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(57) Abstract :

Abstract: Perovskite oxides with a high-spin d4 electronic configuration (t2g3eg1), such as LaMnO3,SrFeO3, and CaFeO3, have garnered significant research interest due to their exoticelectronic and magnetic properties. At high temperatures, CaFeO3 adopts a cubic structure, where Fe-O-Fe super exchange interactions stabilize a Néel antiferromagnetic (AFM) state, with each Fe ion possessing exactly four electrons.Above 290 K, delocalization of the egelectrons in CaFeO3 results in metallic conductivity. However, below this temperature, the material undergoes a metal-insulator transition near 290 K, often associated with charge ordering or the Verwey transition. Mössbauer spectroscopy at 4.2 K reveals the presence of two chemically distinct Fe sites, indicating charge disproportionation of the type $2Fe^{4+}(d4) \rightarrow Fe^{3+}(d5)+Fe^{5+}(d3)$.According to the Goodenough-Kanamori rules of super exchange theory, AFM interactions dominate between neighbouring sites with an equal number of electrons, while FM interactions occur between sites with unequal electron counts. Consequently, below the Verwey transition, two types of magnetic interactions are observed in CaFeO3: FM interactions between Fe^{3+} and Fe^{5+}, and AFM interactions between $Fe^{3+}-Fe^{3+}$ and $Fe^{5+}-Fe^{5+}$.With this background, we synthesized CaFeO3orthoferrite nanoparticles via a sol-gel route, achieving a pure polycrystalline phase with controlled particle size (below 30 nm) and oxygen deficiency (δ=0.5). The physical properties of the prepared nanoparticles were extensively characterized, including:Structural (using powder XRD with a synchrotron source at KEK Photon Factory, Japan), Structure and Chemical composition (using high-resolution transmission electron microscopy (HRTEM) at the Saha Institute of Nuclear Physics), Magnetic properties (using Quantum Design SQUID VSM) and Electrical properties (using PPMS Re-Liquefier system).The prepared nanopowders exhibited excellent crystallinity and scalability with precise control through the chemical synthesis route. Magnetic phase transitions in CaFeO3nanoparticles were investigated as a function of temperature below 300 K. Exchange bias measurements suggest a magnetically core-shell structure, where the core transitions from an A-type AFM state to a FM state and back to a spiral AFM state as the temperature decreases. This re-entrant magnetic behaviour is corroborated by the exchange bias data.

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