Telecom C-band emission from droplet etched quantum dots in the InP/$In_yAl_{1-y}As/In_xGa_{1-x}As$ system

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Semiconductor quantum dots (QDs) have been established as promising sources for on-demand single photon and entangled photon pair generation for quantum communication applications. [1] In the case of polarization entangled photons it is possible to utilize the biexciton-exciton cascade of a QD system. Here $GaAs/Al_xGa_{1-x}As$ QDs grown via local droplet etching (LDE) have been proven to be the current gold standard, as they exhibit very low fine-structure splitting (fss) due to good in-plane symmetry and their negligible strain. [2] However, for the $GaAs/Al_xGa_{1-x}As$ system one is limited to photon emission around 780 nm. In this talk, we present the adaptation of the LDE technique to the InP/$In_yAl_{1-y}As/In_xGa_{1-x}As$ system for photon emission in the optical C-band. We show that under optimized process parameters for the etching process we can produce nanoholes that display very good symmetry when measured with atomic force microscopy (AFM). We will discuss the influence of the etching material (In, Al, InAl), the etching temperature and the amount on etching material on the resulting nanohole geometry. The nanohole density decreases exponentially with increasing etching temperature and at high etching temperatures the holes show a significant elongation. Etching temperatures of 410 °C and 435 °C are optimum regarding hole depth and in-plane symmetry. Our experiments further show that these nanoholes can be filled with $In_xGa_{1-x}As$ and that the filling works better when utilizing an As_4 environment instead of As_2. Finally, we demonstrate that the filled nanoholes emit light when embedded in an $In_{0.52}Al_{0.48}As$ matrix. The wavelength redshifts with increasing filling height and that ultimately, we were able to create QDs that show emission up into the optical C-band. µ-photoluminescence spectroscopy reveals sharp emission line typical for semiconductor QDs.

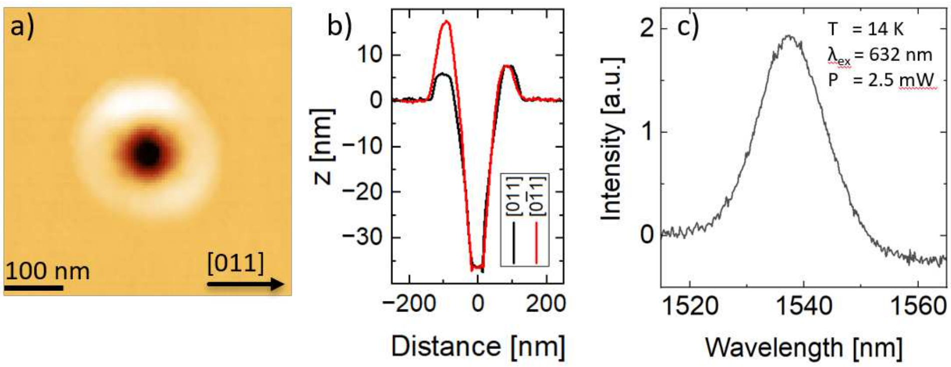

Figure 1 - a) Exemplary AFM image of a nanohole etched into an $In_{0.52}Al_{0.48}As$ layer by depositing InAl droplets. b) Corresponding line scans in the two main crystalline directions. c) Ensemble photoluminescence signal from $In_{0.56}Ga_{0.44}As$ QDs embedded in an $In_{0.52}Al_{0.48}As$ matrix, grown by filling nanoholes produced with the same parameters as in a) and overgrown with $In_{0.52}Al_{0.48}As$.

References

[1] S. F. C. da Silva et al., App. Phys. Lett. **119,** 120502 (2021).
[2] Y. Li et al., Chinese Physics B **27**, 020307 (2018).