"Mechanism of the aluminum induced crystallization of germanium as pseudo-substrates for solar cells epitaxy"

Daniel Pelati (1,2), Andrea Cattoni (1), Stéphane Collin(1), Jean-Christophe Harmand (1), Frank Glas (1), Phannara Aing (2), Fabrice Oehler (1)

(1) C2N, CNRS – Univ. Paris-Sud – Université Paris-Saclay, Site de Marcoussis - 91460 Marcoussis, France
(2) Riber SA, 95870 Bezon, France

We report on the mechanism of the crystallization of germanium induced by aluminum (AIC) at low temperature (220 – 300 °C). We observe that the initial structure, an amorphous Ge layer (20 nm) deposited on a metal Al layer (20 nm), evolves in two steps upon heating. We first observe the formation of dendritic crystals of Ge randomly on the surface. In a second step, the Al and Ge layers are then seen to exchange position locally and this inverted structure propagates over the whole surface. The second step is associated with the macroscopic crystallization of the Ge layer, as determined by X-ray diffraction after the annealing. The two steps are identified by in-situ optical microscopy during the annealing, Figure 1. When stopping the annealing at t = 15 hours, we extract a TEM cross-section (not shown) near the inversion front. The amorphous Ge material (initially at the top) moves to the bottom after its crystallization while the Al layer performs the opposite movement. The inversion front is characterized by the presence of double Al layer, at the top and bottom layers.

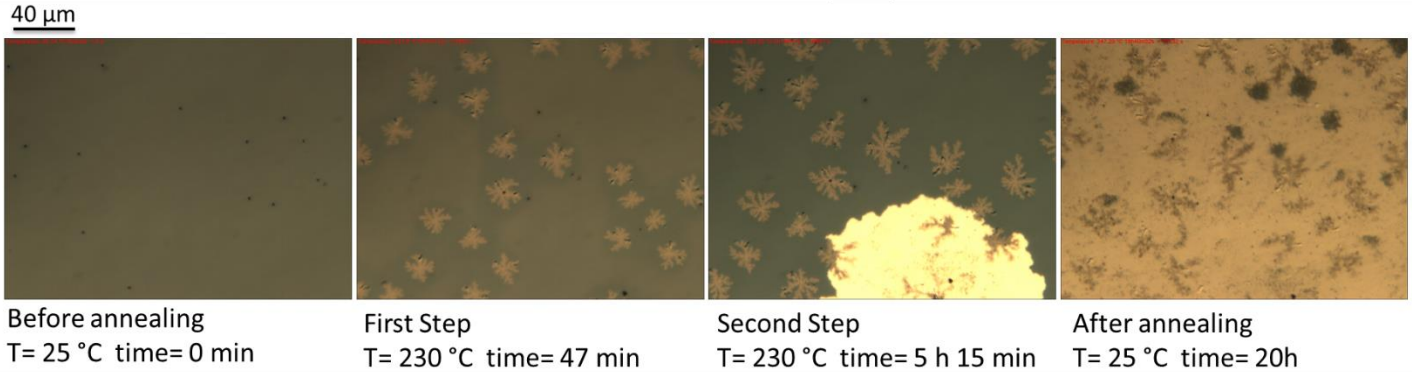

Figure 1: In-situ optical characterization during AlGe annealing at 230 °C

Most of the crystalline Ge exhibit a preferential orientation with the 111 orientation normal to the surface. However, this only applies to the Ge crystallized during the second step through the layer inversion. The dendritic Ge crystals grown in the first step are mostly defective area with no clear orientation. In-plane EBSD characterization shows that the 111-oriented Ge domains consist in macro-grains (>40 microns large) subdivided in sub-domains (~10 microns) with different random in-plane orientations.

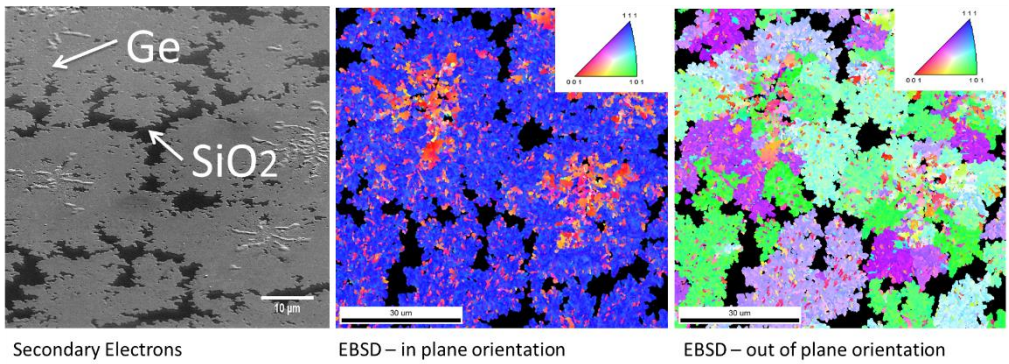

Figure 2: Electron backscatter diffraction spectroscopy characterization of Ge after recrystallization

Lithographic techniques are currently investigated to guide the crystallization process and obtain large islands with a regular shape.
Using this oriented Ge pseudo-substrates on glass sheets, we will try to grow GaAs and to reduce the substrate costs for the fabrication of high efficiency III-V solar cells.