Thermometry with optical cavities made of luminescent Ga_2O_3:Cr nanowires

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The ultra-wide bandgap semiconductor gallium oxide is currently attracting great interest, mainly for high power electronics [1]. Photonics applications are being parallelly explored, paying special attention to solar-blind UV photodetector applications and tuneable emitters from the near-UV to the IR [1].
In this work, further applications of β-Ga_2O_3 in the field of nanophotonics are explored by designing, optimizing, characterizing and applying optical microcavities created within nanowires [2]. These cavities are based on pairs of distributed Bragg reflectors (DBR) patterned by focused ion beam (FIB) in the nanowires, which results in widely tuneable Fabry-Perot (FP) optical resonances. A complete analysis of their photonic behaviour has been carried out both experimentally and with analytical models, as well as finite-difference time-domain (FDTD) simulations. These approaches are in good agreement with each other and allow to predict and optimize the design and performance of the cavities.
We have developed a novel design of thermometer based on β-Ga_2O_3:Cr microcavities [3]. Thermal shifts of two different PL features are monitored, namely the characteristic R-lines of Cr^{3+} ions and the FP resonances created within the cavity. Each of the mechanisms is optimum for a different temperature range, allowing to sense at least from 150 K up to 550 K. Precision is around 1 K and the full width at half maximum of the FP peaks is nearly unchanged in the whole temperature range. These temperature sensors present a wide dynamic range, high spatial resolution, very high thermal and chemical stability and can be used in harsh environments, ideal for high electronic/optical power devices, among other applications.

References

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Figures

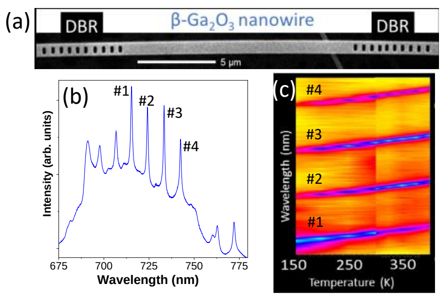

Figure 1: (a) Optical cavity created in a β-Ga_2O_3:Cr nanowire, (b) room temperature local micro-photoluminescence spectrum, (c) FP peak positions dependence on temperature.