Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Towards defect-free 1-D GaAs/AlGaAs Heterostructures based on GaAs nanomembranes

G. Tutuncuoglu,[a] M. de la Mata[b,c], D. Deiana[e] , H. Potts[a] , F. Matteini[a], J. Arbiol[b,d] and A. Fontcuberta i Morral[a]

[a] École Polytechnique Fédérale de Lausanne (EPFL) Lausanne, Switzerland
[b] Institut Català de Nanociència i Nanotecnologia (ICN2), Campus UAB, 08193 Bellaterra, Catalonia, Spain
[c] Institut de Ciència de Materials de Barcelona, ICMAB-CSIC, Campus de la UAB, 08193 Bellaterra, Catalonia, Spain
[d] Institució Catalana de Recerca i Estudis Avançats (ICREA), 08010 Barcelona, Catalonia, Spain
[e] Centre Interdisciplinaire de Microscopie Electronique, Ecole Polytechnique Fédérale de Lausanne, EPFL, 1015 Lausanne, Switzerland

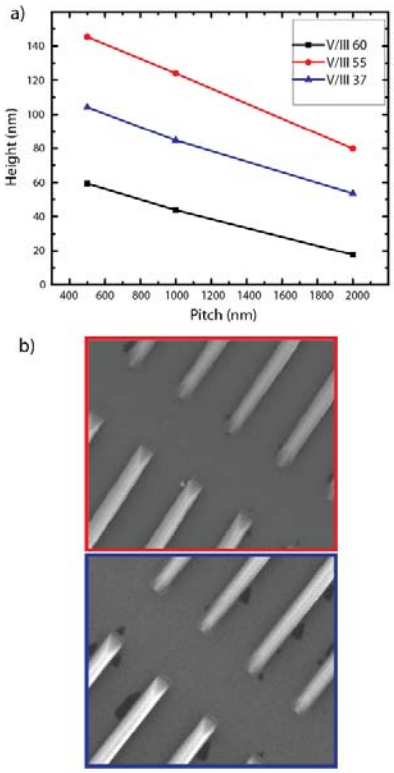

Figure 1: a) Pitch Dependency of the GaAs nanomembrane height in function of V/III ratio which is controlled via changing Arsenic BEP (Beam Equivalent Pressure) by keeping Gallium (Ga) growth rate fixed at 0.3 A/s b) SEM images of the samples grown under the conditions specified above, the colour of the frame is matched to the colour of the data line.

It has been shown that varying Arsenic flux did not affect the faceting and the growth dynamics of the GaAs nanomembrane growth. The decreasing trend of height - pitch dependency does not change upon different Arsenic fluxes.

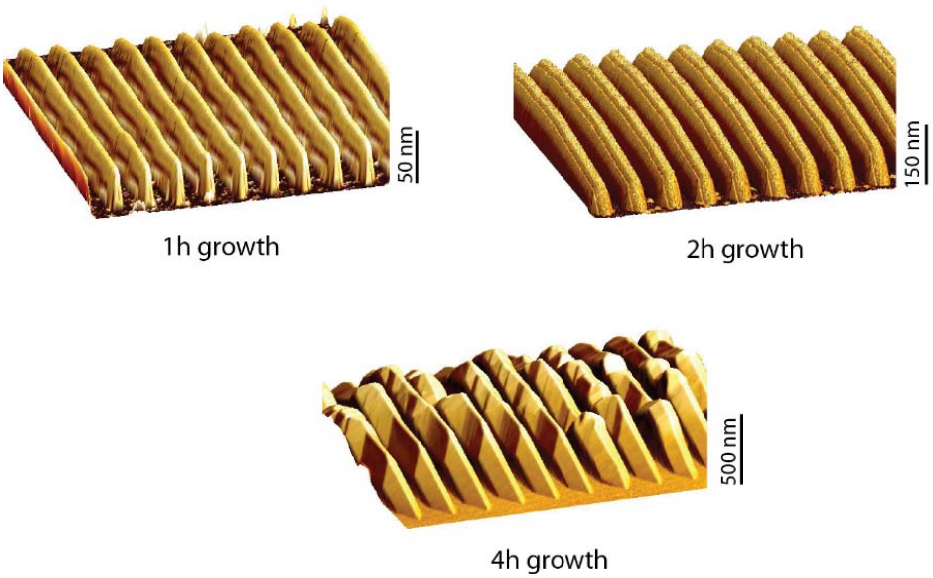

Figure 2: Time series of samples grown with 0.3 A/s Ga rate and 60 of V/III ratio.

