Effect of Synthesis Temperature on the Structural and Luminescent Properties of Cr $^{3+}$ Doped Al_2O_3 Phosphors

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Abstract

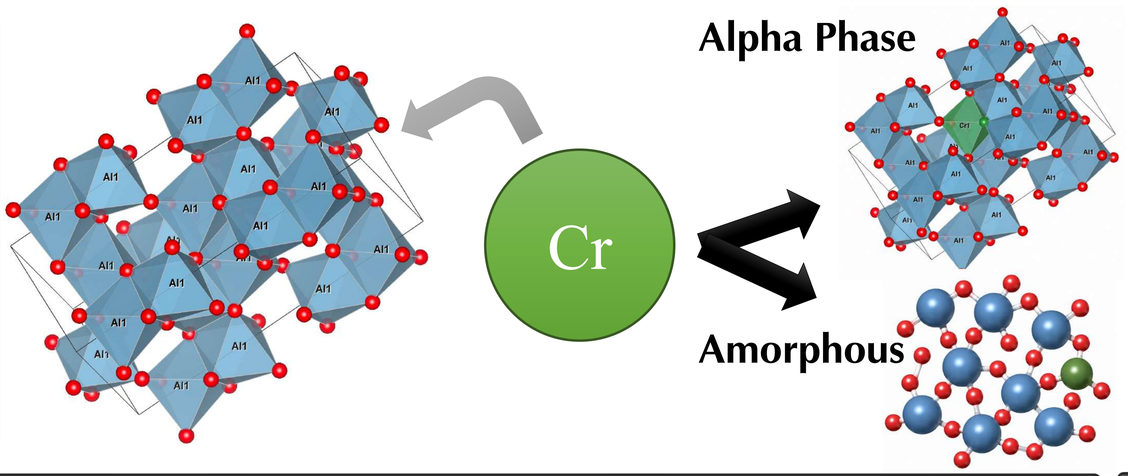
Cr $^{3+}$ doped Al_2O_3 is a promising luminescent material because of its high chemical stability and strong optical emission. In this study, its potential application is extended toward **functional textiles**, where luminescent particles are intended to be incorporated into the fiber-forming process rather than simply deposited on the textile surface. For such applications, **reducing the particle size to the nanoscale is particularly important**, as smaller particles can provide better dispersion, stronger interfacial interaction, and more uniform incorporation within textile materials.

However, reducing the particle size introduces a critical challenge. The stable **α-Al_2O_3 phase**, which generally exhibits favorable luminescent properties after Cr $^{3+}$ incorporation, is typically promoted by high-temperature treatment. Such thermal treatment may simultaneously induce crystallite growth and particle agglomeration, compromising the nanoscale characteristics required for textile applications. In contrast, lower synthesis temperatures may better preserve the nanoscale structure but result in metastable Al_2O_3 phases and weaker luminescence.

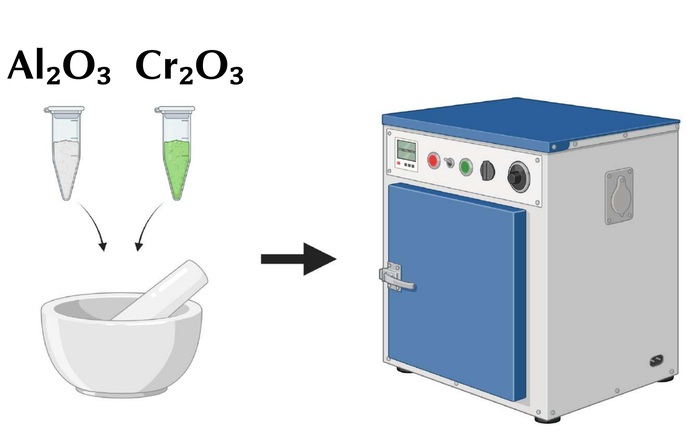
Therefore, this study investigates the **temperature-dependent structural and luminescent evolution of Cr $^{3+}$ doped nanoscale Al_2O_3**, with particular emphasis on determining whether sufficient luminescence can be achieved **before complete transformation into the α phase**. By correlating phase evolution and crystallite growth obtained from XRD with photoluminescence behavior, an optimal synthesis condition that balances **small particle size and luminescent performance** is explored.

