Assessment of the anisotropic electrical conductivity of GaInP $CuPt_B$ type ordering by in-situ TEM

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III-V semiconductors have been explored as active materials for high-speed electronics, opto-electronic devices and high-efficiency photovoltaic devices. The widespread use of III-V semiconductors, such as GaInP is due to the inherent advantages of direct bandgap and high electron mobility. Indeed, GaInP is a key material of multijunction solar cells (MJSCs), which are one of the most efficient photovoltaic devices, achieving conversion efficiencies of in excess of 45%[1]. GaInP presents a CuPt ordering in the group III sublattice, as many other III-V ternaries. This ordering consists of alternating Ga- and In-rich planes on the four equivalent {111} planes of the zinc-blende structure. Misorientation of the (001) substrate by a few degrees towards (111) favors the formation of a single GaInP variant, exhibiting ordering only on the (-111) and (1-11) planes ($CuPt_B$ type).

Moreover, during the growth of GaInP by metalorganic vapor phase epitaxy, the addition of a surfactant flux, of Sb among others, is useful to control the degree of order, (that has great influence on the energy bandgap (Eg) of the alloy) without changing other process variables[4].

Nevertheless, to further increase the performance of the aforementioned devices, a deep understanding of the relationship between the growth conditions and the electrical properties of the devices is mandatory. In particular, it has been shown that the presence of ordered domains affects the electrical properties of GaInP, leading to anisotropic minority carrier diffusion lengths and layer conductivity[2], with reduced carrier mobility values[3] as well.

In the present work, the anisotropic electrical conductivity of GaInP $CuPt_B$ type ordered layers will be assessed by using *in-situ* biasing in a Transmission Electron Microscopy (TEM). The electrical conductivity of GaInP thin films with different degree of order (controlled by the amount of Sb flux during the growth) will be measured in the orthogonal [110] and [1-10] directions. The anisotropy will be evaluated as a function of the density or ordered domains and antiphase boundaries and the results will be discussed in the light of DFT simulations.

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References

[1] M.A. Green, K. Emery, Y. Hishikawa, W. Warta, E.D. Dunlop, D.H. Levi, and A.W.Y. Ho-Baillie, Prog. Photovoltaics Res. Appl. **25**, 3 (2017).

[2] L. Chernyak, A. Osinsky, H. Temkin, A. Mintairov, I.G. Malkina, B.N. Zvonkov, and Y.N. Saf'anov, Appl. Phys. Lett. **70**, 2425 (1997).

[3] S.P. Najda, A. Kean, and G. Duggan, J. Appl. Phys. **82**, 4408 (1997).

[4] C. Coll, E. Barrigòn, L. Lòpez-Conesa, J. Rebled, L. Barrutia, I. Rey-Stolle, S. Estradé, C. Algora, and F. Peirò, Phys. Chem. Chem. Phys. **19**, 9806 (2017).

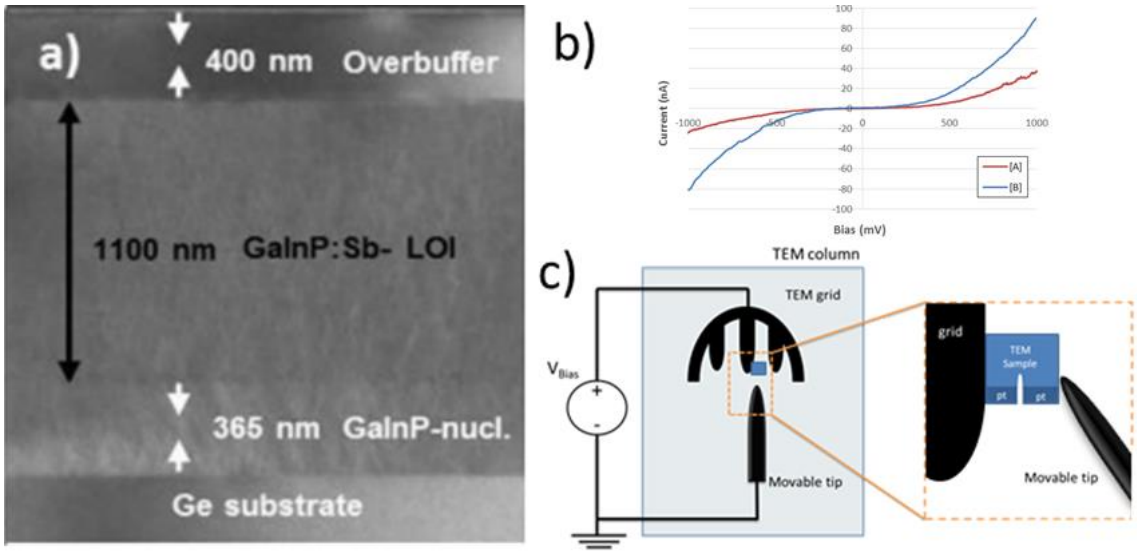

Figure: (a) low magnification TEM image of the sample, (b) I-V characteristic of the sample for the two orthogonal [110] and [1-10] directions, (c) schematic of the *in-situ* biasing in a TEM system.