In order to observe the growth dynamics and the faceting of the nanostructures, a series of samples are grown with varying growth durations from one hour to four hours. It has been observed that initial facets of the nanomembranes do not change into vertical {110} facets as growth continues, on contrary dynamic faceting is observed and several new facets are formed as growth continues.

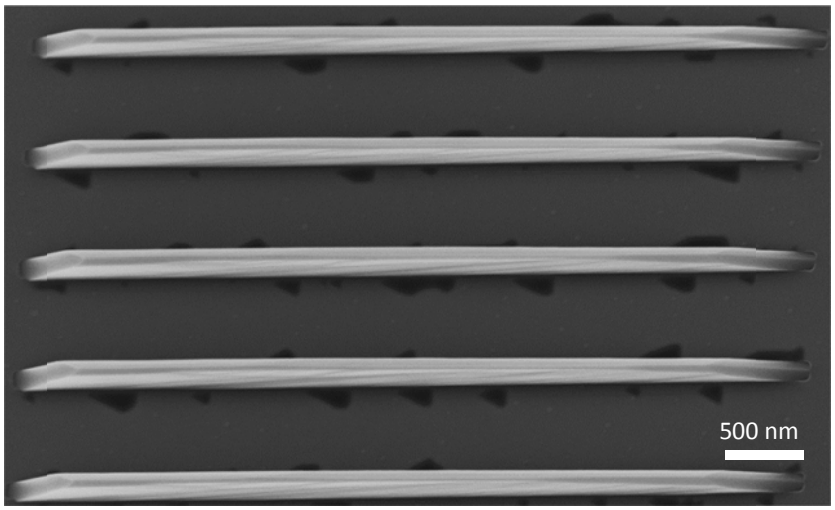

Figure 3: Twin defects formed at the side facets of the GaAs nanoscale membranes grown at 660 °C

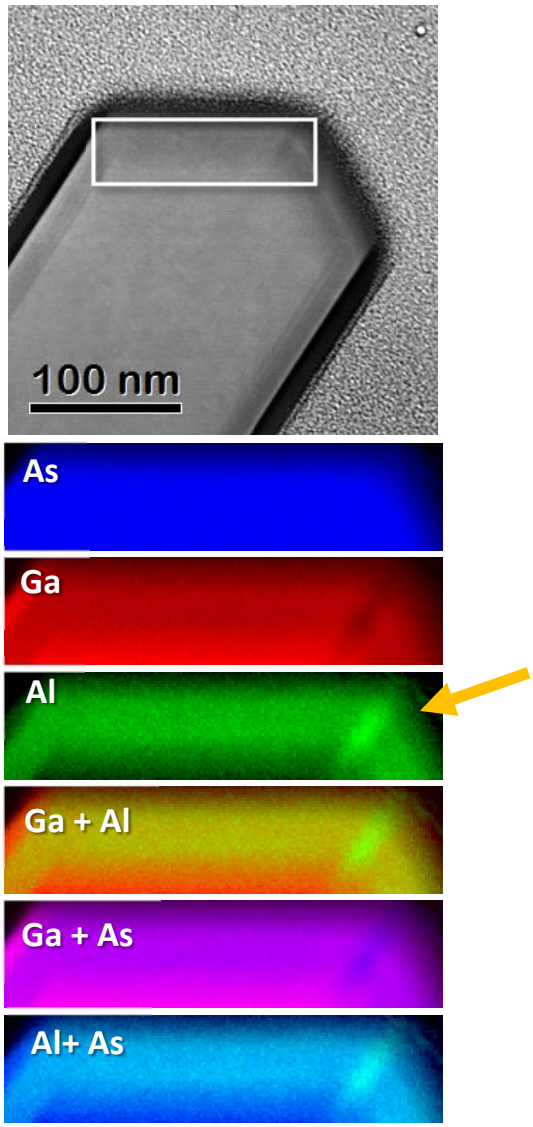

Figure 4: EELS mapping at the top part of the membranes along the [112] direction.

