Droplet Epitaxy of Quantum Nanostructures

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Quantum materials represent the novel frontier of physics, chemistry, and engineering, aiming to tailor the electronic and optical properties of materials via the artificial nano-synthesis of quantum nanostructures (QNs). QNs have been systematically explored to improve "classical" optoelectronic devices like low-threshold and thermally stable semiconductor lasers, amplifiers, detectors, solar cells, etc. Even more relevant is their application as solid-state building blocks for emerging quantum technologies, allowing the fabrication of deterministic sources of single photons and quantum entangled photon pairs for quantum communication, quantum simulation, and computing.

Among the more successful growth processes to self-assemble three-dimensional quantum nanostructures, Droplet Epitaxy has demonstrated a high flexibility, from non-classical photon sources to quantum infrared photodetectors, thus becoming a fundamental growth procedure for the fabrication of advanced quantum devices. The Droplet Epitaxy growth protocol [1] exploits the controlled crystallization of metal nano-droplets into compound semiconductor QNs of high crystalline and optical quality. This makes it possible, by controlling the process kinetics, to obtain QNs with an extended chart of materials, and to tailor shape and topology, thus making it possible to engineer electronic, spin, and optical properties for targeted applications [2,3].

We report on the recent advances in the understanding of droplet epitaxy self-assembly fundamental processes and in the fabrication of non-classical photon emitters (optimizing entangled photon cascade devices, tuning the emission in the telecom range, etc.) and of advanced optoelectronic devices.

[1] K. Watanabe, N. Koguchi, and Y. Gotoh, Jpn. J. Appl. Phys. 39, L79 (2000)
[2] S. Sanguinetti, S. Bietti, N. Koguchi, Chapter 13 - Droplet Epitaxy of Nanostructures, Editor(s): Mohamed Henini, Molecular Beam Epitaxy (Second Edition), Elsevier, 293 (2018)
[3] M. Gurioli, Z. Wang, A. Rastelli, T. Kuroda, and Stefano Sanguinetti, Nature Materials, 18, 799 (2019)

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