

Luminescence properties of Cr⁴⁺:YAG nanocrystals



Beata Barszcz*, Weronika Bodylska-Maj, Mykhailo Chaika

Institute of Low Temperature and Structure Research PAN, Okolna 2, Wrocław 50-422, Poland



The problem and results

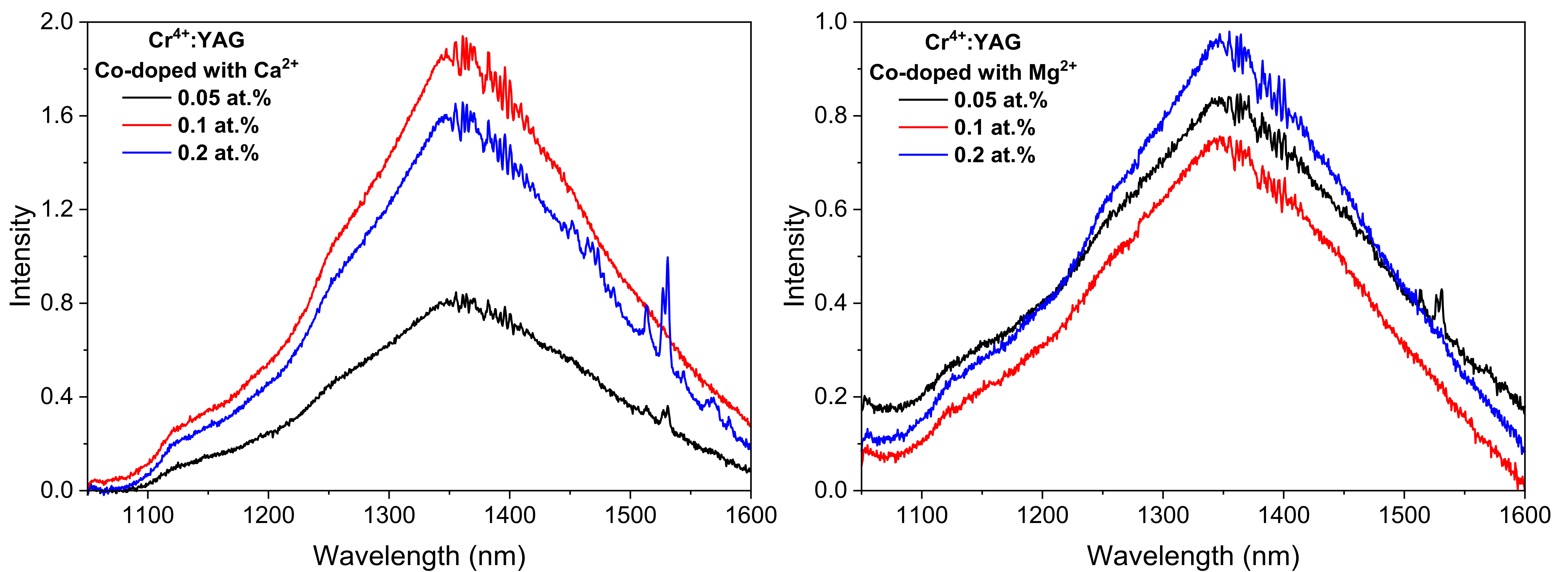
Cr⁴⁺-doped Y₃Al₅O₁₂ is used as a CW laser that operates from 1.2 μm to 1.7 μm or as saturable absorbers for NIR lasers operating from 0.7 μm to 1.1 μm [1]. The YAG crystal is cubic (space group Ia3d), with eight formula units in a unit cell. Its general structure can be written as [C₃][A₂][D₃]O₁₂, where “C,” “A,” and “D” denote cation sites in dodecahedral, octahedral, and tetrahedral coordination positions. The “A” and “D” sites are occupied by the Al³⁺ ions, while the Y ions occupy the “C” site [2]. As a single dopant, Cr is incorporated into YAG as a trivalent Cr³⁺ in the “A” site. Cr³⁺ to Cr⁴⁺ ion valence transformation requires co-doping with divalent ions such as Ca²⁺ or/and Mg²⁺ in the YAG lattice [1]. Cr⁴⁺ ion formation occurs in both octahedral and tetrahedral sites, where the latter is responsible for laser properties.

