

Europium-doped Cerium Oxide Nanotubes as a potential probe for bioimaging and optical sensors

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I. Introduction

Cerium oxide (CeO_2) nanostructures are versatile materials with regenerative and catalytic properties. They have applications in biomedical therapies, drug delivery, and as industrial agents. Doping CeO_2 nanoparticles with rare earth elements adds visible fluorescence to the properties of these nanostructures. To explore this application, Eu^{3+} doped CeO_2 nanotubes were synthesized at various Eu^{3+} concentrations and analyzed for their optical properties, crystalline structure, and morphology. The desired characteristic fluorescence of the nanotubes enables their use in bioimaging and as optical sensors.

II. Experimental

A. Synthesis of EuCeO_2 Nanotubes

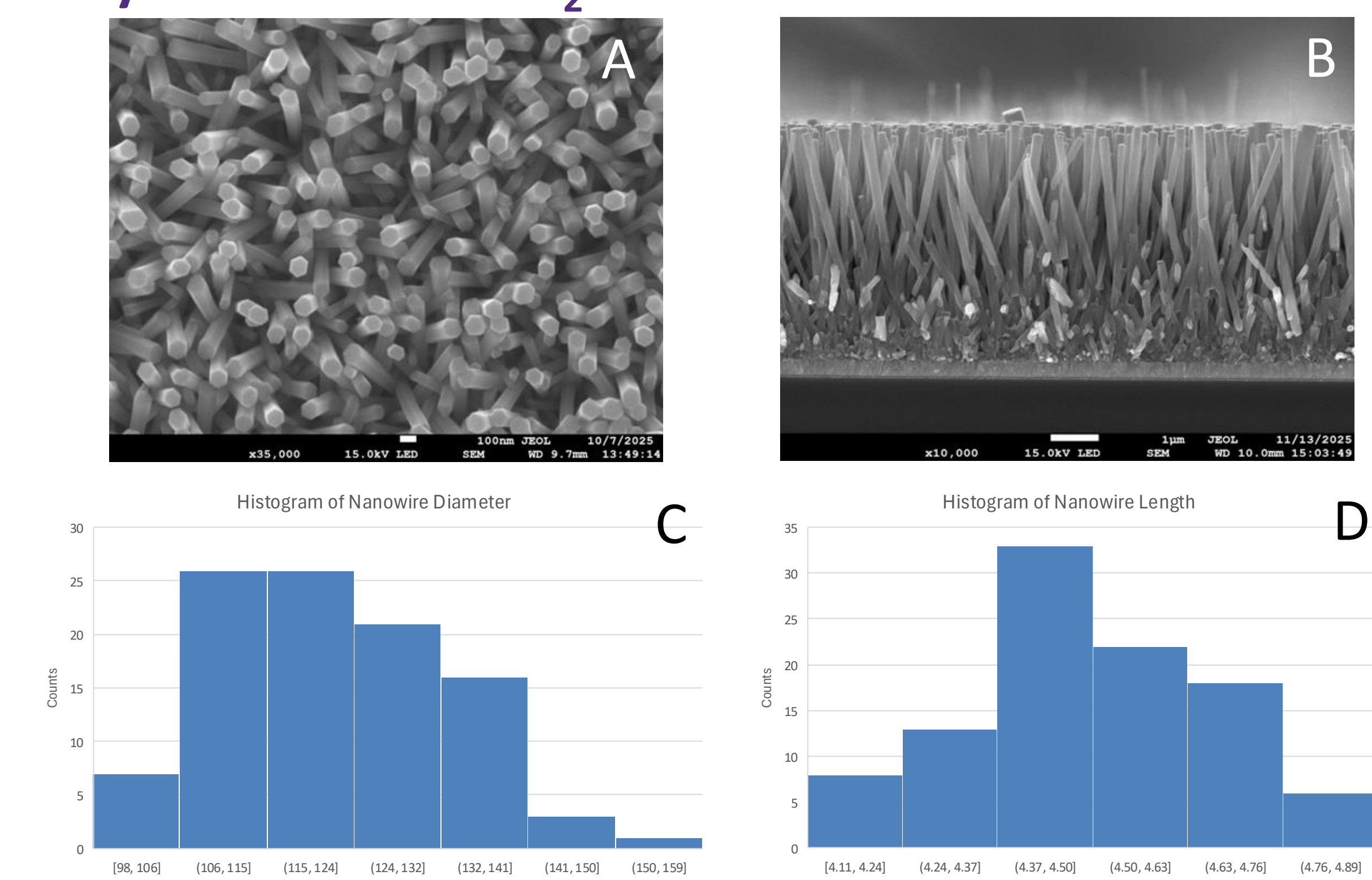


Fig 1. (A) SEM image of ZnO NWs on fluorine-doped tin oxide (FTO) substrate; scale bar 100 nm. (B) SEM image cross-section of ZnO NWs on FTO substrate; scale bar 1 μm . (C) Histogram of ZnO NW diameter (in nm). (D) Histogram of ZnO NW length (in μm).

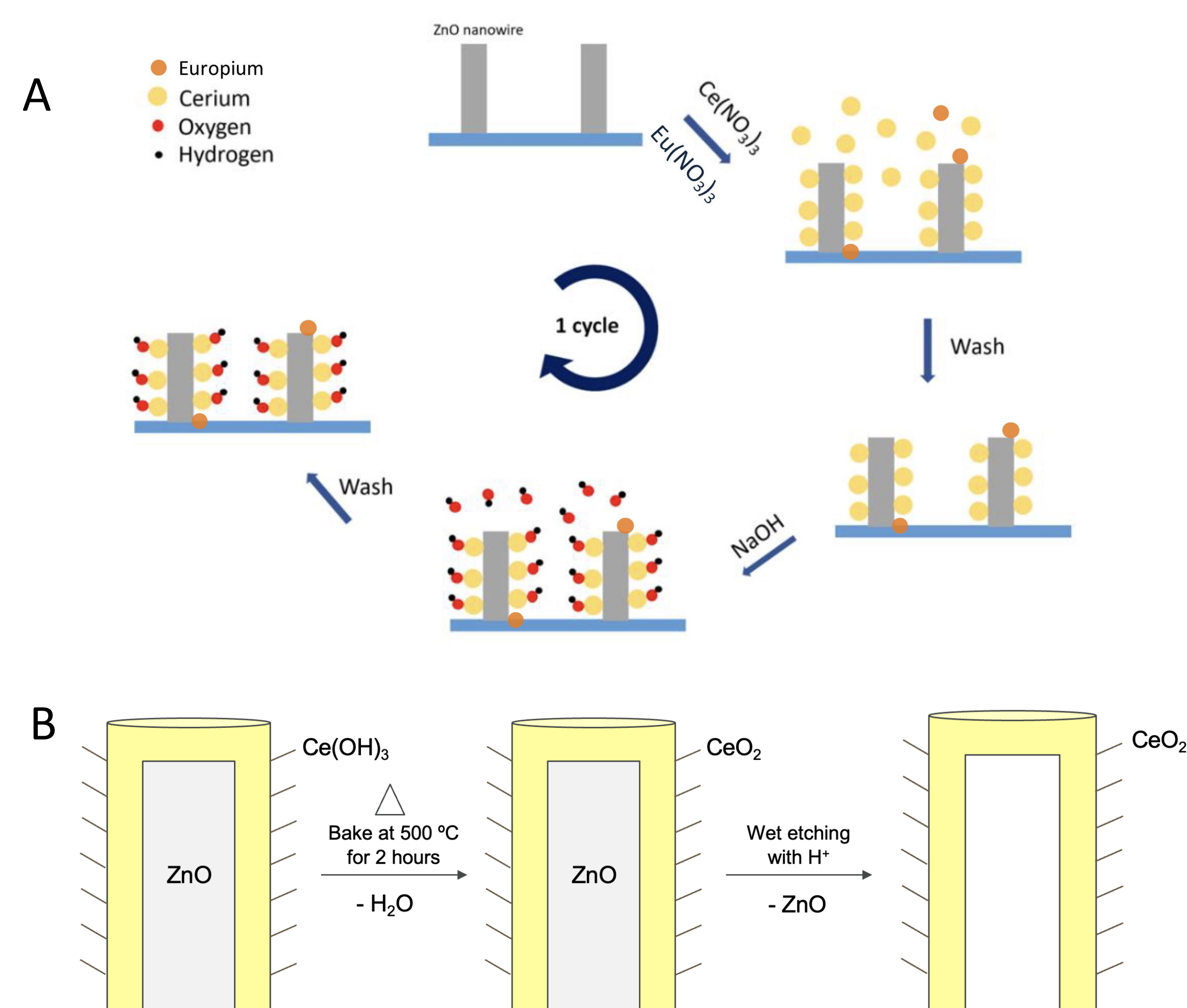


Fig 2. (A) Cycling deposition method of the Eu^{3+} doped CeO_2 nanotubes using the spin coater. (B) Sketch of the sample before & after baking and before & after etching.

