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Synthesis, Structures, and Multiferroic Properties of Strontium Hexaferrite Ceramics

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Simultaneous occurrence of large ferroelectricity and strong ferromagnetism has been observed in strontium hexaferrite ($SrFe_{12}O_{19}$) ceramics. Strontium hexaferrite powders with hexagonal crystal structures have been successfully synthesized through the co-precipitation precursor method using strontium nitrate and ferric nitrate as starting materials. The powders were pressed into pellets and then sintered into ceramics at a temperature range of at 1000°C to 1100°C for 1 h. The structure and morphology of the ceramics were determined using x-ray diffraction and field-emission scanning electron microscopy techniques. Clear ferroelectric hysteresis loops demonstrated large spontaneous polarization in the $SrFe_{12}O_{19}$ ceramics at room temperature. The maximum remnant polarization of the $SrFe_{12}O_{19}$ ceramic was estimated to be approximately 15 μC/cm^2. The FeO_6 octahedron in its perovskite-like hexagonal unit cell and the displacement of Fe^{3+} off the center of the octahedron are proposed to be the origin of electric polarization in $SrFe_{12}O_{19}$. In our experimental observations, the $SrFe_{12}O_{19}$ ceramic also revealed strong ferromagnetism at room temperature.

Key words: Strontium hexaferrite, ferroelectric, multiferroic, polarization, ferromagnetism, ceramics

INTRODUCTION

In recent years, there has been increasing interest in multiferroic materials that provide useful properties in a wide range of potential applications, such as multiple-state memory elements, novel memory media, transducers, and new functional sensors.[1,2] However, materials in which ferroelectricity and ferromagnetism coexist are rare and mostly exhibit rather weak ferromagnetism.[3,4] Because room-temperature multiferroism is essential to the realization of multiferroic devices that exploit the coupling between ferroelectric and ferromagnetic orders at ambient conditions, $BiFeO_3$ and the more recently revealed $LuFe_2O_4$, $Pb_2Fe_2O_5$, and $PbFe_{12}O_{19}$[5–9] are currently considered to be promising candidates in device applications. The perovskite $BiFeO_3$ exhibits weak magnetism that could limit its practical applications. Therefore, preparation of a material in which large ferroelectricity and strong ferromagnetism coexist would be a milestone for modern electrical and functionalized materials.[10]

There have recently been research interests in a number of prototypical magnetic ferroelectrics, including $YMnO_3$, a hexagonal perovskite that is antiferromagnetic and ferroelectric in the ground state,[2,11] and $ErMnO_3$, a hexagonal perovskite that is both ferromagnetic and ferroelectric.[12] In 2005, a strong interplay of electric polarization and magnetization was observed in $Ba_{0.5}Sr_{1.5}Zn_2Fe_{12}O_{22}$ hexaferrite at 10 K.[13] Large ferroelectric polarization was also found in $PbFe_{12}O_{19}$ ceramics with hexagonal structure.[9] Electric polarization has been frequently found in materials with hexagonal structure, which opens up a new path for potential multiferroic candidates in such traditional ferromagnetic oxides as strontium hexaferrite ($SrFe_{12}O_{19}$) that exhibits similar perovskite-like unit cells in a hexagonal structure.

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