Cr⁴⁺:YAG is typically produced in the form of single crystals, transparent ceramics, or epitaxial films. In contrast, Cr⁴⁺:YAG nanopowders have received comparatively little attention. In this work, Cr⁴⁺:YAG nanopowders were synthesized via the Pechini process at 900 °C. Structural and morphological analyses (XRD, TEM) confirmed the formation of nanocrystalline YAG. The recorded emission spectra were consistent with Cr⁴⁺ emissions in the garnet host. No significant difference in the emission spectral shape was detected between Ca²⁺ - and Mg²⁺ - co-doped samples. In some samples, emission lines attributed to Er³⁺ were also observed, which may originate from trace impurities in the yttrium precursor.

References

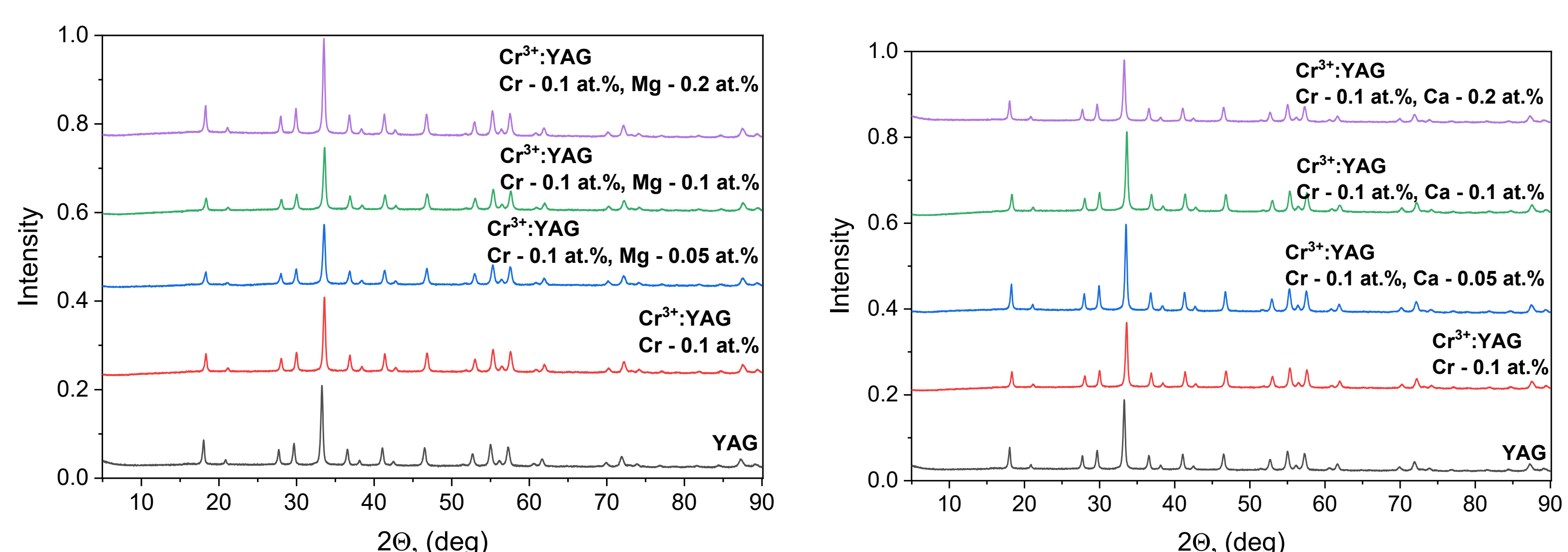
1. Chaika, M. (2026). J. Am. Ceram. Soc., 109(2), e70553.
2. Chaika, M., Tomala, R., Strek, W., et al. J. Chem. Phys., 151(13).

Emission spectra



Cr⁴⁺:YAG emission spectra collected at $\lambda_{\text{exc}} = 980$ nm and T = 295 K.