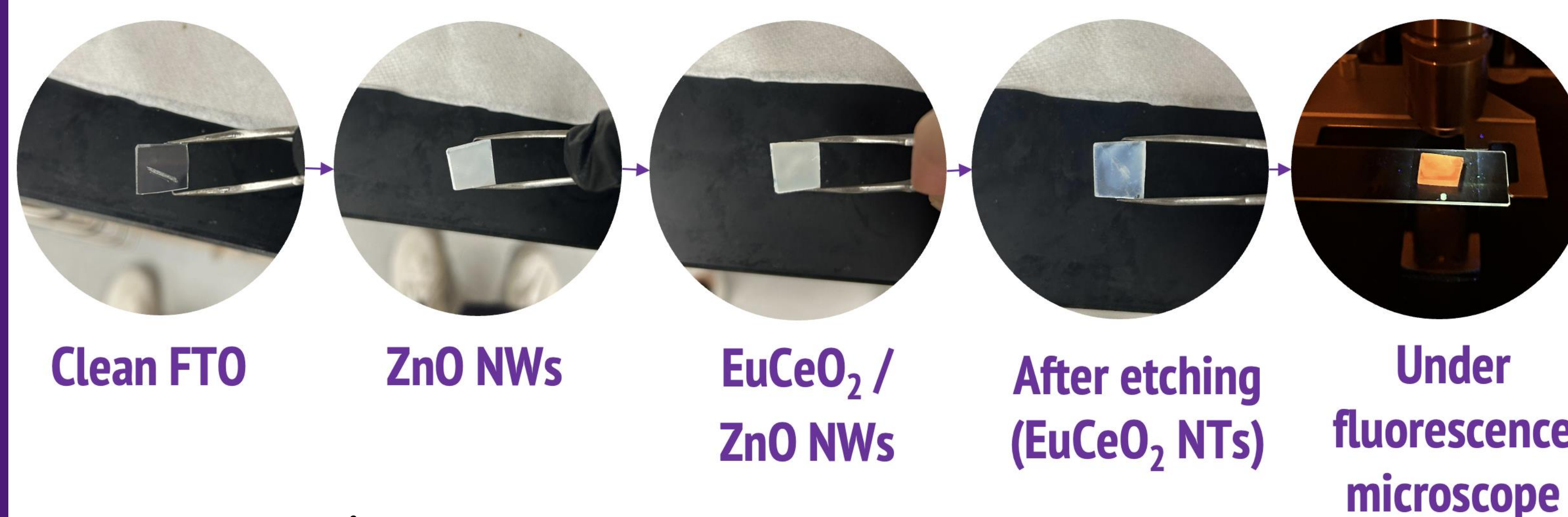


Fig 3. Visual of the Eu^{3+} doped CeO_2 nanotube synthesis process.

