RELAXATION PROCESSES IN DOPED SILICON NANOCRYSTALS

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Incorporation of various silicon-based structures in optoelectronics is an actual problem up to now. Because of indirect band gap of silicon, light emission turns out to be suppressed or completely forbidden in such structures. As a means to improve the emittance of silicon crystallites, their doping with phosphorus was proposed. It has been shown experimentally that doping with phosphorus can several times increase photoluminescence intensity at certain conditions [1]. Theoretical estimations [2] show an increase of radiative recombination rate by 1 – 3 orders of magnitude depending on the phosphorus concentration.

However, not only radiative transitions, but also some nonradiative processes strongly influence the photon generation efficiency in Si nanocrystals. The goal of the present work is to examine the effect of doping on the nonradiative processes.

One of these processes is Auger recombination having in undoped nanocrystals the rate about 1 – 4 orders of magnitude higher [3] than the rate of the radiative transitions. We have found that in doped nanocrystals, the rate of Auger recombination increases with increasing phosphorus concentration, but slower than the radiative recombination rate.

There are as well in Si quantum dots some relaxation processes being typical for ensembles of nanocrystals. Nanocrystals in an ensemble “interact” with each other, through, e.g., migration of excited carriers, or exciton transfer. We have calculated the rate of the carrier migration in an ensemble of doped Si crystallites, and found out that the rate sharply drops when the donor concentration achieves some critical value. This substantially enhances the radiative channel efficiency, and the quantum yield in whole.

References

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