Phosphors

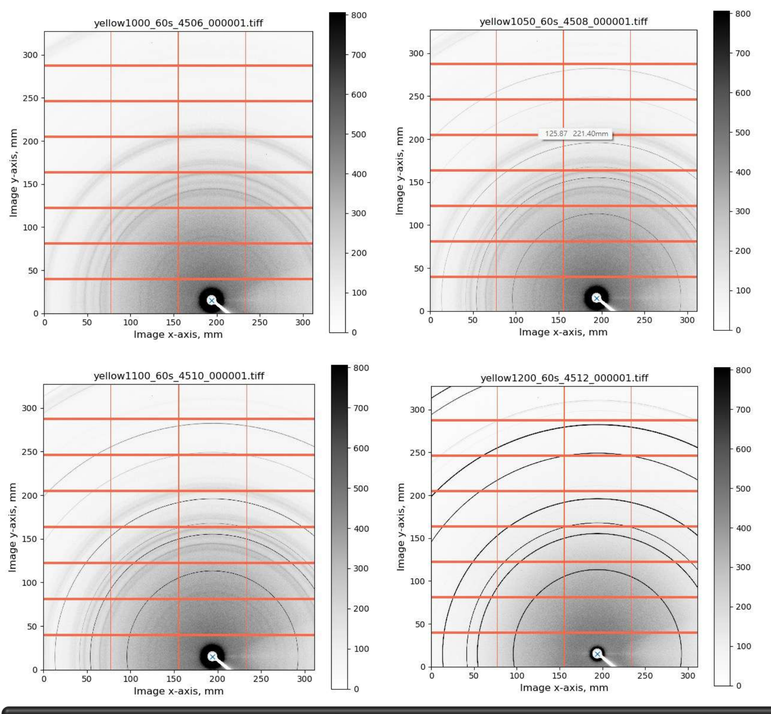
Introduction

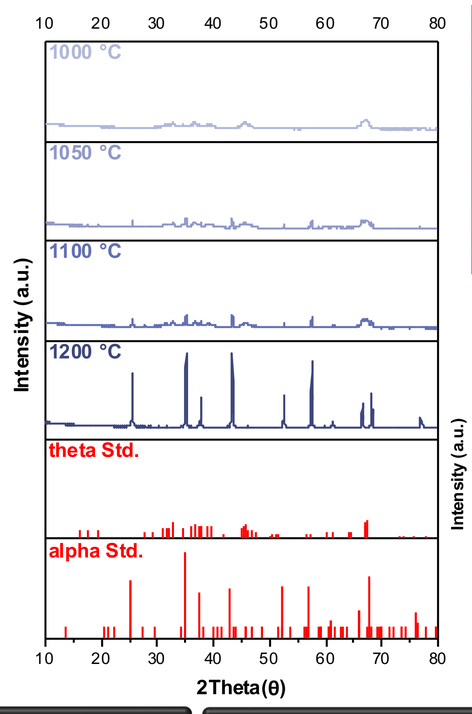


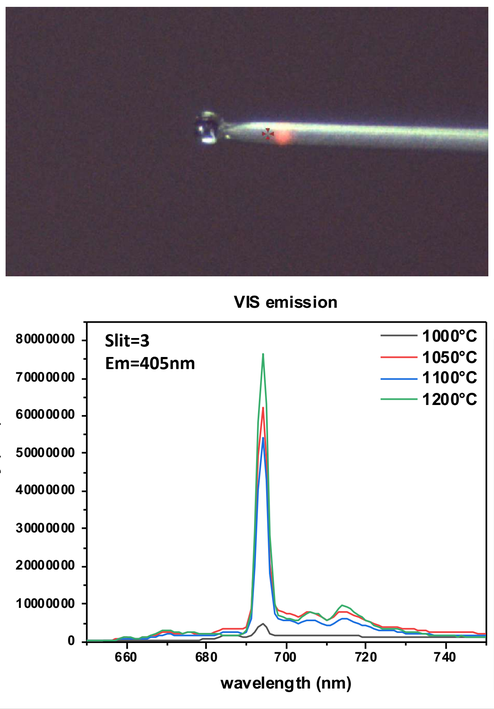
Methodology



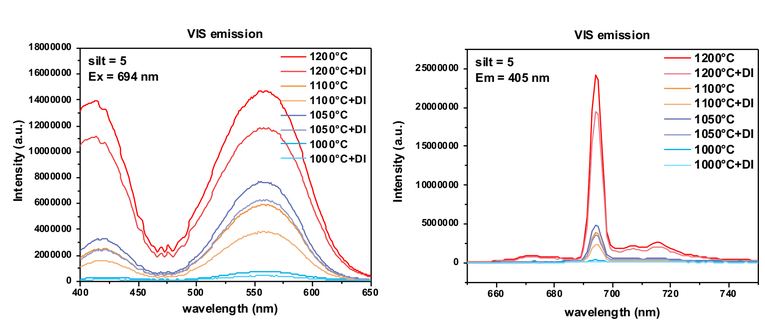
Different Temperature Analyses





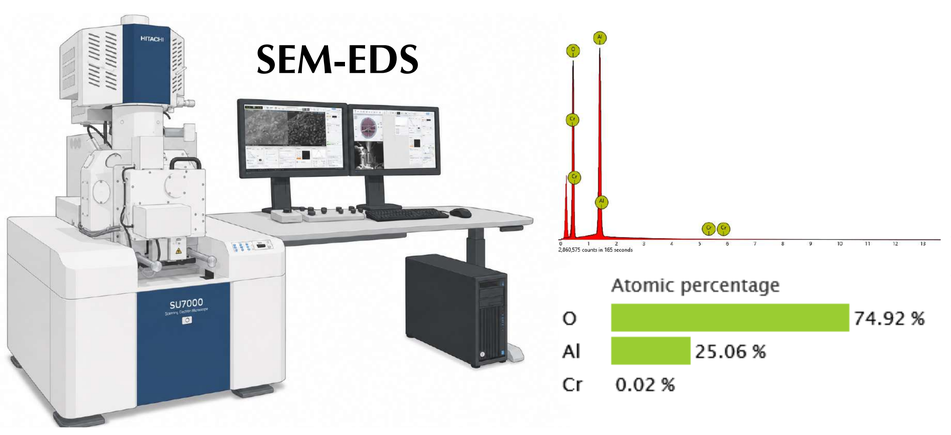


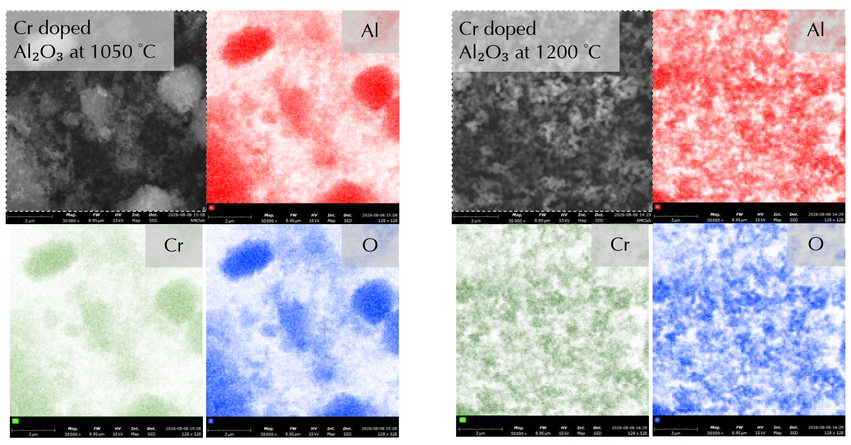
Drop to water



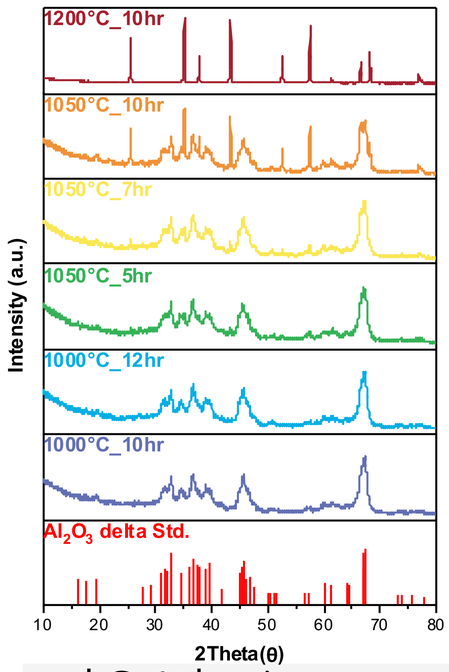
Water-immersion experiments revealed that the **luminescence intensity decreased for all samples** after exposure to water, regardless