Nonlinear optical properties due to inter and intraband transitions in PbS quantum dots

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The nonlinear refractive index n2 and absorption coefficient β of PbS quantum dots (QDs) is determined around 1550 nm with the Z-scan technique, using a picosecond pulsed laser. These materials are interesting candidates for integration with SOI (Silicon On Insulator) optical devices to enhance the weak Si nonlinearities around telecom wavelength. PbS QDs are centrosymmetric crystals and their nonlinear optical properties are therefore characterized by the nonlinear refractive index n2 and a Figure of Merit FOM, which yields the maximum nonlinear phaseshift achieved before absorption reduces the intensity too much for nonlinear effects to occur. We find that n2 is wavelength tunable and follows the PbS absorbance spectrum. At fixed wavelength, n2 is constant in the optical intensity range used (1–25MW/cm2), indicative of a third order nonlinear effect.

A FOM >1 is obtained together with an n2 of 10^{-11} cm²/W which are respectively one and two orders of magnitude larger than the values found with Si. It is argued that the creation of excitons and the resulting intraband absorption in the PbS Qdots lie at the origin of the observed n2 and β. Femtosecond four–wave mixing (FWM) experiments at low intensities show that the dynamics of the nonlinear optical response shows a nanosecond decay, which is attributed to exciton thermalization. At higher excitation intensities an additional 100 ps component appears, which is due to carrier- carrier assisted processes. In combination with the facile integration of QDs on SOI using wet deposition techniques, this indicates that PbS QDs have a potential as efficient and fast nonlinear materials for low-cost photonic devices.

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Monday, 5/14 Poster Session 17:55 – 20:00

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M 1	Michiel Aerts (Delft University of Technology)	**Efficient formation of multiple mobile electron-hole pairs in PbSe Quantum Dots arrays and Nanorods**
M 2	Janice Boercker (U.S. Naval Research Lab)	**PbSe Nanostructures: 0D to Quasi-1D**
M 3	Patrick R Brown (MIT)	**Improved Current Extraction from PbS Quantum Dot Heterojunction Photovoltaics Using a MoO3 Interfacial Layer**
M 4	R J Curry (University of Surrey)	**Temperature-dependent magneto-optical characterisation of PbS nanocrystals**
M 5	Pieter Geiregat (University of Ghent)	**Ultrafast Intraband Absorption in Lead-Chalcogenide Core and Core/Shell Nanocrystals for Near- to Mid-IR All-Optical Signal Processing**
M 6	Serguei Goupalov (Jackson State U)	**Anomalous suppression of valley splittings in lead salt nanocrystals without inversion center**
M 7	Svetlana Kilina (North Dakota State University)	**Modeling of Optoelectronic Properties of Rock-Salt IV-VI Semiconductor Quantum Dots Functionalized by Ru-bipyridine Complexes**
M 8	Maksym Kovalenko (ETH Zürich)	**Inorganically Functionalized PbS/CdS Colloidal Nanocrystals: Integration into Amorphous Chalcogenide Glass and Luminescent Properties**
M 9	Michal Malicki (Northwestern U)	**Hole Transfer from Photoinduced PbS Quantum Dots to Aminoferrocene**
M 10	Abdoulghafar Omari (Ghent University)	**Nonlinear optical properties due to inter and intraband transitions in PbS quantum dot**
M 11	Jayson T Stewart (LANL)	**Shape and composition effects on carrier multiplication efficiency in PbX salts**
M 12	Lyudmila Turyanska (The U of Nottingham)	**Photoluminescence of colloidal PbS quantum dots at magnetic fields up to 30T**
M 13	Woojun Yoon (Naval Research Lab)	**Temperature dependence of hole transport in PbSe nanocrystal films passivated by remote plasma atomic layer deposition of Al_2O_3**
M 14	Bhola Pal (Los Alamos National Laboratory)	**High-sensitivity p-n junction photodiodes based on PbS nanocrystal quantum dots**
M 15	Hunter McDaniel (LANL)	**Highly Luminescent Cadmium Treated CuInS2 Quantum Dots**
M 16	Young-Kuk Kim (Korea Institute of Materials	**Surface modification on the photoluminescence of CuInS2 quantum dots**