Title: Time-resolved measurement of optical gain in silicon based nanostructures

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Abstract: The aim of this work is to study the optical properties of the material based on oxidized silicon nanocrystals (Si-ncs) embedded at high densities in SiO_2-based matrix. These materials seem to be very promising on the way towards silicon laser. Using our preparation technique - modified electrochemical etching and post-etching in H_2O_2 - we obtain small Si-ncs with the mean core size of 2-3 nm, incorporated at high densities of $\sim 10^{19}$ Si-ncs/cm^3 into an SiO_2-based matrix. In this work, we focused on studying their photoluminiscence (PL) properties and measuring the net optical gain of these samples. Therefore, we investigated their time-resolved and steady-state PL emission spectra which revealed two emission bands - the F-band ($\sim$ 435 nm) with ns decay-time and the S-band ($\sim 600 - 620$ nm) with μs decay-time. Moreover, we observed a "green" emission band ($\sim$ 500 nm) present only during the pulsed excitation and immediately after. We performed time-resolved gain spectroscopy using combination of Variable Stripe Length (VSL) and Shifting Excitation Spot (SES) techniques which allows to study optical gain in materials with relatively low optical gain coefficient such as our samples. We observed stimulation emission (StE) onset for higher excitation densities in different Si-ncs/SiO_2 samples, which denotes the presence of the positive optical gain, from both the F-band and S-band emission components. Finally, we attempted to describe recombination processes in nanosecond and microsecond regimes and a possible origin of optical gain.

Keywords: silicon nanocrystals, optical gain, photoluminiscence