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TECHNICAL PAPER

Fe_2O_3/La_2O_3 nanocomposite thick film sensor for low-temperature NO_2 detection and visible-light photocatalysis

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Abstract

A Fe_2O_3/La_2O_3 nanocomposite was synthesized by mechanically blending of iron oxide and lanthanum oxide powders, each prepared individually via the co-precipitation method. The resulting binary oxide was employed to fabricate a thick film sensor using a conventional screen-printing technique. Structural characterization by X-ray diffraction (XRD) confirmed the high crystallinity of the nanocomposite with an average crystallite size of 48 nm. Scanning electron microscopy (SEM) revealed a rod-like morphology with an interconnected network, and an average particle size of 158.84 nm. Elemental analysis using EDAX confirmed the presence of Fe, La and O without any detectable impurities. Optical characterization using UV–Visible spectroscopy estimated the optical band gap to be 1.18 eV. FTIR analysis indicated the presence of characteristic Fe–O and La–O bonds, while the Raman spectrum revealed structural features associated with Fe_2O_3 and La-induced lattice distortions. Photoluminescence (PL) studies showed strong emission peaks at 511 nm and 603 nm, suggesting efficient radiative recombination. The gas sensing performance of the Fe_2O_3/La_2O_3 thick film sensor was evaluated towards various gases such as H_2S, NO_2, ethanol, LPG, CO_2 and demonstrated the highest gas response and selectivity towards NO_2 gas. A maximum response of 87.6 was observed at 100 ppm NO_2 concentration and an operating temperature of 60 °C, with a rapid response and recovery time of 8 s and 9 s respectively. Additionally, the photocatalytic activity of the nanocomposite was tested for the degradation of methyl green (MG) dye under visible light. Optimal degradation efficiency reached 95.45% at pH 4, highlighting the material's potential for environmental remediation. These results establish Fe_2O_3/La_2O_3 as a promising multifunctional material for gas sensing and photocatalytic applications.

1 Introduction

The growing need for efficient environmental monitoring and remediation has spurred intensive research into nanostructured metal oxide materials, particularly for applications in gas sensing and photocatalytic degradation of organic pollutants. Metal oxides such as ZnO, SnO_2, NiO, CeO_2, TiO_2, Fe_2O_3 and their composites have attracted considerable attention due to their tunable electronic structures, chemical stability, and ease of synthesis (Aher et al. 2026; More et al. 2024a, b; Ahemad et al. 2025; Patil et al. 2012). These materials are widely employed in detecting toxic gases e.g., H_2S, NH_3, NO_2, ethanol and decomposing hazardous organic dyes e.g., methylene blue, rhodamine B, two of the most pressing issues in environmental technology (Wang et al. 2010; Xu et al. 2008; Betty et al. 2023; Matthew et al. 2025).

Among them, iron oxide (Fe_2O_3), particularly in its α-phase, stands out due to its abundance, chemical stability, low cost, and visible-light responsiveness owing to its

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