B. Imaging of EuCeO_2 Nanotubes

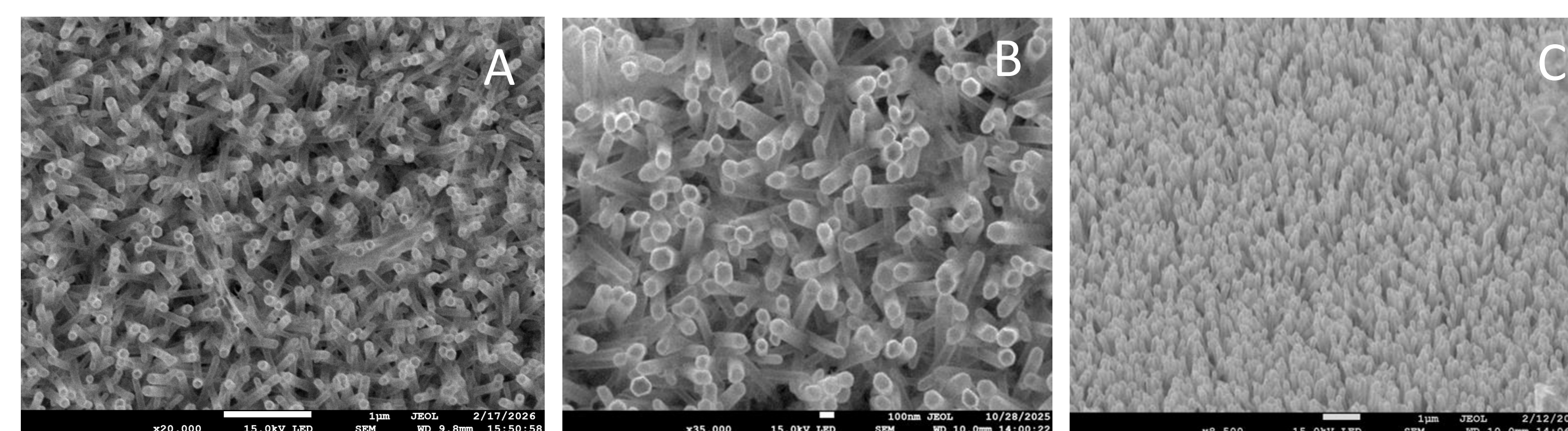


Fig 4. (A) SEM image of 10% Eu^{3+} doped CeO_2 nanotubes; scale bar 1 μm . (B) SEM image of 10% Eu^{3+} doped CeO_2 nanotubes; scale bar 100 nm. (C) Angled view SEM image of 10% Eu^{3+} doped CeO_2 nanotubes; scale bar 1 μm .

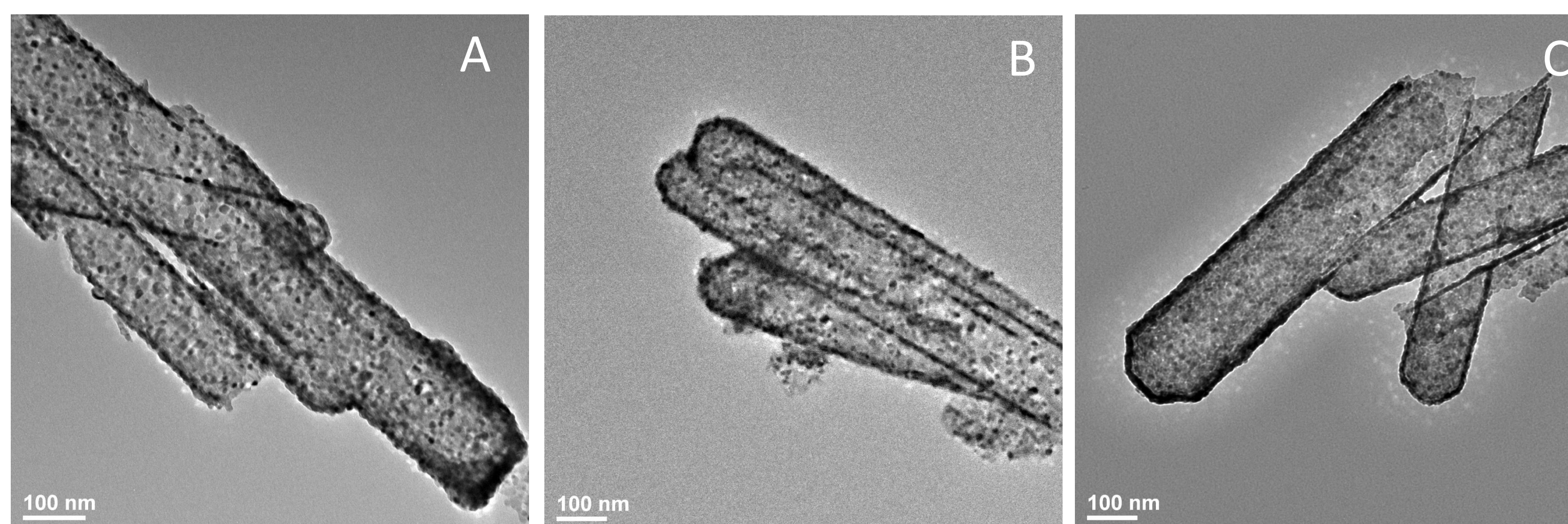


Fig 5. (A) TEM image of 5% Eu^{3+} doped CeO_2 nanotubes; scale bar 100 nm. (B) TEM image of 10% Eu^{3+} doped CeO_2 nanotubes; scale bar 100 nm. (C) TEM image of 15% Eu^{3+} doped CeO_2 nanotubes; scale bar 100 nm.

