Er Doping of Ordered Size controlled Si Nanocrystals

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Room temperature luminescence of the Er intra-*4f* transition depends on the optical cross section of the first excited state, which is typically on the order of only 10^{-21} cm^2. There is considerable interest in sensitizing the Er^{3+} ions by adding a strongly absorbing material that can transfer the energy efficiently to Er. Recently, it was reported that the presence of Si nanocrystals in Er doped SiO_2 effectively enhances Er luminescence [1,2]. As a model, it was suggested that light is absorbed within the Si nanocrystals resulting in confined e-h pairs. An energy transfer either by an Auger process or by dipole- dipole coupling mediates than the excitation of the Er^{3+} ions.

A dense and ordered arrangement of the Si nanocrystals can be realized by fabricating amorphous SiO/SiO_2 superlattices and their thermal phase separation and Si crystallization [3,4]. This work is focused on the optical and structural properties of the Er doped crystallized SiO/SiO_2 superlattices.

A strong increase of the Er^{3+} luminescence of these samples was observed in comparison with Er doped bulk SiO_2 films and Er doped Si/SiO_2 superlattices (see fig. 1). The correlation of the luminescence of the Si nanocrystals and the Er^{3+} ions is proven. Photoluminescence excitation spectroscopy of the Er luminescence shows that the excitation of the ${}^4I_{13/2} \rightarrow {}^4I_{15/2}$ transition is mediated by the Si nanocrystals. The discrete energy levels of the erbium are playing only a subordinated role (see fig. 2). The influence of the size of the Si nanocrystals, Er dose as well as the annealing and excitation conditions on the efficient luminescence of the erbium and its decay time behavior in the temperature range of 5 - 300 K will be discussed.

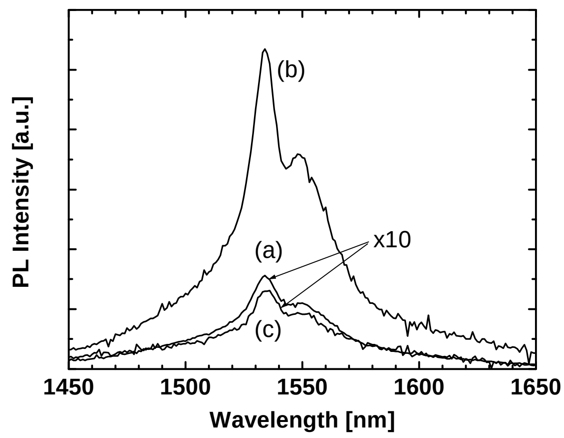

Fig. 1: Room temperature PL of Er doped (a) Si/SiO_2 superlattices and (b) SiO/SiO_2 superlattices and (c) SiO_2.

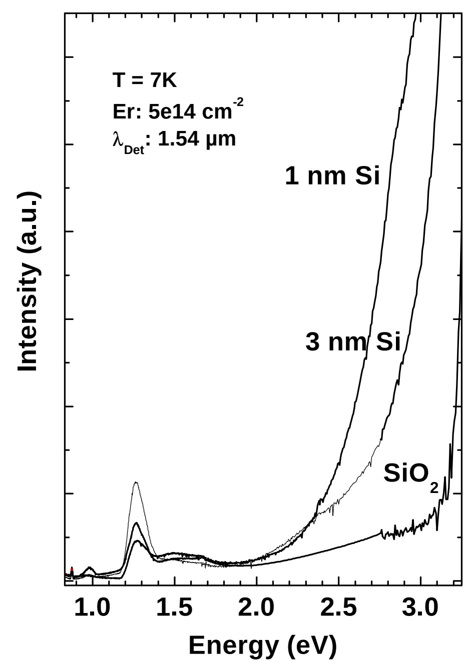

Fig. 2: Excitation luminescence spectroscopy of Er doped SiO/SiO_2 superlattices

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[4] J. Heitmann, M. Zacharias, M. Schmidt, submitted to J. Non- Cryst. Solids (ICAMS 2001).