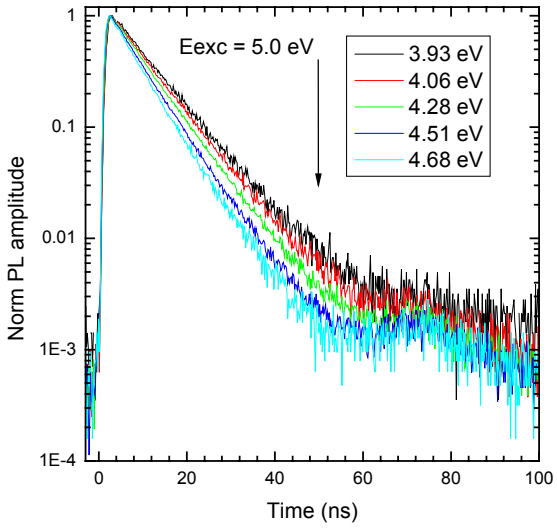

Figure 1: Decay kinetics monitored at different emission energies detected in bulk Ge-doped SiO_2 under excitation at 5.0 eV at T=8.0 K.

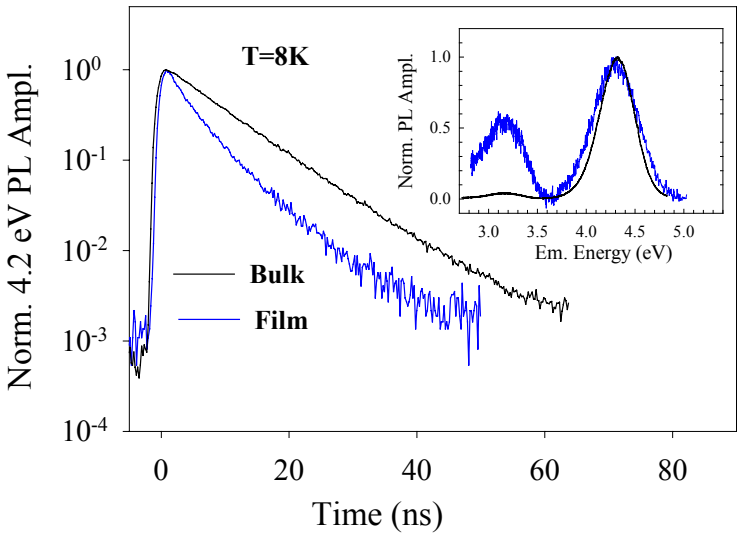

Figure 2: Decay kinetics of the 4.2 eV emission after 5.0 eV excitation at T=8K in film (blue) and bulk (black) sol-gel Ge-doped a-SiO_2. The inset shows the comparison between the PL spectra normalized to the maximum of the 4.2eV band.

The optical properties of GeODC centers in a 100nm thick Ge-doped silica film were investigated under 5.0 eV excitation. Emission spectra and lifetime measurements evidence a higher efficiency of the ISC process in the defects embedded in the film with respect to their bulk counterpart. This feature has been shown by the not single exponential decay of PL at ~4.2 eV (Fig.2) and the concomitant presence of intense triplet emission due to the active ISC at low temperature [3].

This work was partially supported by European Community (project no. 11-03-005-EC).

References

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