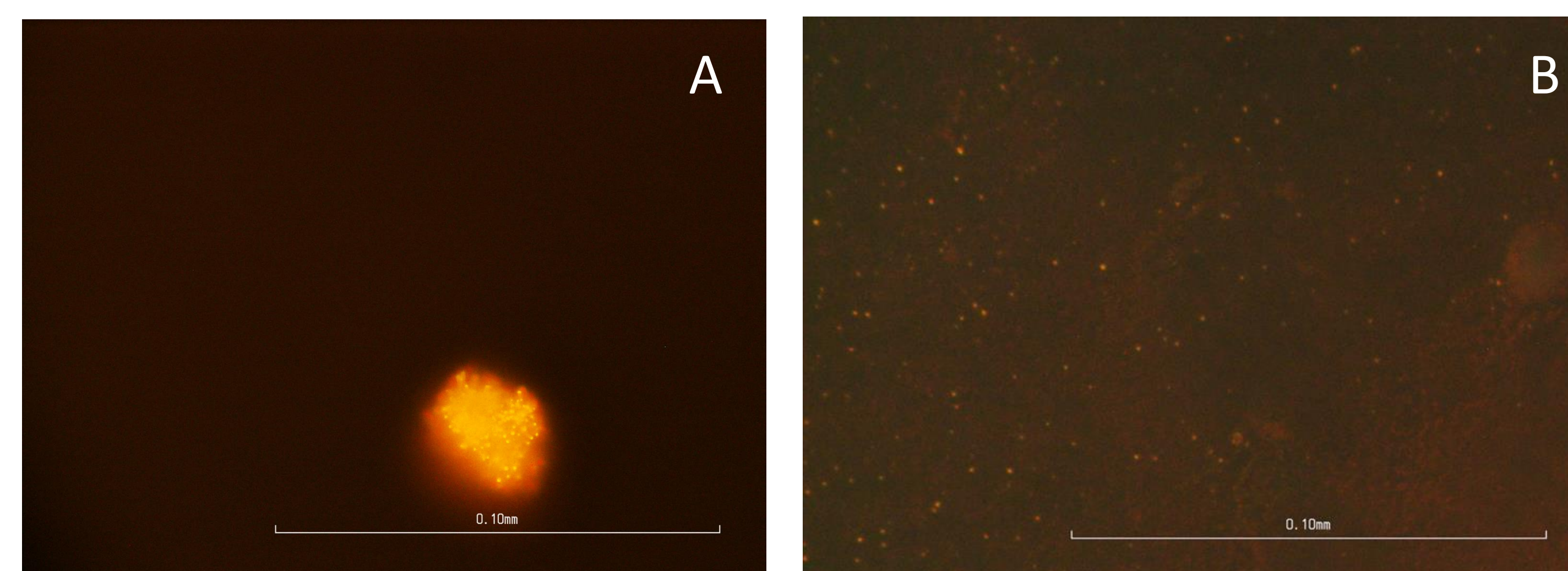


Fig 6. (A) Fluorescence image of 15% Eu^{3+} doped CeO_2 nanotube cluster before etching; scale bar 0.10 mm. (B) Fluorescence image of 15% Eu^{3+} doped CeO_2 nanotubes after etching; scale bar 0.10 mm.

