Electronic Supplementary Material (ESI) for Nanoscale

- Supplementary Information -

Light-emitting Ga-oxide nanocrystals in glass: a new paradigm for low-cost and robust UV-to-visible solar-blind converters and UV-emitters

Vladimir N. Sigaev*, *Nikita V. Golubev*, *Elena S. Ignat'eva*, *Alberto Paleari* and *Roberto Lorenzi

Department of Materials Science, University of Milano-Bicocca, via Cozzi 53, 20125 Milano (Italy)
Sarkisov International Laboratory of Glass-based Functional Materials, Mendeleev University of Chemical Technology of Russia, Miusskaya Square 9, 125190 Moscow (Russia)

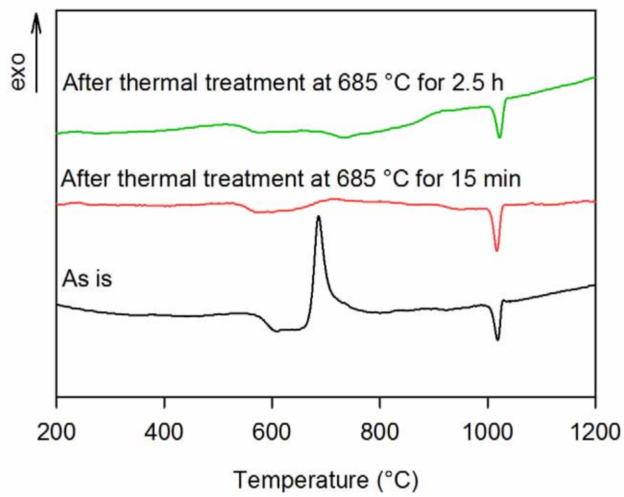

Figure S1. *Differential-scanning-calorimetry data*. Representative DSC curves before and after 15 min treatment and after prolonged treatment of 2.5 hours at the temperature of the exothermic peak of crystallization of the γ-Ga_2O_3 nanophase in 7.5Li_2O-2.5Na_2O-20Ga_2O_3-35GeO_2-35SiO_2 with 0.1 mol% NiO.

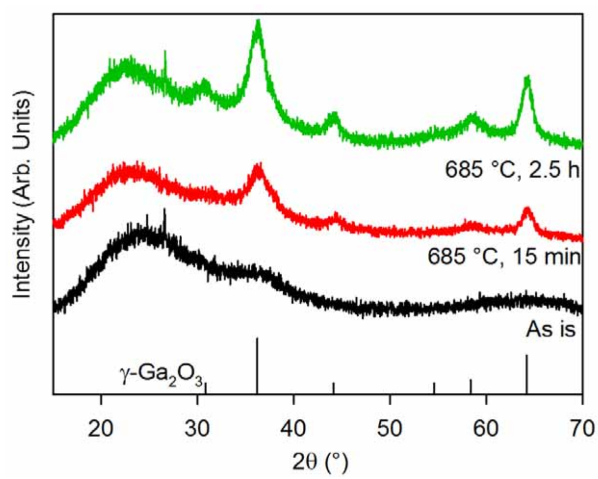

Figure S2. X-ray-diffraction data. Representative XRD patterns before and after 15 min treatment and after prolonged treatment of 2.5 hours at the temperature of the exothermic peak of γ-Ga_2O_3 crystallization in 7.5Li_2O-2.5Na_2O-20Ga_2O_3-35GeO_2-35SiO_2 with 0.1 mol% NiO. Analogous changes are observed in undoped and heavier doped (1 mol% NiO) glass after thermal treatment at the exothermic peak. The pattern of treated material comprises the broad amorphous halo from the glass matrix (with maximum between 20 and 30°) and reflections ascribable to γ-Ga_2O_3 nanocrystals (stick pattern according to JCPDS card No. 20-0426). The narrow weak reflection at about 27° is caused by quartz impurities introduced during sample preparation for XRD analysis using agate mortar.

Electronic Supplementary Material (ESI) for Nanoscale

Estimation of nanocrystal concentration n_{NC} from the mean NC radius R and the nanophase volume fraction f_V.

