Experiment MA-2786, ID16

Title: 2D nano patterned luminescence from rare-earth ions coupled to metal nanostructures: a XEOL experiment

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Experimental conditions: 16 keV, 50 nm size x-ray beam. IR detection by an optical fiber.

Samples:

A. Er-doped silica film

B. Er-doped silica film + Au nano hole array (NHA). A SEM image of the sample is shown in Figure 1.

C. Er-Au co-doped silica film + Au NHA. In this case the emission of Er ions is sensitized by Au sub nanometer clusters. In this way the excitation occurs over a broad energy range.

D. Er-doped glass, to be used as standard reference.

Report

The 1.54 μm emission of Er^{3+} ions in a silica layer can be efficiently coupled with the optical properties of a Au film where a 2D array of nano holes are drilled. In this case the Er emission is not spatially uniform, but is instead 2D-patterned. A spatial resolution better than 100 mm is needed to observe the patterning. This modulation of the Er emission (lifetime) is deduced by simulations, while it is not experimentally observed yet.

The aim of the experiment was to study the 2D patterning of the Er emission when coupled with a 2D array of nano holes.

The x-ray beam (energy of 16 keV) was stable and with lateral size of about 50 nm. The setup to collect the infrared luminescence was completely misaligned at the beginning of the experiment, the optical fiber was broken. After several test to realize it, we started from the very beginning the alignment procedure, first with a detection apparatus for visible light, then with the apparatus for the IR emission. In this way, we could record a XEOL signal from Er^{3+} ions. It is reported in Figure 2 and compared to the standard photoluminescence signal

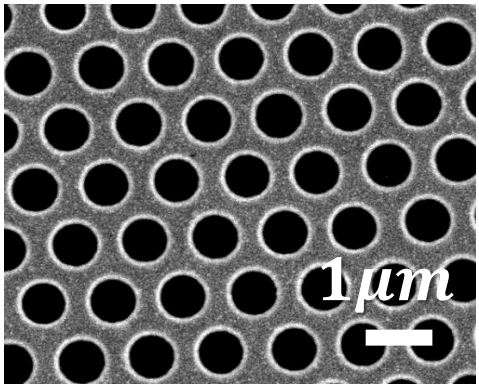

Figure 1. SEM image of the Nano hole array, drilled on a Au film. Below the array, a Er-doped silica layer is present.

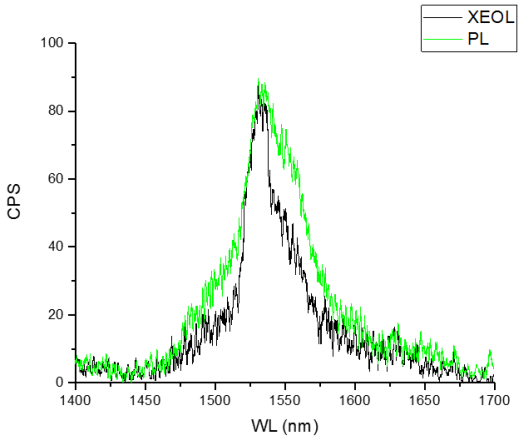

Figure 2. Er emission spectrum around 1.54 um of Er^{3+}-doped glass, upon excitaton either by 488 nm light (green) or by 14 keV x-rays.

recorded from the same sample. The signal intensity from the reference sample was so low, that there was no way to hope to get any XEOL signal from the other samples. We guessed that the only way to possibly measure some XEOL signal was a) to improve the detection efficiency; b) to work at low temperature and c) to use sample 'C', where Au clusters absorb x-rays and transfer part of the absorbed energy to Er ions: the cross section of the Er emission process in this case is 2-3 orders of magnitude with respect to the case without Au clusters.

Since a) was not feasible during the beamtime, we tried b) and c). So, we used the He cryostat available at the beamline. Unfortunately, the cryostat is not well designed to be used to collect the XEOL signal: when the sample is in the cryostat, we found that there was no way to properly align the fiber to collect the light from the region of the sample shined by the x-rays. So, at the end also this test failed.

Maybe the beamline setup (XEOL acquisition apparatus) can suitably work with samples whose XEOL signal is very intense. Certainly, it was never tested with low emitting systems, where a careful alignment is mandatory to collect a signal.