Temperature dependent Ga_2O_3 refractive index for nanowire-based thermometers

Daniel Carrasco[1]
Manuel Alonso-Orts[1,2], Eva Nieto[3], Rosalía Serna[3], José María San Juan[4], María Luisa Nó[4], Alicia de Andrés[5], Jani Jesenovec[6], John S. McCloy[6], Emilio Nogales[1] and Bianchi Méndez[1]

[1] Dpto. Física de Materiales, Fac. CC Físicas, UCM, Madrid 28040, Spain
[2] Inst. Solid State Physics, UB, Otto-Hahn-Allee 1, 28359 Bremen, Germany
[3] Inst. de Óptica, CSIC, Serrano 121, 28006 Madrid, Spain
[4] Dpto. Física, Fac. de Ciencias y Tecnología, UPV-EHU, Apdo. 644, Bilbao 48080, Spain
[5] Inst. de Ciencia de Materiales de Madrid, CSIC, Cantoblanco, Madrid 28049, Spain
[6] Inst. of Materials Research, Crystals and Semiconductors Group, WSU, Pullman WA 99164, USA
Contact email: daniecar@ucm.es

Gallium oxide is currently attracting great interest on the semiconductor field as it is a transparent conductive oxide (TCO) with an ultra-wide bandgap (~ 4.8 eV), high thermal and chemical stability and it can be doped with different rare earths ions, making it a very suitable material for high power electronics and photonics applications [1].

In this work, we present our recent results designing, optimizing, characterizing, and applying optical microcavities based on a pair of distributed Bragg reflectors (DBR) patterned by focused ion beam in the waveguiding β-Ga_2O_3:Cr nanowires, which results in widely tunable Fabry-Perot (FP) optical resonances enhanced by the great photonic properties of Cr^{3+} ions, and their use as wide dynamical range temperature sensor (at least from 150 K to 550 K, with a precision around 1 K) based on the thermal position shift of the characteristic R-lines of Cr^{3+} and the FP resonances observed by local photoluminescence [2]. This study has been carried out both experimentally and with finite-different time-domain (FDTD) simulations. Also, the monoclinic crystal structure of Ga_2O_3 results in an anisotropic refractive index, making it necessary a detailed analysis to fully understand the optical behaviour and its temperature dependence. By ellipsometry, we have obtained our own measurements of temperature dependent refractive index of a bulk monocrystalline β-Ga_2O_3 and discuss the validity with another previous work [3] and by using an interferometry method.

References

[1] S. J. Pearton J. Yang, P. H. Cary IV, F. Ren, J. Kim, M. J. Tadjer, and M. A. Mastro, Appl. Phys. Rev. 5 (2018) 011301.
[2] M. Alonso-Orts, D. Carrasco, J. M. San Juan, M. L. Nó, A. de Andrés, E. Nogales, B. Méndez, Small 18 (2022) 2105355
[3] C. Sturm, R. Schmidt-Grund, V. Zviagin, and M. Grundmann , Appl. Phys. Lett. 111, 082102 (2017)

Figures

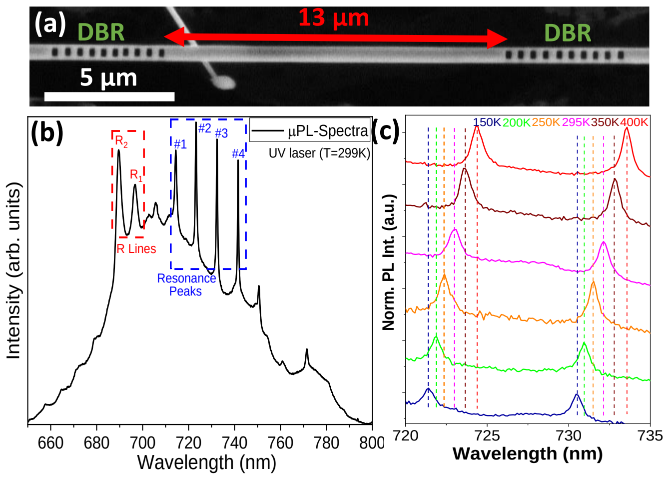

Figure 1: (a) Optical cavity created in a β-Ga_2O_3:Cr nanowire, (b) Room temperature local micro-photoluminescence spectrum, (c) FP peak positions shift with temperature.