Al segregation through the apex is obvious, as it happens in NWs.

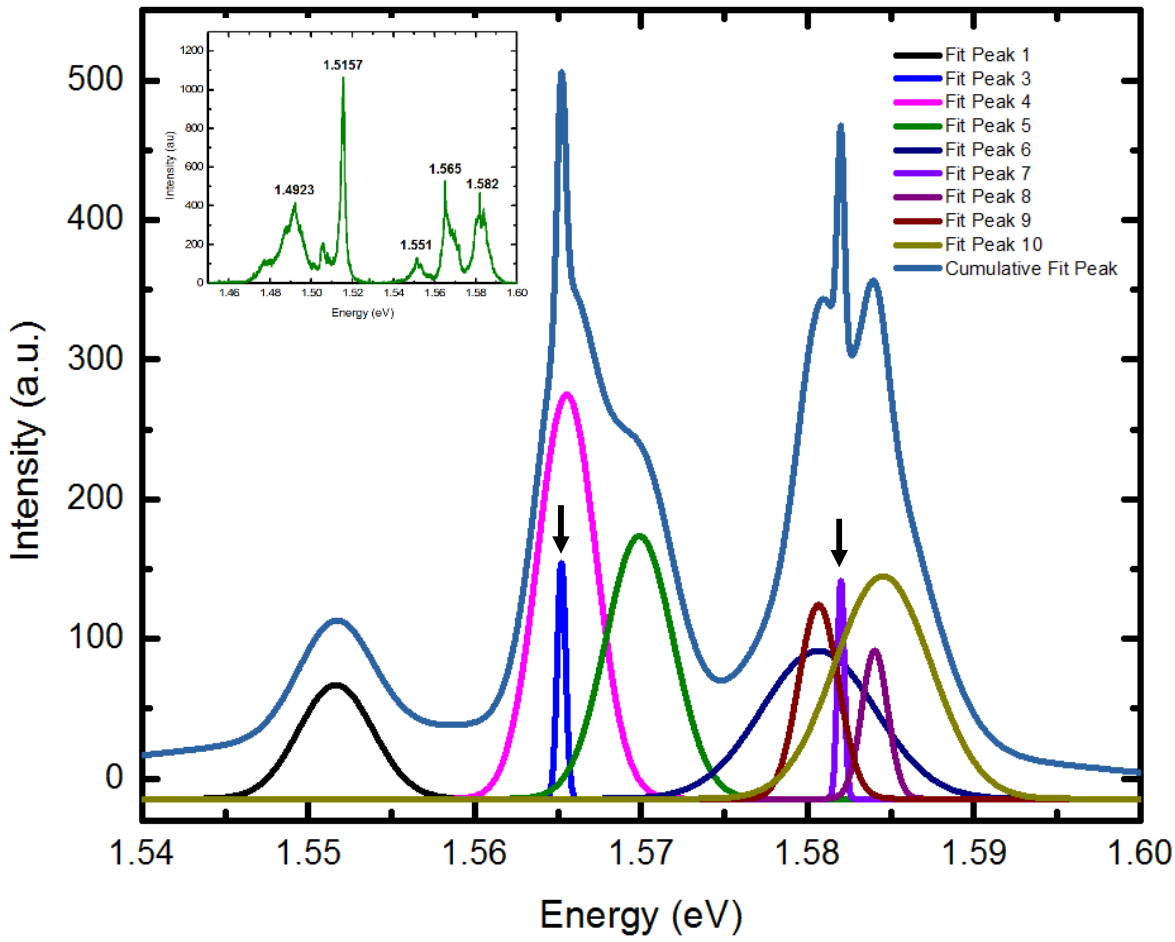

Figure 5: 1.54 eV-1.60 eV section of a PL spectrum of a GaAs nanoscale membrane with 8 nm (nominal) of GaAs QW sandwiched between 20 nm (nominal) of AlGaAs layers. Full spectrum is shown in the inset

In the shown spectrum minimum FWHMs of the narrowest peaks are 490 and 590 µeV (pointed with black arrows) while the maximum one is 8 meV.

