Time-resolved photoluminescence spectroscopy of Si nanocrystals prepared by SiO_x/SiO_2 superlattices technique

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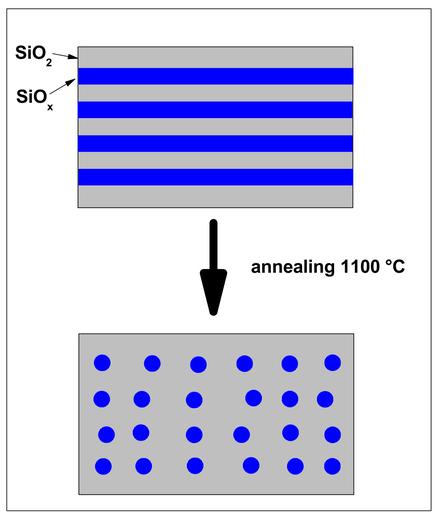
Introduction

- **Si nanocrystals** (Si-NCs) are promising material for application in optoelectronics [1], biophysics [2] and photovoltaics (**the third generation solar cells** [3]).
- It is generally accepted that the unique properties of Si-NCs result from both **the quantum confinement effect** and presence of **the surface states**. The predominantly used matrix material for Si-NCs is SiO_2 due to its high band gap and the well understood properties of the bulk Si/SiO_2 interface [4].
- The aim of this study is **time-resolved photoluminescence spectroscopy** of Si-NCs prepared by SiO_x/SiO_2 superlattices technique for photovoltaic application.

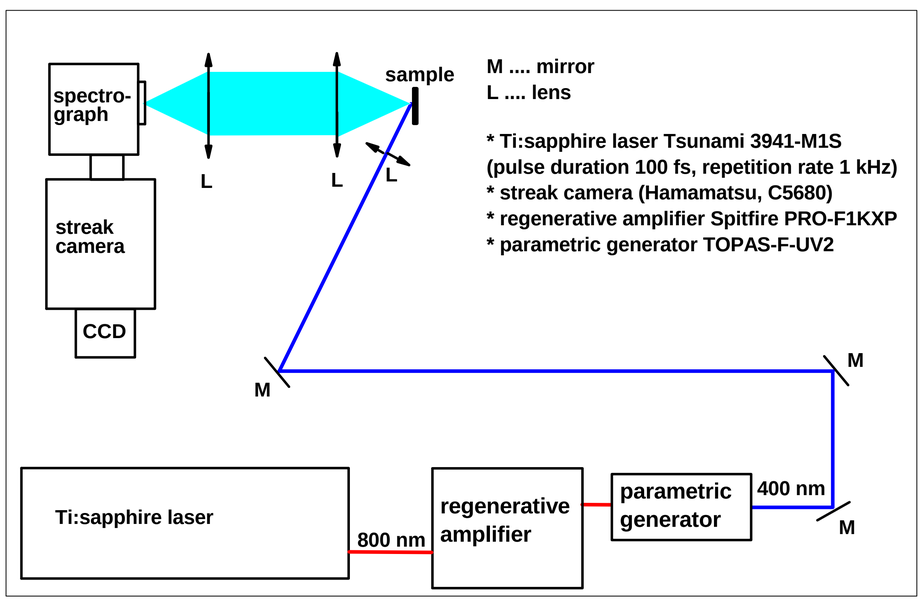
Samples

- samples Da125H2 and Da125 fabricated by IMTEK (Freiburg)
- amorphous SiO_x/SiO_2 superlattices prepared by reactive evaporation of SiO powders in oxygen atmosphere
- annealing at 1100 °C in N_2 for 1 hour
- sample Da125H2 additionally post-annealed in H_2 at 450 °C
- the high temperature annealing results in phase separation
  $SiO_x \rightarrow \frac{x}{2} SiO_2 + \left(1 - \frac{x}{2}\right) Si$ [5]
- 30 layers of $\sim$ 3.5 nm nanocrystals



Two samples with well defined nanocrystal size, density and stoichiometry which differ in the surface quality.

