

Telecom-band emission from hexagonal germanium quantum dots grown on the facets of GaAs nanowires

I. Dudko,^{1,2} A.D. Lamirand,¹ C. Botella,¹ P. Regreny,¹ A. Danescu,¹ M. Bugnet,³ M. Krämer,⁴ B. Gault,^{4,5} M. Túnica,⁶ R. Rurali,⁷ M. Amato,⁶ S. Walia,² J. Penuelas,¹ and N. Chauvin¹

¹ Ecole Centrale de Lyon, CNRS, INSA Lyon, UCBL, CPE Lyon, INL, UMR 5270, 69130 Ecully, France

² School of Engineering, RMIT University, Melbourne 3001, Victoria, Australia.

³ CNRS, INSA Lyon, UCBL, MATEIS, UMR 5510, 69621 Villeurbanne, France.

⁴ Max-Planck-Institut für Eisenforschung, Düsseldorf, Germany.

⁵ Department of Materials, Royal School of Mines, Imperial College, London, UK

⁶ Université Paris-Saclay, CNRS, LPS, 91405 Orsay, France

⁷ ICMAB-CSIC, Campus UAB, 08193 Bellaterra, Spain

Presenting author email address: nicolas.chauvin@insa-lyon.fr

Hexagonal Germanium (hex-Ge) has the particularity of being a group-IV semiconductor material with a direct band-gap energy (≈ 0.35 eV). Up to now, the best procedure to epitaxy this material is to grow a Ge shell on the facets of wurtzite (Wz) GaAs nanowires (NWs).

In this work, hex-Ge was grown on the facets of self-assisted GaAs nanowires grown by molecular beam epitaxy using the vapor-liquid-solid mechanism [1]. A pure Wz GaAs segment was maintained by adjusting the V/III ratio during the axial growth of the NWs [2]. We investigated the start of the hex-Ge growth on the NW facets. Measurements by atom probe tomography (APT) and high-resolution transmission electron microscopy (TEM) allow us to conclude that hex-Ge growth starts with the formation of small quantum dots (QDs) [Figure 1.a], which then expand until coalescing to form a radial quantum well. Photoluminescence (PL) spectroscopy performed on these hex-Ge/GaAs QDs shows a strong quantum confinement leading to a light emission in the telecom bands. A redshift of the PL emission is observed when the QD size increases along with a strong decrease of the PL emission when the QD coalescence begins [Figure 1.b]. Moreover, a type I band alignment is observed in agreement with DFT calculations.

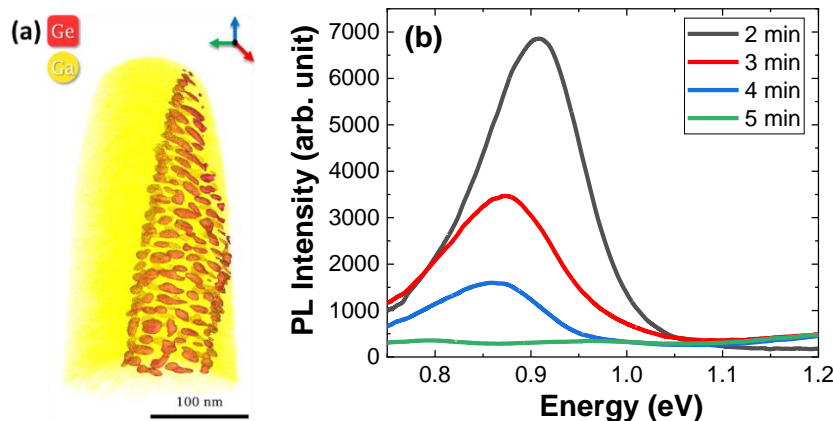


Figure 1. (a) APT showing small QDs. (b) low temperature PL as a function of the Ge growth duration in min.

[1] I. Dudko, *et al* Crystal Growth & Design 22, 32 (2021)

[2] T. Dursap, *et al* Nanotechnology 32, 155602 (2021)

Acknowledgments:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 801512. This work was supported by the LABEX iMUST of the University of Lyon (ANR-10-LABX-0064), created within the program « Investissements d'Avenir » set up by the french government and managed by the French National Research Agency (ANR). We thank Uwe Tezins, Andreas Sturm, and Christian Broß for their support at the FIB & APT facilities at Max-Planck Institut für Eisenforschung GmbH. M.K. and B.G. acknowledge financial support from the German Research Foundation (DFG) through DIP project no. 450800666.