

## Supporting Information

### Photoluminescence and Stoichiometry Correlation in Nanocrystalline EuO<sub>x</sub> Thin Films: Tunable Colour Emission

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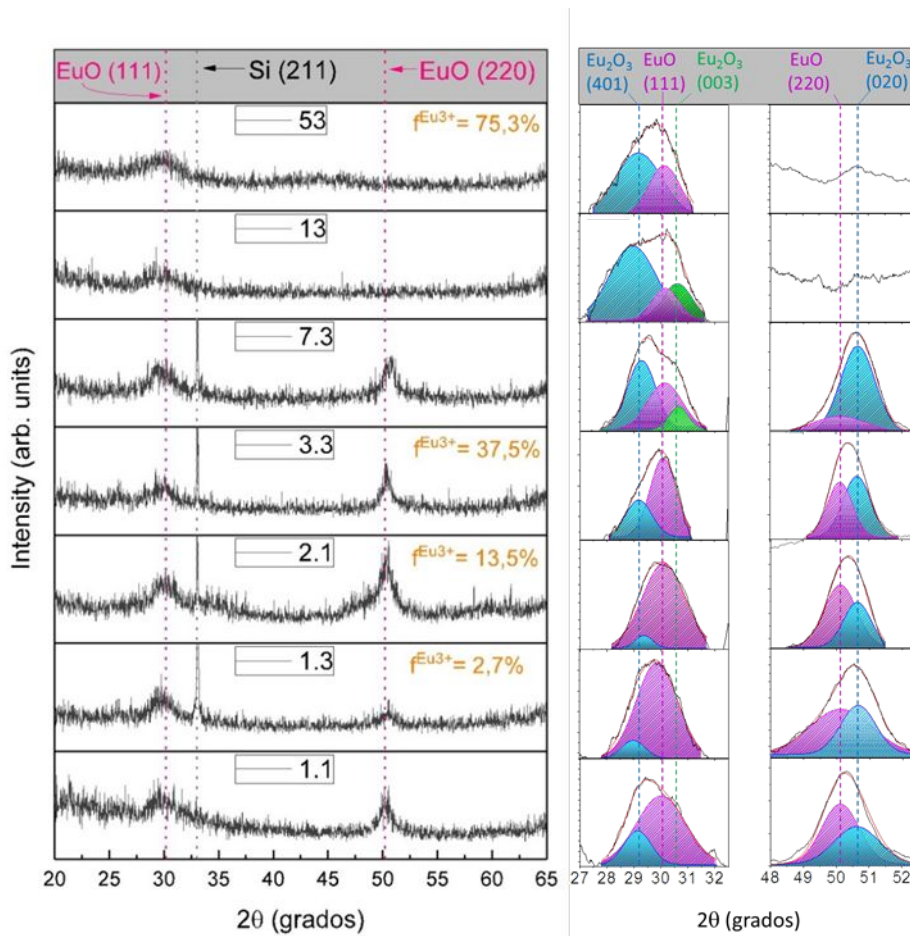
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#### S-1. XRD characterization.

In Figure S1, the XRD measurements as a function of the base pressure for films 1.1, 1.3, 2.1, 3.3, 7.3, 13 and 53 ( $\cdot 10^{-7}$  mbar) are shown. The XRD spectra show broad peaks corresponding with EuO nanocrystals with crystalline planes (111) y (220). The peak centered at  $33^\circ$  that appears in some spectra corresponds to the Silicon substrate. Looking more closely at the deconvolutions obtained for the spectra in the range from  $27^\circ$  to  $33^\circ$ , it can be seen that the EuO peak corresponding to the plane (111) is present in all the spectra. However, for films 7.3, 13 and 53, a peak associated with the Eu<sub>2</sub>O<sub>3</sub> (401) crystalline plane is resolved. In addition, for films 7.3 and 13 there is a small contribution from the Eu<sub>2</sub>O<sub>3</sub> (003) crystalline plane. All these contributions from the Eu<sub>2</sub>O<sub>3</sub> belong to the monoclinic phase. In addition, it is noted that the (111) EuO contribution increases to a maximum value for the film of 1.3. This result was corroborated by the XPS analyses where it is observed that for films grown at lower pressure, the europium content in the 2+ oxidation state increases. Analyzing the spectra for the peak corresponding to the plane (220) of the EuO it is find the more significant

differences. One of the most striking results is that the (220) EuO crystalline plane is not observed for the films 13 and 53, but yes for the films 1.1, 2.1, 3.3 and 7.3. In other words, it is not found any contributions of EuO nanocrystals at (220) when a high base pressure ( $> 7.3 \times 10^{-7}$  mbar) in the growth chamber is used. These results also correspond to those found by the deconvolutions and by the XPS where it is observed that the  $\text{Eu}^{3+}$  relative percentage fraction is bigger for films deposited at higher pressures. Conventionally, the growth of EuO nanocrystals is accomplished by raising the substrate temperature up to 350 °C for both MBE and PLD.<sup>1,2</sup> On the other hand, in this work we achieved the growth of EuO nanocrystals at room temperature.



**Figure S1:** XRD spectra for films 1.1, 1.3, 2.1, 3.3, 7.3, 13 and 53. Dotted lines identify the crystalline planes of the EuO and  $\text{Eu}_2\text{O}_3$  present in thin films. In orange the  $\text{Eu}^{3+}$  relative percentage fraction obtained by means of XPS analysis are represented. On the right-hand side of the screen the deconvolutions obtained for the region 27°-33° and 48°-53° are shown. The peak at 33° corresponds to the orientation (211) of the Silicon substrate.

To obtain quantitative data of the EuO nanocrystals the (220) peak has been adjusted by means of a Gaussian function. For the calculations, the instrumental widening contribution was discounted taking in consideration the broadening obtained for the (211) monocrystalline Silicon peak. The peak centered in  $50.5^\circ$  is a combination of the (220) EuO and (020)  $\text{Eu}_2\text{O}_3$  crystalline planes as it is showed in the XRD analysis. Therefore, this shift is related to a tensile stress. The presence of compressing and tensile stresses upon the deposition of films with different composition has been discussed in several works (see review and others),<sup>3,4</sup> and has recently attracted great interest for other magnetic oxides like magnetite ( $\text{Fe}_3\text{O}_4$ ).<sup>5</sup> Moreover, the effect of stress is particularly relevant in the case of Europium oxides since we have shown that the influence of stress can induce the stabilization of thermodynamically unfavored phases of  $\text{Eu}_2\text{O}_3$ .<sup>6</sup> In this work it is observed that the (220) XRD peak position in average shifts to higher diffraction angles when increasing the base pressure in the growth chamber. This displacement corresponds to an increasingly reduced out-of-plane lattice constant compared to the films grown at lower base pressures, and therefore it is related to a tensile strain. When films are under tensile strain the in-plane lattice constant stretches, while the out-of-plane lattice constant shrinks. The origin of the in plane tensile strain in our case is the oxygen incorporation during film growth as demonstrated by the XPS analysis. This tensile strain upon oxygen incorporation during growth has been reported for other oxides, and in particular for oxides grown by PLD.<sup>7</sup> The observation of tensile strain due to oxygen incorporation during growth is contrast to the incorporation of oxygen by post deposition oxidation that usually leads to a compressive strain,<sup>6</sup> or to strain relief with substantially more homogenous internal strain fields.

## References

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