All-optical Wavelength Conversion by Hot Carrier Intraband Absorption in Colloidal PbS Quantum Dots

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All-optical wavelength conversion is more energy and cost effective than current electro-optical conversion schemes to transfer data between different wavelength channels in optical communication. The lack of suitable cost-effective materials hampers the deployment of the all-optical approach. Owing to their tuneable optical properties, solution processability and strong light-matter interaction, colloidal nanocrystals (QDs) are considered for these next-generation photonic devices. Using QDs for wavelength conversion is however limited by either slow interband dynamics or energy consuming multi-exciton dynamics. Here we show that the interplay between two intrinsic material properties of PbS QDs, intraband absorption and interband bleach, can lead to a very strong modulation of technologically relevant near-infrared light on an ultrafast, picosecond, timescale (1). The normalized absorption change reaches up to 12 dB for an exciton population below 1 per dot, both in solution and thin films, reaching up to 5200/cm. To show the potential for high speed conversion, a pump pulse sequence of up to 4 femtosecond pulses , separated by 2.2 and/or 4.4 ps, is converted to a probe wavelength while preserving the intrinsic strength, speed and zero background of the single pulse case, showing the ability for handling 450 and 225 Gb/s datastreams. Combining QDs with existing photonic devices is viable with conversion energies as low as a few femtojoule per bit with small footprints

References

1. Geiregat, P., Houtepen, A. J., Van Thourhout, D. & Hens, Z. All-Optical Wavelength Conversion by Picosecond Burst Absorption in Colloidal PbS Quantum Dots. ACS Nano, Accepted, (2016).