Process Related Challenges

After pattern fabrication steps and necessary optimizations we did not encounter a problem with yield under optimum growth conditions. An example is demonstrated at the following figure. Few defective structures can be noticed at the first glance however their ratio is below 5%. We believe such defects are formed due to the imperfections at the lithography or following dry etching steps.

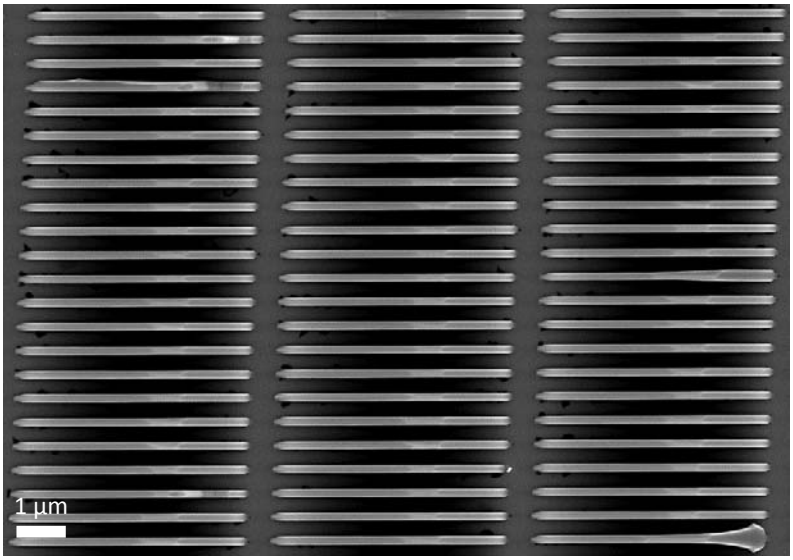

Figure 6: Part of a 1mmx1mm size pattern. Nanoscale membranes are grown at 640 °C and 17 of V/III.

In the second figure 20 degree tilted image of the same sample is demonstrated. In such magnified view the openings at the oxide layer can be observed. As inherent to (111) B GaAs substrates we observe triangular shaped openings. We associate such deformations with decomposition of GaAs at such elevated temperatures and local thinning of the dielectric layer during fabrication.

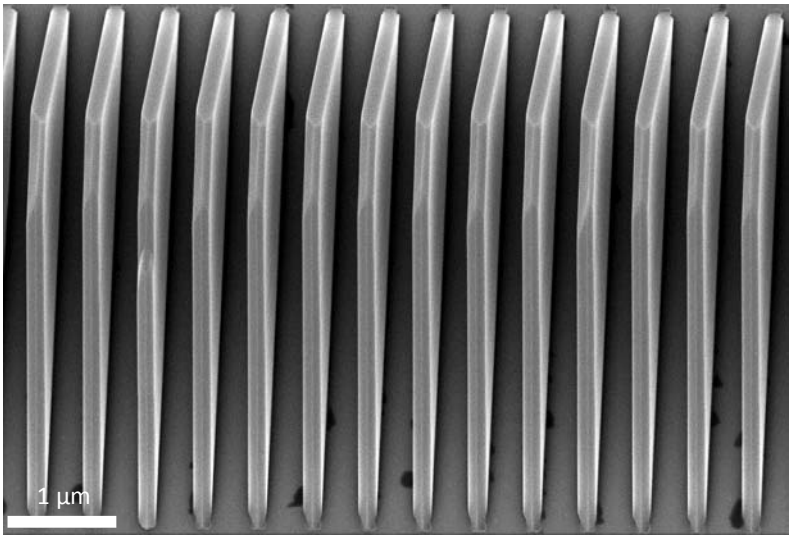

Figure 7: Higher magnification and tilted view of the previous sample