The volume occupied by all γ-Ga_2O_3 nanocrystals (NCs) s is equal to the mean NC volume $V_{NC}=4\pi R^3/3$ (approximated as a sphere) multiplied by the number N_{NC} of NCs. So, f_V may be written as $N_{NC}V_{NC}/V_{GC}$, where V_{GC} is the total volume occupied by the glassceramic sample. Since the concentration n_{NC} of NCs per unit volume is the ratio N_{NC}/V_{GC} between the total number of NCs in the sample and the total sample volume, we obtain that $n_{NC} = f_V/(4\pi R^3/3)$. On the other hand, the volume fraction f_V is also related to the molar fraction f through the relation $f_V=f(M_{Ga2O3}/M_{GC})(\rho_{GC}/\rho_{Ga2O3})$, where M_{Ga2O3} and M_{GC} are the molar mass (in g/mol) of γ-Ga_2O_3 and glassceramic material, respectively, and ρ_{Ga2O3} and ρ_{GC} the density (in g/cm^3) of nanophase and material. Therefore, n_{NC} may also be estimated from f by using information on molar mass and density of nanophase and material. For instance, taking f=0.2 (supposing 20 mol% of crystallized nanophase in the material), M_{Ga2O3} and M_{GC} 187.5 and 98.9 g/mol, respectively, ρ_{Ga2O3} and ρ_{GC} 6.05 and 3.66 g/cm^3, respectively, and R=3 nm, we have f_V=0.23 and $V_{NC}=1.13\times10^{-19}$ cm^3. Finally, from f_V and V_{NC}, we obtain $n_{NC} = 2\times10^{18}$ cm^{-3}, i.e. 2 million NCs per μm^3. From $(1/n_{NC})^{1/3}$ we can also give a rough estimation of the inter-nanoparticle mean distance, which in this example turns out to be about 8 nm.

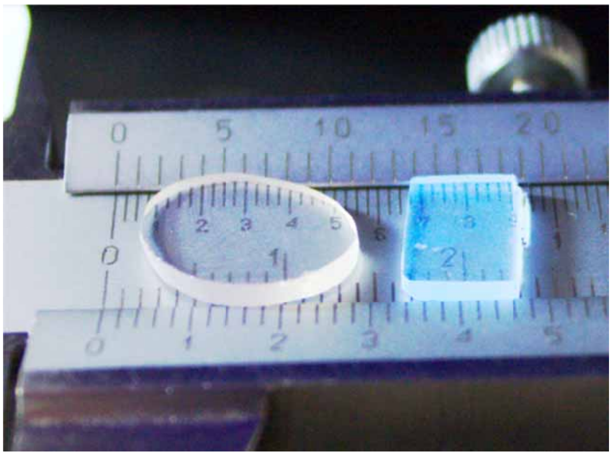

Figure S3. Fluorescence under UV-C illumination. Untreated (left) and treated nanostructured (right) samples of 7.5Li_2O-2.5Na_2O-20Ga_2O_3-35GeO_2-35SiO_2 glass under UV-C illumination of a mercury lamp.

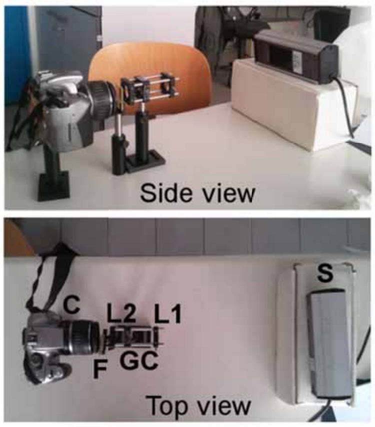

Figure S4. Lab-version of optics for UV-to-visible converter. The adopted experimental set-up to collect images in Figure 7 of the article consists of an UV source (S), a lens (L1) that focuses the image on the glassceramic plate (GC), a second lens (L2) that collects the light coming from the focus in GC, a UV cut-off filter (F) and a digital camera (C).