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Characterization of extrinsic centers in AlGaAs for quantum light sources

Quantum emitters of light are building blocks for many applications in quantum communications technologies and so far different routes have been chosen to implement quantum emitters in solid state systems. Recent studies [1] have found extrinsic centers in AlGaAs epilayers built on Ge substrate emit peculiar multiplets lines in a similar way quantum dots do. But there is still no evidence of a exciton-biexciton cascade, or a unique determination of the nature of these centers. In literature exciton (X) and biexciton (XX) cascade has been recently demonstrate for dyads of impurities [2], or from spontaneous nucleation of AlGaAs nanocrystals with different Al concentration in a nanowire system of GaAs/AlGaAs leading to Al segregation [3]. In this thesis we start providing a clear-cut attribution to X-XX cascade via fine structure splitting (FSS) measurements of the two photon cascade, then we perform a statistical surface characterization for samples with different growth parameters in order assess the nature of the extrinsic centers concluding that the Ge contamination is likely to play the major role. Finally a sample with Ge ions implanted via FIB has been characterized in order to test the capability to create in a deterministic way quantum emitters based on Ge dyads. A micro-photoluminescence

setup has been used to perform FSS polarization maps and a peculiar cryostat mounted on sub-micrometric servo-motors allowed us to perform spatial characterization over wide surfaces; micro-PL is necessary in these kind of measurements since single emitters photoluminescence would otherwise be overwhelmed by the background. Our results clearly attribute to Ge contamination the capability to create extrinsic centers with quantum emitter property even if the damage of the sample by FIB implantation needs to be reduced in order to exploit the method for a deterministic site control of the quantum emitter.

- [1] F. Sarti, Single photon emission from impurities centers in AlGaAs epitaxial layers on Ge Substrate. Master degree thesis - Università degli studi di Firenze
- [2] S. Marcet, C. Ouellet-Plamondon, G. Éthier-Majcher, P. Saint-Jean, R. André, J. F. Klem, S. Francoeur, Charged excitons and biexcitons bound to isoelectronic centers. Phys. Rev B **82**, 235311 (2010)
- [3] M. Heiss, Y. Fontana, A. Gustafsson, G. Wüst, C. Magen, D. D. O'Regan, J. W. Luo, B. Ketterer, S. Conesa-Boj, A. V. Kuhlmann, J. Houel, E. Russo-Averchi, J. R. Morante, M. Cantoni, N. Marzari, J. Arbiol, A. Zunger, R. J. Warburton, A. Fontcuberta i Morral, Self-assembled quantum dots in a nanowire system for quantum photonics. Nature Materials **12**, 439–444 (2013)

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