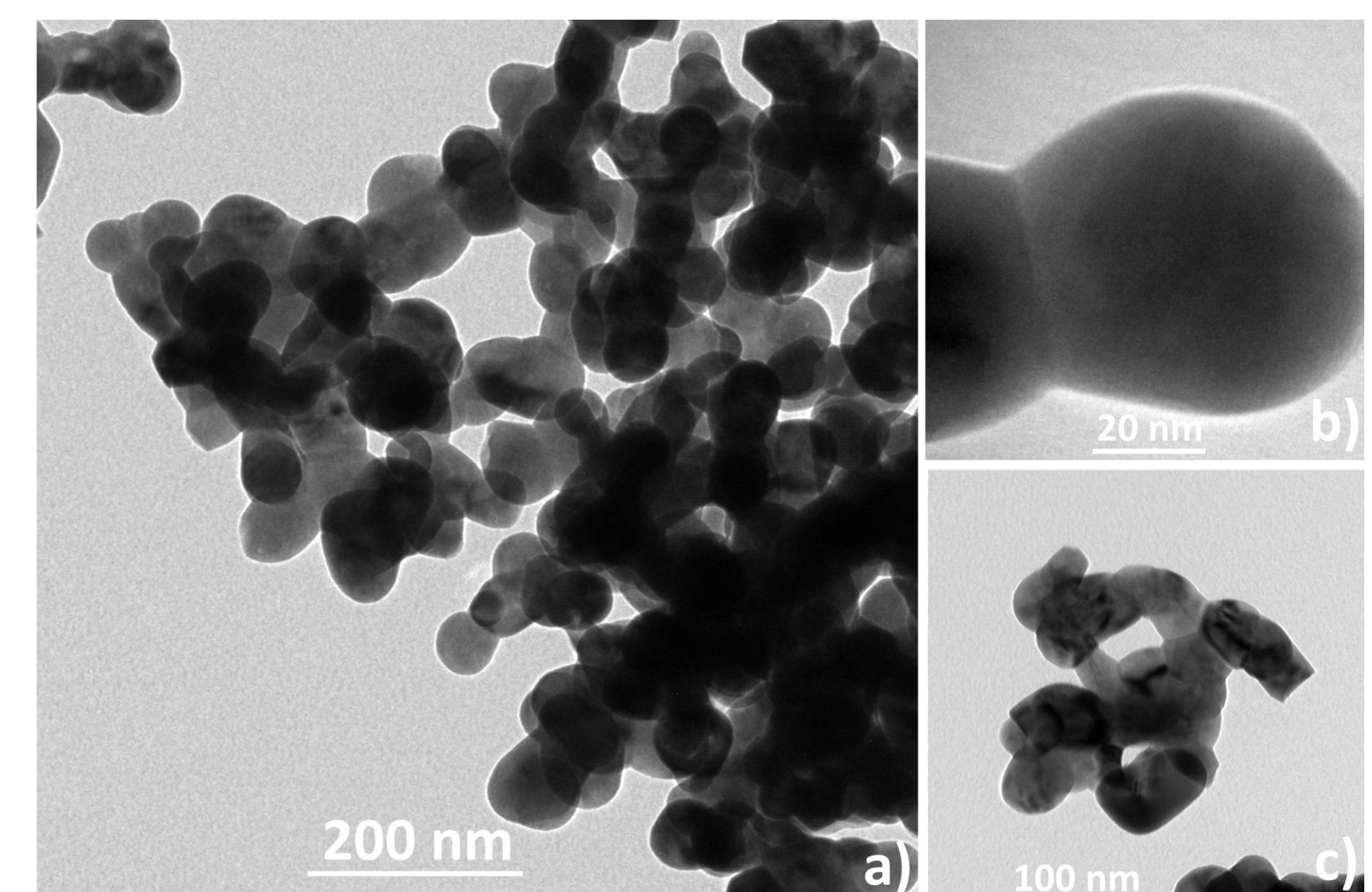
XRD



XRD diffraction pattern of Cr⁴⁺:Y₃Al₅O₁₂ co-doped with Mg²⁺ ions

XRD diffraction pattern of Cr⁴⁺:Y₃Al₅O₁₂ co-doped with Ca²⁺ ions

TEM



TEM image of Cr⁴⁺:Y₃Al₅O₁₂ nanocrystals