of synthesis temperature.The decrease in PL intensity after water immersion is mainly attributed to optical and surface-related effects rather than structural degradation.

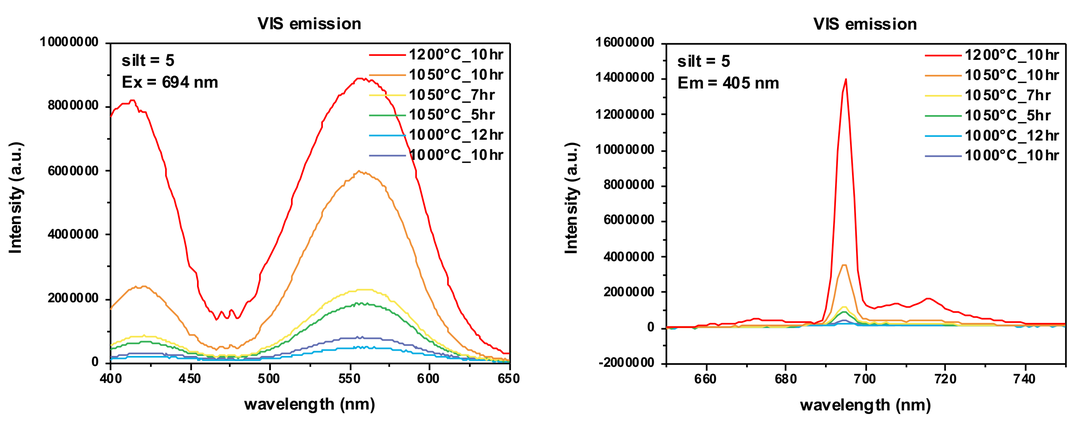
Surface Morphology and Elemental Analyses





Different Time Analyses





Conclusion

A pronounced enhancement in PL intensity was observed once **α-Al_2O_3 peaks emerged in the XRD patterns**, demonstrating a strong correlation between α-phase formation and Cr $^{3+}$ luminescence. Among the investigated conditions, **1050 ˚C for 10 h** provided the best balance between phase evolution and luminescent performance. For samples without detectable α-phase formation, **1050 ˚C for 7 h** exhibited the highest PL intensity; however, its emission remained only about **10% of that of the fully α-phase 1200 ˚C sample**, indicating that substantial luminescence is strongly dependent on the formation of α-Al_2O_3.

References: Zhu, Y.-L. et al., IOP Conf. Ser.: Mater. Sci. Eng. 382, 022037 (2018).