Carrier multiplication by Si nanocrystals in SiO_2

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Solid state dispersions of high-quality Si nanocrystals in an SiO_2-matrix are intensively investigated due to their interesting optical properties. Particularly interesting is the efficiency of electron-hole pair formation in these materials upon absorption of light at different wavelengths. Here the most recent findings demonstrate that the rigorously calibrated external quantum efficiency of photoluminescence increases above a certain threshold value of the excitation photon energy. The increase has a step-like character [1]. This behavior is reproduced also in the wavelength dependence of the carrier generation rate, measured by induced absorption [2]. Both effects are interpreted as fingerprints of a specific, very efficient carrier multiplication process which takes place with only marginal energy loss. The induced absorption experiment is conducted with the temporal resolution of 80 fs and reveals that the carrier multiplication process does not change no change the decay dynamics. This indicates that the exciton relocation between neighboring nanocrystals successfully competes with Auger recombination. The results are compared with theoretical modeling of impact ionization processes for densely packed small Si nanocrystals [3].

These studies reveal that carrier multiplication by Si nanocrystals in SiO_2 matrix generates excitons with effective lifetimes in the microsecond range – this in contrast to results for nanocrystals of other materials, where picosecond lifetimes are commonly found.

[1] D. Timmerman *et al*., Nature Nanotechnology 6, 710-713 (2011)
[2] M.T. Trinh *et al*., Nature Photonics 6, 316-321 (2012).
[3] M. Govoni *et al*., Nature Photonics 6, 672-679 (2012)