Optical cavity modes in luminescent β-Ga_2O_3:Cr nanowires for thermometry

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Gallium oxide is currently attracting great scientific and technological interest, due to several special features, some of them derived from the fact that it is an ultra-wide bandgap semiconductor [1]. Within the area of photonics, applications based on this oxide include solar-blind UV photodetectors and tuneable emitters from the near-UV to the near-IR [1]. Such potential is also being explored in the nano regime. In this work, nanophotonics applications of optical microcavities created within β-Ga_2O_3 nanowires are studied. In particular, they are designed, optimized and characterized [2]. Pairs of distributed Bragg reflectors (DBR) patterned by focused ion beam (FIB) in the waveguiding nanowires, define optical microcavities that result in widely tuneable, strong Fabry-Perot (FP) optical resonances. Experimental results and analytical models, as well as finite-difference time-domain (FDTD) simulations have allowed a thorough discussion of their photonic behaviour. These approaches allow prediction and optimization of the design and performance of the cavities. In the light of the photonic properties deduced from the β-Ga_2O_3:Cr cavities, a novel design of thermometer [3] has been developed. Thermal shifts of the characteristic R-lines of Cr^{3+} ions and the FP resonances observed by local photoluminescence are monitored. These two features result in a wide temperature sensitive range, at least from 150 K up to 550 K, with a precision around 1 K. On the other hand, the full width at half maximum of the FP peaks is nearly constant. The wide dynamic range, high spatial resolution, very high thermal and chemical stability and the fact that this material can be used in harsh environments, make these temperature sensors ideal for high electronic/optical power devices, as well as other possible applications.

References

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Figures

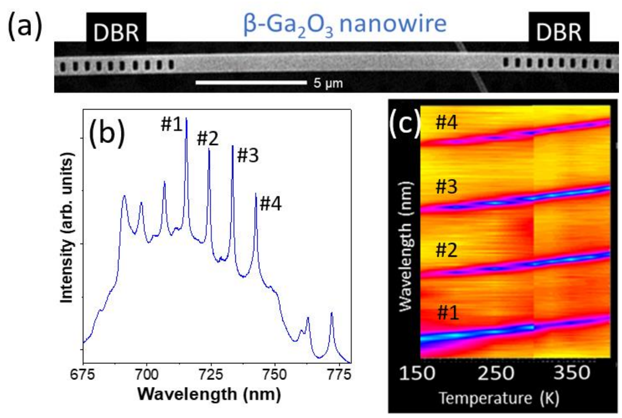

Figure 1: (a) Optical cavity created in a β-Ga_2O_3:Cr nanowire, (b) room temperature local micro-photoluminescence spectrum, (c) FP peak positions dependence on temperature.