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► To cite this version:

L. Dentz, F. Hamouda, G. Hallais, L. Vincent, E. Herth, et al.. From nanosphere lithography to localised heteroepitaxy of GaAs on Si. *Gettering and Defect Engineering in Semiconductor Technology GADEST 2024*, Sep 2024, Bad Schandau, Germany. hal-04790713

HAL Id: hal-04790713

<https://hal.science/hal-04790713v1>

Submitted on 19 Nov 2024

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From nanosphere lithography to localised heteroepitaxy of GaAs on Si

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The scientific community has long pursued the integration of GaAs on Si, especially for optoelectronic applications, particularly in the fields of photovoltaics and photonics. The main challenge to GaAs integration on Si is related to their significant lattice mismatch (4.1%) which leads to the formation of dislocations. The anti-phase domains creation remains also a problem. To address these issues, we have developed the ELTON method (Fig. 1.): Epitaxial Lateral overgrowth on Tunnel Oxide from nano-seed. This involves epitaxially growing GaAs microcrystals from nano-openings (< \varnothing 90 nm) thermally formed in the ultra-thin silicon oxide layer (< 2 nm) (Fig. 2.). This process has demonstrated perfectly epitaxial GaAs microcrystals on silicon without structural defects, with good optoelectronic integration across their entire surface (GaAs/Si and GaAs/SiO₂/Si stacking by tunnel effect) [1].

Our current objective is to cover as much silica surface as possible with GaAs to achieve a quasi-layer. For this purpose, we are developing a quick, reproducible, and cost-effective lithography method based on nanosphere lithography to localize the growth of μ -crystals in a hexagonal array (Fig. 3.). This lithography method have the advantage to maintain a very thin silica layer and create nano-openings to preserve defect-free and electrically connected crystal growth.

The other essential part of the project focuses on controlling the doping of GaAs micro-crystals. The crystals had previously exhibited significant unintentional P-type doping due to high carbon incorporation resulting from improper dissociation of the precursor gas used for Gallium (TMGa) [2]. TEGa can also be used as the Gallium precursor gas to enhance doping control. We will present and compare the results with those previously obtained with TMGa (Fig. 4.).

[1] C. Renard et al, *Sci. Rep.*, 2016, 6, 25328. doi:10.1038/srep25328.

[2] T. Molière et al, *Journal of applied physics*, 2017, 121(3):035704

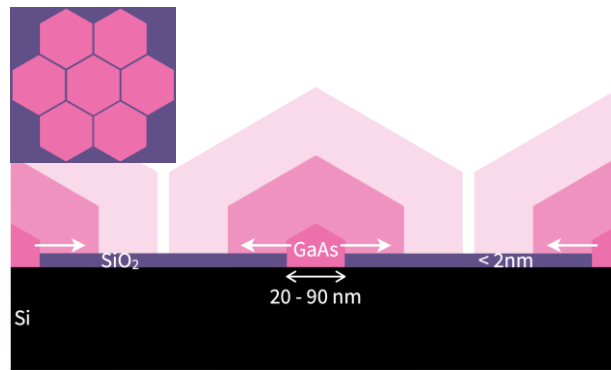


Fig. 1. Targeted architecture: GaAs μ -crystal growth on Si by ELTON method.

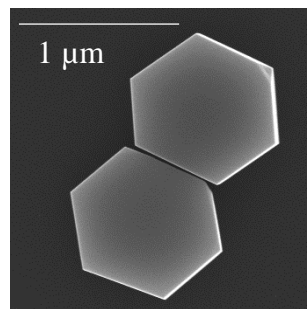


Fig. 2. GaAs μ -crystal on Si.

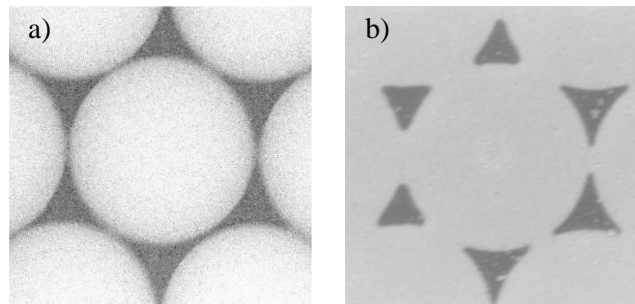


Fig. 3. a) Polystyrene nanosphere of 1 μ m diameter on Si; b) Metallic deposition in the gaps between the nanospheres.

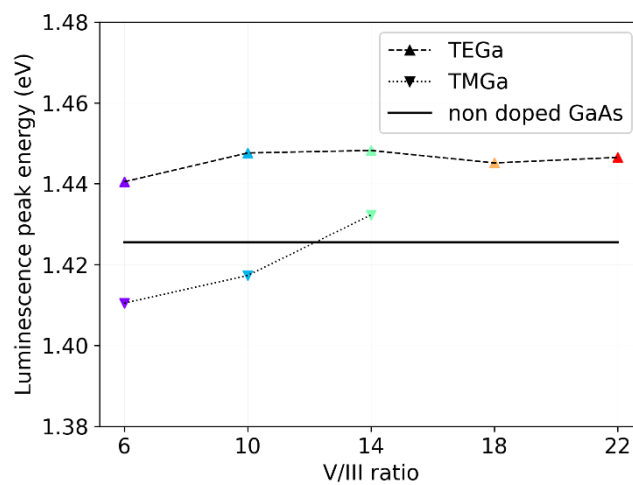


Fig. 4. Photoluminescence peak position of the GaAs crystals resulting from growth at different V/III ratios of the precursor gases (TEGa and TMGa) compared with the photoluminescence peak of an undoped GaAs (110) substrate.