XRD study of thin films of Y-type hexaferrites prepared by chemical solution deposition

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Thin films of several phases of hexagonal ferrites with a potential of magnetoelectric effect (ME) were prepared by a chemical solution deposition method, and the number of processing parameters was tested and optimized with the of minimizing the amount of impurities that could spoil the magnetic properties of the final material. To prepare highly oriented ferrite films, several substrates were used, and different substrate/seeding layer/ferrite layer architectures were proposed. [1-5].

The mechanism of ME in Y-type hexaferrite films appears to be significantly influenced by lattice parameters. New Y-ferrite phases were prepared with the composition $Ba_xSr_{2-x}Co_2Fe_{11.1}Al_{0.9}$O22, and it was found that the magnetic structure is non-colinear ferrimagnetic type. These films could be prepared with good out-of-plane and in-plane orientation directly on STO - SrTiO (111) substrate, but the M-phase seeding layer usually leads to better results. The ME effect was identified to be maximum for $x = 1$ but its dependence on x is now studied in more detail. In the project, we investigate the influence of the degree and type of preferred orientation of the films as well as their real structure on the ME effect. By using different substrates, different preferred orientations and strains can be obtained.

Symmetrical θ–θ scans often indicated a strong preferred orientation (000*l*) on STO (111). This is the so-called out-of-plane orientation. In case of fiber texture, its degree can be well characterized by the ω scans (rocking curves). For the estimation of the alignment of planes perpendicular to the substrate, measurement of additional asymmetric Bragg reflections is necessary, simply by the φ scans (rotation on the axis perpendicular to the film plane). The lattice parameters of the films were obtained by evaluating the maxima positions of about 30 diffraction profiles measured at different sample inclinations and φ angles corresponding to the maxima, i.e., by creating a powder-like pattern.

To get obtain a general picture fast reciprocal space mapping was performed by placing a 2D detector close to the sample [6]. In this configuration, the continuous θ–2θ scan fully probes a long stripe in a reciprocal space. Such a measurement can be performed for different sample azimuths. The obvious advantage of this approach is a possibility to quickly visualise the intensity in reciprocal space and to compare the obtained images with the simulations based on some expected phase/texture/stress model, giving semi-quantitative results. The possible fraction of randomly oriented crystallites can be seen immediately on the maps.

Several sets of films were investigated. Films with different thicknesses were deposited on the STO substrate with orientations (111), (110), (100), ceramics. In all cases, (00*l*) textures of Y-phases of different degrees were observed but only for (111) also a strong (111) texture was detected. Then other substrates were used - MgO (111), $LaAlO_3$ (111) - LAO, and stabilized cubic zirconia (ZrO_2). In this case, significant out-of-plane and in-plane orientations of Y-films were observed for LAO substrates with FWHMs of both ω and φ scans of approximately 0.4°. For MgO substrates both orientations were also indicated with a slightly wider FWHMs (over 1°). On zirconia, the preferred orientations are relatively poor with clear domains in in-plane orientations. Another set of substrates used were differently oriented sapphire substrates (rhombohedral Al_2O_3) – *c*-cut (000*l*), *a*-cut (11-20), *m*-cut(10-10), *r*-cut (1-120). It seems that different pronounced textures of Y-hexaferrites can grow there including the (*h*00) orientation on *a*-cut of substrate, or (*hh*0) on *m*-cut of substrate.

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