Epitaxial growth and properties of ε-Ga_2O_3 thin films

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The possibility of growing high-quality gallium oxide (Ga_2O_3) single crystals and films has triggered a great interest on this materials, as very promising candidate for applications in new areas such as high-power transistors and UV detectors.

Although the homo-epitaxy is possible, most research on Ga_2O_3 thin films is still carried out on hetero-substrate such as sapphire. Despite the relatively quick advancements of the last few years, there are still many open questions regarding the deposition of Ga_2O_3 on foreign substrates, for instance related to the appearance of different crystallographic phases: beta (monoclinic), alfa (hexagonal), gamma (cubic), delta (cubic) and epsilon (hexagonal/orthorhombic).

This talk will focus on the recent advancements in epitaxial growth ε-Ga_2O_3 [1] and the extensive characterization by X-ray, TEM, photo-conductivity and absorption spectroscopy. The interest in ε phase arises from the possibility of coupling its high energy gap, similar to that of the more popular β-Ga_2O_3, with less critical growth conditions, for example a much lower deposition temperature. Moreover, ε-Ga_2O_3 films provide a more advantageous crystallographic symmetry than monoclinic β-Ga_2O_3 and can be easily deposited on c-oriented sapphire and gallium nitride, which is good in view of developing a novel oxide-nitride technology. The growth of ε-Ga_2O_3 was seen to proceed via generation of small oriented nuclei that later expand to produce large hexagonal islands (size of 200-400 nm), which ultimately merge producing a flat and homogeneous film. Under appropriate growth conditions, epilayers of the same ε-Ga_2O_3 phase were also successfully deposited on alternative hetero-substrates such as (0001)-GaN and (111)-SiC with good results. The major disadvantage of the epsilon phase comes from its intrinsic instability: it tends to convert to monoclinic beta when annealed above 700 °C. Nevertheless, this is a relatively high value, which in principle enables the use of hexagonal Ga_2O_3 for device fabrication.

[1] F. Boschi, M. Bosi, T. Berzina, E. Buffagni, C. Ferrari, R. Fornari, J. Cryst. Growth 443 (2016) 25