Novel Fabrication Techniques of GaAsN Quantum Dots

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The interest in semiconductor Quantum Dots (QDs) is increased in the last decades because, thanks to their ability to act as sources of non-classical light states, they could become the fundamental building block for the large-scale development of the quantum information technologies (e.g. quantum computers and quantum cryptography). However, many of the most advanced applications of QDs require a fine control of the QDs’ position and confinement potential, which cannot be achieved with conventional growth techniques. Moreover, since the QDs are embedded in a high refractive index layer, only a small fraction of their luminescence is typically collected, an issue further exacerbated by the finite numerical aperture (NA) of the collecting optics. This prevents the usage of QDs in most applications, such as quantum cryptography and quantum computing, where higher collection efficiencies enable faster and more reliable operations.

In this seminar, three novel QD fabrication techniques are presented. They are able to solve, or partially solve, the aforementioned issues of controlled positioning and luminescence collection. All these methods rely on the properties of the hydrogenated dilute nitride GaAsN:H. Hydrogen incorporation in GaAsN results in the formation of N-2H and N-2H-H complexes, which neutralize all the effects of N on GaAs, therefore obtaining GaAsN:H, a material with a larger band gap with respect to GaAsN. Starting from a GaAs/GaAsN/GaAs quantum well, the QDs are fabricated by depositing an array of hydrogen opaque masks and subsequently irradiating the sample with hydrogen. Alternatively, starting from a fully hydrogenated GaAs/GaAsN:H/GaAs quantum well, QDs can be obtained by breaking the N-H bonds located within the light spot generated by a Scanning Near-field Optical Microscope tip or by a microsphere photonic nanojet. In all these cases, GaAsN QDs surrounded by a barrier of GaAsN:H (laterally) and GaAs (above and below), are obtained.