

MAP-fis Essay Proposal, 2013-2014

Supervisor

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Title

Physical characterization of InAlGaAs nanowires for application in solar cells

Area

(Materials, Optics, Condensed Theory, High Energy Theory,...);

Materials Science

Summary of Proposal

Semiconductor nanostructures have been emerging in many research fields as a consequence of the scientific progress and the ability to fabricate low-dimensional structures with tunable properties for each specific application. An exciting example is the recent and until now little explored use of nanowires in solar cells which presents several advantages in comparison with more conservative proposals [1,2], namely, increase of electrical charge collection when compared to the percolative transport through a random polycrystalline network, high area for light harvesting, lower production costs due to a several times higher growth rate of the nanowires in comparison to the one observed for the traditional thin layers (in particular of GaAs) [3]. The increase of the efficiency of the final devices depends on the evaluation of the structural, electrical and optical properties of the nanowires, and of their tuning as the absorber layer in solar cells. The control of the growth parameters is of particular relevance namely due to the formation of the wurtzite (WZ) phase which is generally favored by processes arising from the large surface-to-volume ratios of the nanowires. Questions like the type of substrate, dimensions of the catalyser, temperature of the growth and level of doping are open. Also, the study of physical properties of nanowires based on GaAs is presently under an intense experimental and theoretical investigation, namely the orientation of the nanowires, dimensions, simultaneous occurrence of zinc-blende and wurtzite phases and doping parameters [4-7].

In this proposal, it will be carried out an extensive study of the physical properties of $\text{In}(x)\text{Al}(y)\text{Ga}(1-x-y)\text{As}$ nanowires as well as of their application in solar cells. The usual experimental techniques [7,8] for the morphological, structural, optical and electrical characterization will be used. Solar cells will be fabricated using the structure used for thin films based solar cells and the performance of device will be evaluated.



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References

(to allow students first look at topic)

- [1] Nanowire dye-sensitized solar cells, M. Law, L. E. Greene, J. C. Johnson, R. Saykally and P. Yang, *Nature Mater.*, vol. 4, p. 455-459 (2005)
- [2] GaAs Core-Shell Nanowires for Photovoltaic Applications, J. A. Czaban, D. A. Thompson and R. R. LaPierre, *Nano Letters*, vol. 9, p. 148-154 (2009)
- [3] GaAs Core-Shell Nanowires for Photovoltaic Applications, J. A. Czaban, D. A. Thompson and R. R. LaPierre, *Nano Letters*, vol. 9, p. 148-154 (2009)
- [4] Structural and optical properties of high quality zinc-blende/wurtzite GaAs nanowire heterostructures, D. Spirkoska, J. Arbiol, A. Gustafsson, S. Conesa-Boj, F. Glas, I. Zardo, M. Heigoldt, M. H. Gass, A. L. Bleloch, S. Estrade, M. Kaniber, J. Rossler, F. Peiro, J. R. Morante, G. Abstreiter, L. Samuelson and A. Fontcuberta i Morral, *Phys. Rev. B*, vol. 80, 245325 (2009)
- [5] Direct correlation of crystal structure and optical properties in wurtzite/zincblende GaAs nanowire heterostructures, M. Heiss, S. Conesa-Boj, J. Ren, H.-H. Tseng, A. Gali, A. Rudolph, E. Uccelli, F. Peiró, J. R. Morante, D. Schuh, E. Reiger, E. Kaxiras, J. Arbiol and A. Fontcuberta i Morral, *Phys. Rev. B*, vol. 83, p. 045303 (2011)
- [6] Luminescence of GaAs nanowires consisting of wurtzite and zinc-blende segments, U. Jahn, J. Lahnemann, C. Pfuller, O. Brandt, S. Breuer, B. Jenichen, M. Ramsteiner, L. Geelhaar and H. Riechert, *Phys. Rev. B*, vol. 85, 045323 (2012)
- [7] Photoluminescence study of GaAs thin films and nanowires grown on Si(111), B. P. Falcão, J. P. Leitão, J. C. González, M. R. Correia, K. G. Zayas-Bazán, F. M. Matinaga, M. B. Moreira, C. F. Leite, A. G. de Oliveira, *J. Mater. Sci.*, vol. 48, p. 1794-1798 (2013)
- [8] Structural and optical characterization of Mg-doped GaAs nanowires grown on GaAs and Si substrates, B. P. Falcão, J. P. Leitão, M. R. Correia, M. R. Soares, F. M. Morales, J. M. Manuel, R. Garcia, A. Gustafsson, M. V. B. Moreira, A. G. de Oliveira, and J. C. González (2013)
- [9] A comparison between thin film solar cells made from coevaporated $\text{CuIn}_{1-x}\text{Ga}_x\text{Se}_2$ using a one-stage process versus a three-stage process, P.M.P. Salomé, V. Fjallstrom, P. Szaniawski, J. P. Leitão, A. Hultqvist, P. A. Fernandes, J. P. Teixeira, B. P. Falcão, U. Zimmermann, A. F. da Cunha and M. Edoff, *Progress in Photovoltaics: Research and Applications*, DOI: 10.1002/pip.2453