III. Results

A. Photoluminescence (PL) spectra

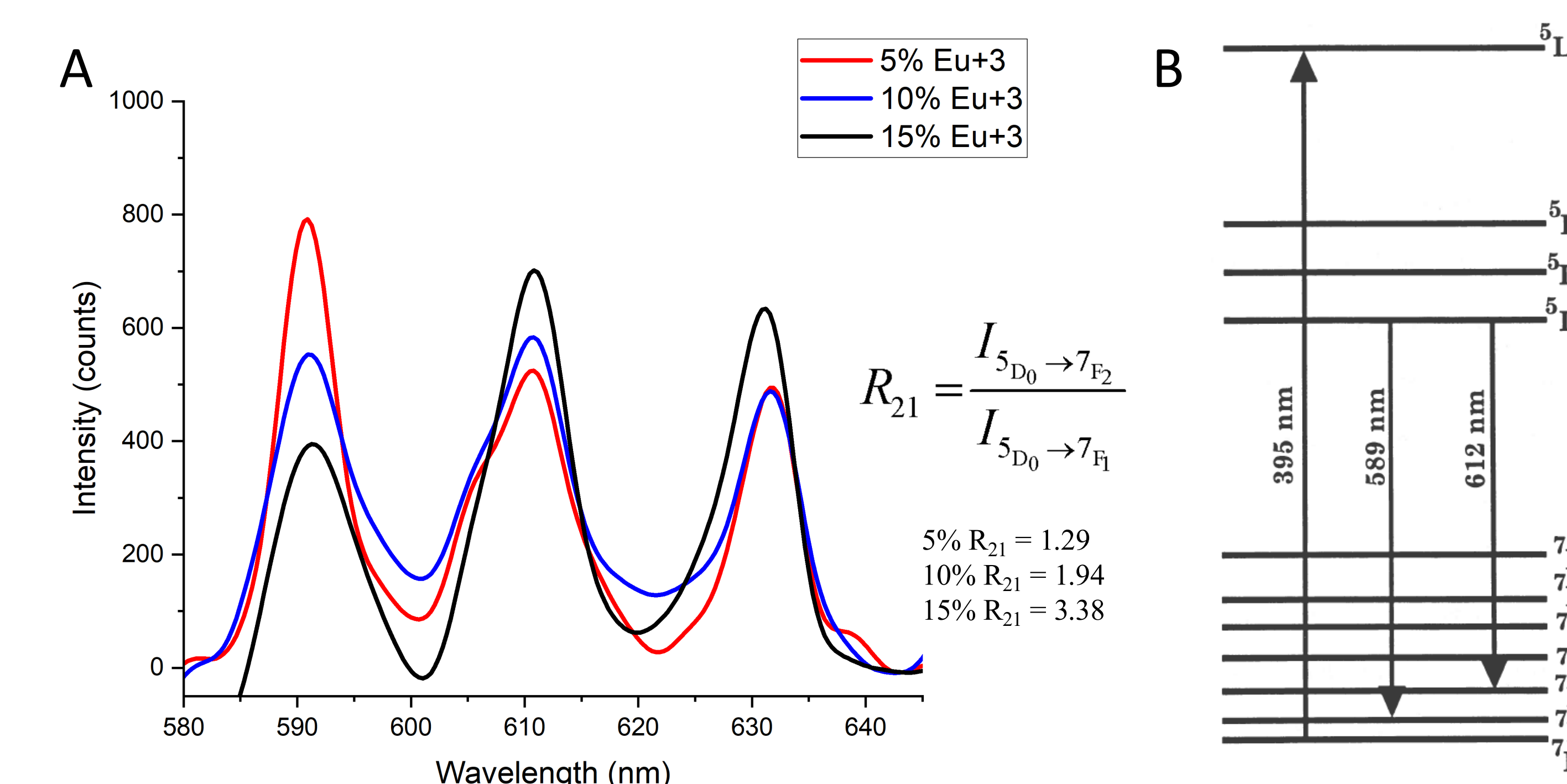


Fig 7. (A) Photoluminescence (PL) spectra of the EuCeO_2 NTs at 5%, 10%, and 15% of Eu^{3+} ; 500 ms acquisition time, 60x lens. (B) Energy diagram of Eu^{3+} emission and fluorescence.