Experimental setup



Results

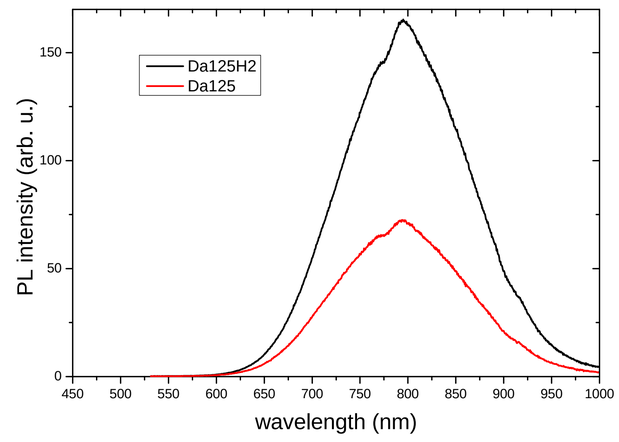


Fig.1: Time-integrated PL spectra of the investigated samples, excited by a 325 nm cw He-Cd laser.

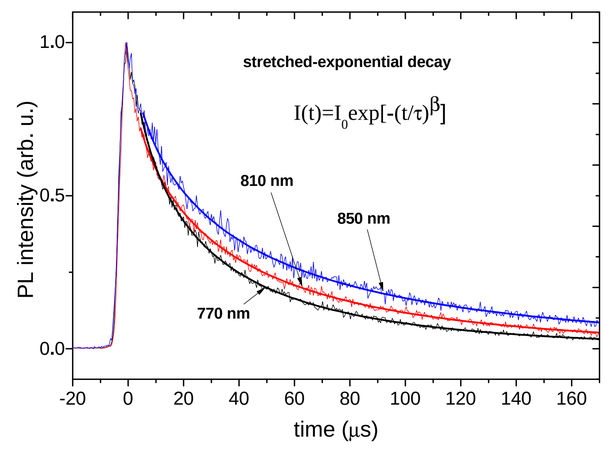


Fig.2: Dynamics of microsecond PL of the sample Da125H2.

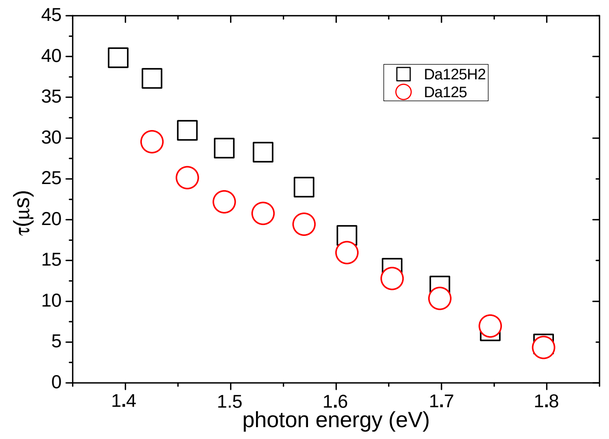


Fig.3: Parameter τ of stretched-exponential function vs the PL photon energy.

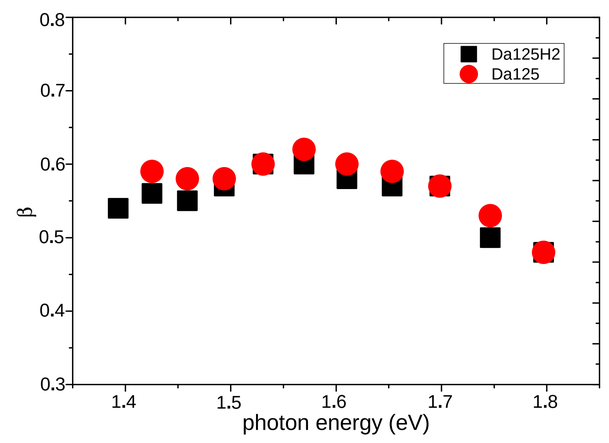


Fig.4: Parameter β of stretched-exponential function vs the PL photon energy.

Proposed explanation

- H_2 annealing = passivation of nonradiative defects at the NC/oxide interface (Si dangling-bond defect [6])
  $\Rightarrow$ PL intensity increase
  $\Rightarrow$ time constant τ increase
- exciton migration (hopping) between different NCs [7]
  $\Rightarrow$ stretched-exponential time decay (dispersion factor β depends on the spatial distribution of localized states)

Acknowledgement

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