Epitaxial III-V growths on 0.1-mm-grain-size polycrystalline germanium thin-films

A. Chikhalkar,[1] C. Zhang,[1] N. Faleev,[1] E. McClure,[2] S. Hubbard,[2] C. Honsberg,[1] and R. R. King[1]

[1] *Arizona State University, Tempe, Arizona, USA, 85281*
[2] *Rochester Institute of Technology, Rochester, New York, USA 14623*

III-V solar cells have demonstrated the highest efficiencies, for both single-junction and multijunction cells. Low defect tolerance and Fermi-level pinning at grain boundaries of these compounds has focused III-V growth on single-crystal thin-films, on single-crystal gallium arsenide, indium phosphide and germanium wafers that are both heavy and costly.

Polycrystalline thin-films of these materials are attractive candidates to reduce high substrate costs, but to maintain high efficiencies we require (a) large grain size, and (b) effective grain boundary passivation. R. Venkatasubramanian *et al.* [1] have demonstrated 18.2% (AM1.5) efficiencies on polycrystalline GaAs solar cells with 1-2 millimeters grain size, grown on polycrystalline germanium wafers cut from ingots with the same size of grains. Use of aluminum-induced crystallization for growth of polycrystalline germanium (AIC germanium) opens a new parameter space for growth of III-V tandem architectures on germanium-templated low-cost substrates such as glass and Mo foil. In addition to the light weight of the substrate, relatively large grain size of ~100 μm with high <111> orientation preference can be achieved, reducing the effect of grain boundary recombination. These characteristics along with the theoretical studies by S. Kurtz et. al. [2] which project >20% GaAs efficiency with grain size of 50-70 μm makes III-V growth on AIC germanium a promising avenue.

In this talk, we demonstrate the epitaxial growth of GaInP and Ga(In)As on AIC germanium. The growth mechanism was studied *in situ* using reflection high-energy electron diffraction. The presence of streaks indicates a layer-by-layer growth. Morphology and surface roughness of the grown film are studied using scanning electron microscopy and atomic force microscopy, respectively, while grain orientation is characterized using X-ray diffraction. A high crystal orientation preference and reduction in surface roughness were observed on the grown III-V films compared to the initial Ge template, both encouraging signs for the grown film quality. Recombination kinetics are characterized through room-temperature photoluminescence (PL) intensity (Fig. 1) and measurements of minority charge carrier lifetime in GaInP/GaAs/GaInP double heterostructures. The influence of substrate grain size and pre- and post-deposition treatments on minority charge carrier lifetime will be presented.

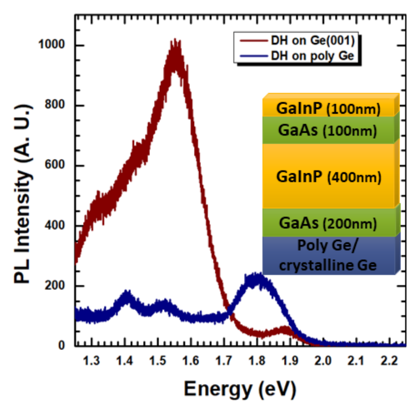

Fig. 1 Photoluminescence of GaInP/GaAs/GaInP double heterostructure grown on AIC germanium.

[1] R. Venkatasubramanian, et. al., IEEE Photovoltaic Specialists Conference Proceeding, 31(1996).
[2] S. R. Kurtz, et. al., AIP Conference Proceedings **404**, 191(1997).

+ Author for correspondence: achikhal@asu.edu

Supplemental Information

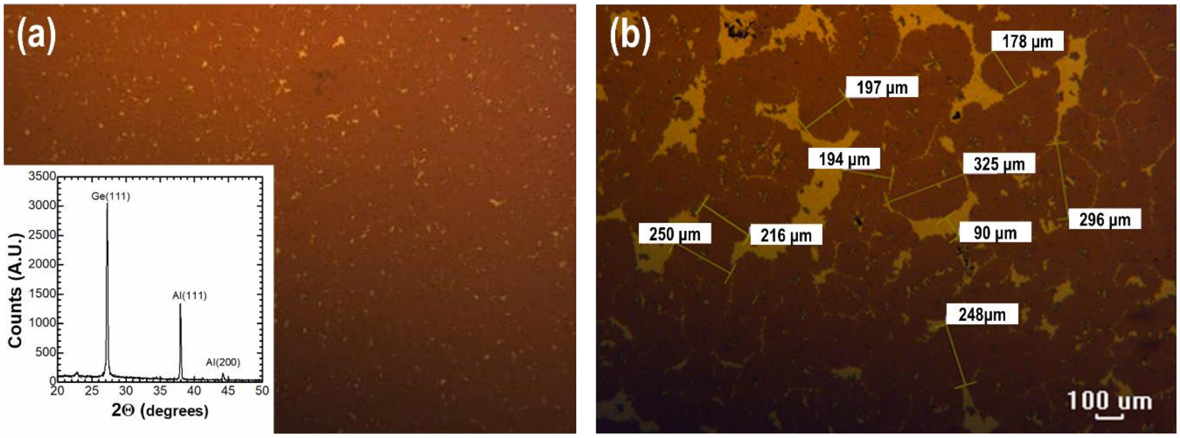

Fig. 1 Optical images showing (a) uniform germanium AIC growth with preferred (111) orientation and (b) large grained AIC germanium on glass slide. (Scale is same for both images)

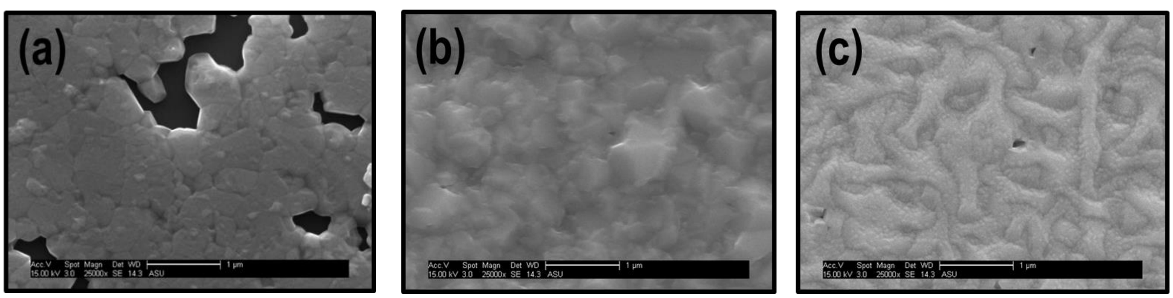

Fig. 2 Scanning electron micrographs showing AIC germanium substrate grown on thermally oxidized silicon wafer (a) before and (b) after double heterostructure growth. Fig. (c) shows the morphology of double heterostructure grown on (100) oriented germanium single crystal