ESRF	**Experiment title:** Solid-liquid eutectic transition in Al-Ge and Al-Si catalysts for the growth of semiconductor nanowires.	**Experiment number**: SI-2093
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Names and affiliations of applicants (* indicates experimentalists):

G. Renaud*[1], T. U. Schülli*[1], R. Daudin*[1], A. Maurice*[1]

[1]*Commissariat à l'Energie Atomique, 17 avenue des Martyrs, 38054 Grenoble, France*

Report:

Semiconductor (SC) nanowires (NWs) are produced via the vapour-liquid-solid (VLS) mechanism [1] in which a low temperature metal/SC eutectic is used to enable their nucleation and their growth. In the case of the Au/Si system we have already reported many results concerning epitaxial relationship, dewetting process and an enhanced supercooling behaviour in presence of the Au-(6x6) surface reconstruction [2]. The potential diffusion of gold on/in the nanowire during the growth and thus the subsequent disruption of the electronic devices lead to the importance of studying other metal/SC couples, such as Al/Si or Al/Ge. The aim of this experiment was to learn more about the promising Al/Si system [3] following the typical procedure used for Au/Si [4].

On the first sample,7 ML (deposition rate: $0.5 ML.s^{-1}$) of Al were deposited at room temperature. Al was found to growth with its (111) plabes parallel to the Si ones. Dewetting happened upon annealing, without clear changes in in-plane epitaxies. We quickly realized that, Al being a too I light material; the deposited amount was too small to get a clear liquid signal. 30 ML were thus deposit on a new sample. During the deposit the Al(220) Bragg peak was recorded along the Si[$1\bar{1}0$] (Figure 1(a)) and the Si[$1\bar{2}1$] (Figure 1(b)) azimuths. In Figure 1(a) the intensity decreases with increasing coverage whereas it increases in Figure 1(b), showing that most of the structure present more a [$1\bar{1}0$]Al(111)$\parallel$[$1\bar{1}0$]Si(111) epitaxial relationship than a [$1\bar{2}1$]Al(111)/[$1\bar{1}0$]Si(111) one. The 'cube on cube' epitaxy is thus dominant at room temperature.

Figure 1: Radial scan performed on the Al(220) Bragg peaks along (a) the Si[$1\bar{2}1$] and (b) Si[$1\bar{1}0$] azimuth at different deposition times (i.e coverage), black: 17min, red: 31min, blue: 45min and green: 60min.

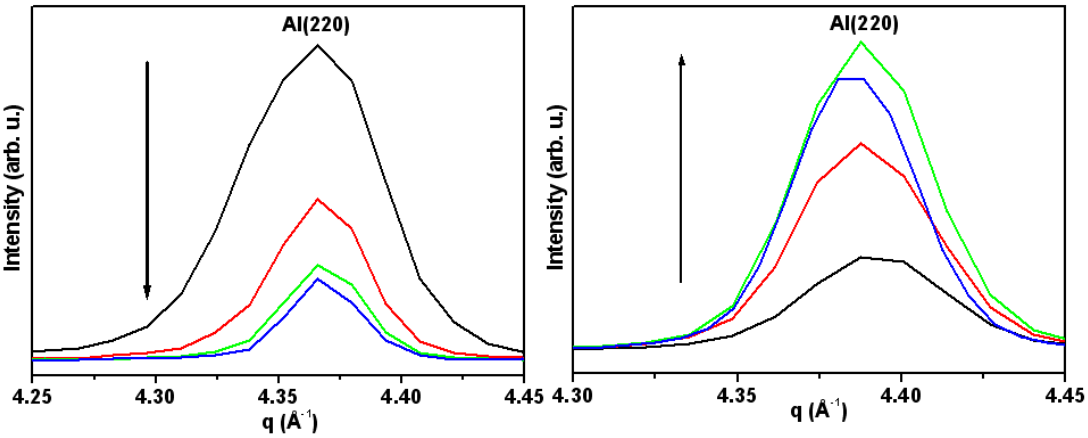


Figure 2(a) is a radial scan performed between the two substrate azimuths (to avoid Si Bragg peaks) at three different temperatures. At 780 K the scan displays all the Al Bragg peaks arising from the polycrystalline film. Note here that the Al(220) peak is the most intense as the major part of the grains have their Al(111) planes parallel to the Si(111) substrate. At 795 K the crystalline peaks start to disappear (Al(220) is still present), the first order of the liquid arises which means that the Si atoms diffuse into the Al island to reach the eutectic composition leading to the melting. The $Al_{88}Si_{12}$ eutectic temperature being 850K, the difference between this value and the observed melting temperature is reasonably attributed to a problem of calibration with the infrared-pyrometer (which can then be re-calibrated). The sample had to be heated up to 835 K to reach total melting (disappearance of the Al(220) peak). This kind of behaviour can come from a higher stability against fusion for grains in this epitaxial configuration or maybe from a non negligible thermal gradient on the surface. Upon cooling (Figure 2(b)) we can see that the first Al crystallites appear at 800 K and that a sharp liquid-solid transition takes place at 790 K. This shows that for this experiment the maximum supercooling is around 50 K, which is not a surprising value comparing to other studies in the literature [5-7]. Figure 2(c) is a reciprocal space map recorded in the solid state on which are present the Si Bragg peaks, the Al polycrystalline rings and several other peaks that could not be assigned to any surface structure. In this experiment, no link between potential reconstructions (little unassigned peaks) nor droplet size and supercooling has been pointed out.