B. X-ray diffraction (XRD) spectra

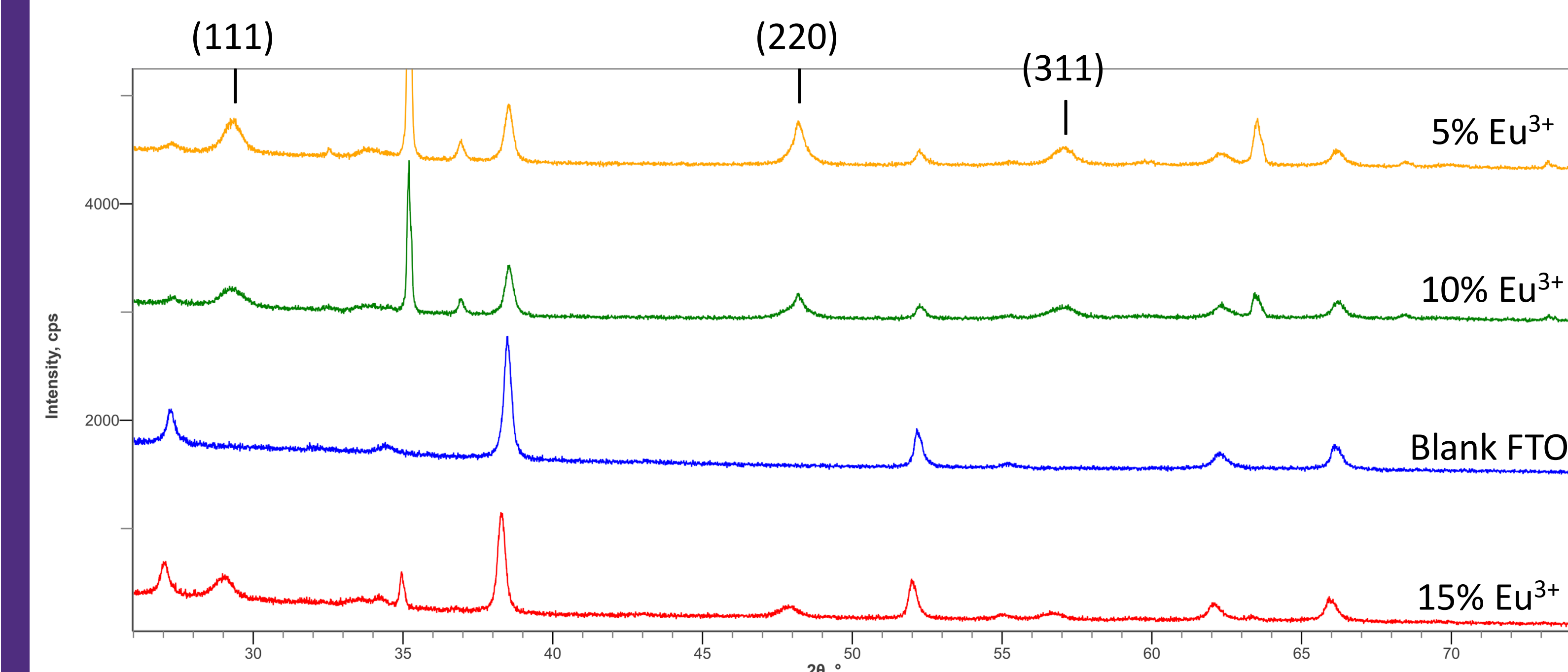


Fig 8. XRD Spectra of EuCeO_2 NTs at 5%, 10%, and 15% of Eu^{3+} compared to blank FTO.

IV. Conclusions and Future Work

- As the concentration of Eu^{3+} in the CeO_2 nanotubes increases, the asymmetry ratio also increases.
- The XRD peaks for 5%, 10%, and 15% Eu^{3+} doped CeO_2 nanotubes occur at similar places, yet the intensity differs due to sample preparation.
- Analyze a greater variety of Eu^{3+} dopant concentrations of CeO_2 nanotubes with XRD, such as 0% and 20%.
- Experiment with different numbers of Eu/Ce cycles and analyze how that affects wall thickness and therefore fluorescence.

V. References

- D'Achille A. E.; Wallace R. M.; Coffey J. L. Morphology-dependent fluorescence of europium-doped cerium oxide nanomaterials. *Nanoscale Adv.* **2021**, (12), 3563-3572.
- Gonzalez-Rodriguez R.; Hathaway E.; Coffey J. L.; Lin Y.; Cui J. Fabrication of 1D-Confined MAPbI₃ in cerium oxide nanotubes for nanowire solar cells. *ACS Applied Nano Materials* **2026**, 9(10), 4482-4812.

VI. Acknowledgments

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