Study of III-V thin films growth directly on silicon by remote-plasma CVD: Towards a reduction in solar cell industrialisation costs

Lise Watrin[1,2]*, François Silva[2], Cyril Jadaud[2], Pavel Bulkin[2], Jean-Charles Vanel[2], Erik V. Johnson[2], Karim Ouaras[2], and Pere Roca i Cabarrocas[1,2].
*lead presenter: lise.watrin@ipvf.fr
1 Institut Photovoltaïque d'Ile-de-France (IPVF), 18 Bvd Thomas Gobert, 91120, Palaiseau, France
2 LPICM, CNRS, Ecole Polytechnique, Institut Polytechnique de Paris, route de Saclay, 91128, Palaiseau, France

Solar cells based on III-V materials have reached the highest efficiency of any technology available today, i.e. up to 47% under concentration [1]. Nevertheless, their cost is a hundred times higher than that of c-Si solar cells [2]. Most of this cost difference comes from i) the substrate required to grow a single crystal layer and ii) the growth process. In a recent project we have shown how the use of a virtual substrate can tackle the first part of the challenge [3]. In this work, we address the second one.

To this end, we have developed a new strategy for the epitaxial growth of III-V materials by using Remote-Plasma Chemical Vapor Deposition (RPCVD) technique. Indeed, plasma assistance allows us to work at lower temperatures thus reducing thermal stresses and hopefully defects, especially the risks of dislocations. Moreover, this process enables low pressure operation, which reduces drastically the precursor consumption when compared to classical Metal Organic CVD (MOCVD). Some works showing the feasibility of such an approach were published in the 1980s [4] and the subject is again attracting interest [5] due to the strong growth of the photovoltaic market.

Recently, we have shown that it is possible to grow gallium nitride (GaN) films by RPCVD at rather low temperature (500°C). By tuning the deposition conditions, thanks to a large number of parameters such as precursor flow rates, plasma power, chamber pressure, substrate and trimethylgallium bubbler temperatures, we were able to grow GaN layers directly on silicon substrates. The obtained films show columnar grains and uniform Ga and N depth profiles with Ga/N ratio close to 1:1. The crystalline quality is promising with a preferred growth orientation along the c-axis of the wurtzite structure. An arsine line has been added to the RPCVD reactor in order to move on to the study of GaAs growth, the results of which would be presented at the ICCGE20 conference.

Our preliminary results raise the prospects of a more affordable method for the growth of III-V materials, with the potential to obtain large-scale epitaxial films, thus addressing the important issue of costs for III-V device industry.

References

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