This experiment offers substantial preliminary results for further studies on metal/SC interactions.

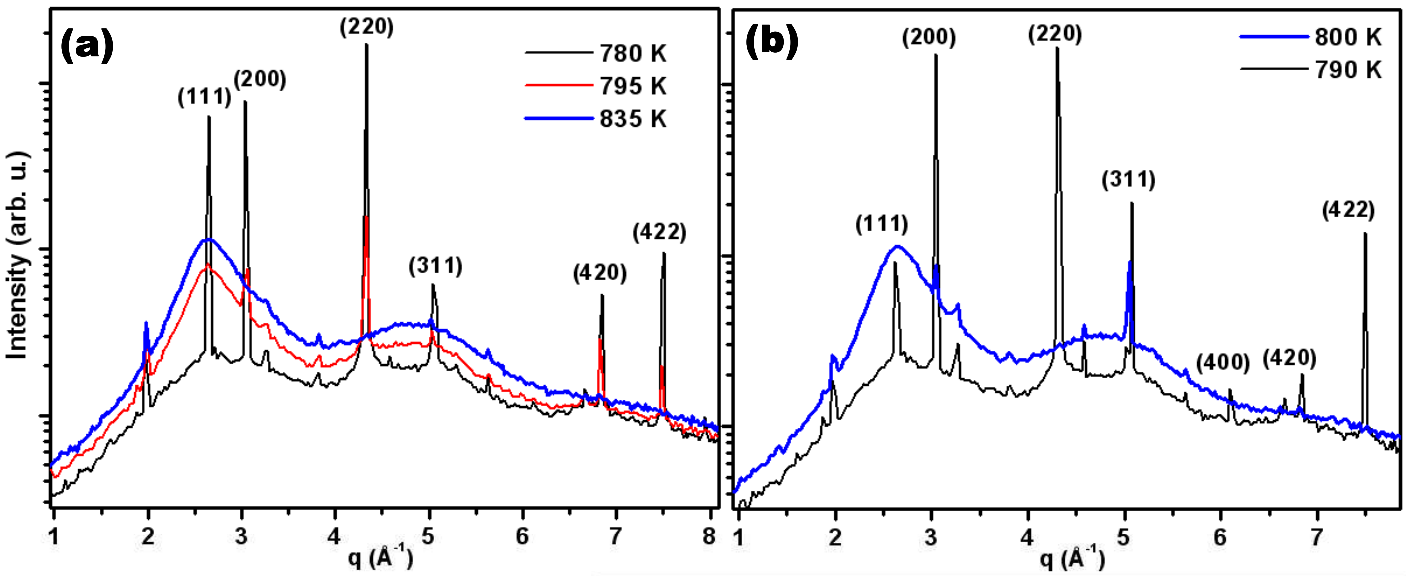
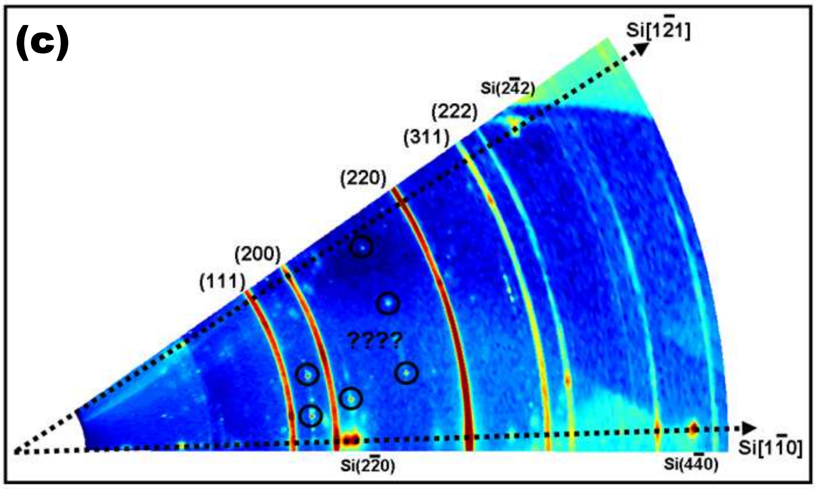


Figure 2: Radial scan between the substrate azimuths, (a) for three temperatures upon heating (780 K, 795 K and 835 K) and (b) upon cooling.
(c) Reciprocal space map of the system after melting and back to solid state. Red, yellow and blue colours correspond to high, intermediate and low intensities. The surrounded peaks are unassigned peaks but may come from surface reconstruction or other unknown crystalline phases.



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