Nonlinear optical properties of Silicon nanocrystals at 1550 nm and their application

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A new generation of all-optical devices based on Silicon nanocrystals (Si-nc) as non linear active material is under development. The key features of Si-nc are their compatibility with the CMOS fabrication processes, their possible large scale production and their potential large Kerr effect. Si-nc are currently better known because of their efficient visible emission [1]. However a few studies have already reported that they can be used for nonlinear optical applications at 800 nm both in the form of porous Silicon or embedded in a SiO_2 matrix [2,3]. In the framework of transparent optical network, the evaluation of the nonlinear response of Si-nc at telecom wavelengths is needed for a proper design of the structural parameters aimed at optimization of the performance of the final device.
Third order nonlinear optical properties of Si-nc embedded in a SiO_2 matrix were investigated by means of the z-scan measurements. The measurements were performed in the femtosecond excitation regime, in order to avoid thermal effect [4], and at different excitation powers in order to manage the free carrier effects. The investigation was performed on different samples with different characteristics, in order to identify the Si-nc parameters more suitable for the application in photonic nonlinear devices.
Once nonlinear optical properties of the bulk material were understood, the nonlinear optical response of Si-nc based waveguides were measured and simulated. Though the material is always Si-nc, waveguide behaviour could be far more complicated by the disclosing of peculiar effects like self-phase modulation (SPM) and group velocity dispersion (GVD) which can be well understood only by a careful joint modelling and experimental investigation.

[1] L. Pavesi and G. Guillot (Eds.), “Optical Interconnects”, Springer Series in Optical Sciences vol. 119.
[2] G. Vijaya Prakash, M. Cazzanelli, Z. Gaburro, L. Pavesi, F. Iacona, G. Franzò and F. Priolo, J. Mod. Opt., vol. 49, 719-730, 2002.
[3] G. Vijaya Prakash, M. Cazzanelli, Z. Gaburro, L. Pavesi, F. Iacona, G. Franzò and F. Priolo, J. Appl. Phys., vol. 91, 4607-4610, 2002.
[4] R. Spano, M. Cazzanelli, N. Daldosso, Z. Gaburro, L. Ferraioli, L. Tartara, J. Yu, V. Degiorgio, S. Hernandez, Y. Lebour, P. Pellegrino, B. Garrido, E. Jordana, J. M. Fedeli, and L. Pavesi, MRS Proc. vol. 958, L08-06(2007).