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Chemical solution deposited strongly oriented thin films with potential magnetoelectric effect

R. Kužel [1], J. Buršík [2], M. Soroka [2], J. Prokleška [1]

[1]Charles University, Faculty of Mathematics and Physics - Prague (Czech Republic), [2]Institute of Inorganic Chemistry of the Czech Academy of Sciences - Husinec-Rez (Czech Republic)

Abstract

Although bulk hexaferrites are known to exhibit strong magnetoelectric (ME) effects near room temperature, the same effects have not been realized much in a thin-film form.

The hexaferrite thin films of different phases (M, Y, W, X and Z) were prepared by chemical solution deposition method, and several processing parameters were tested and optimized with the aim of minimizing the amount of impurities that could spoil the magnetic properties of the final material. For the preparation of highly oriented ferrite films, several substrates were used, and different substrate/seeding layer/ferrite layer architectures were proposed [1]. The preparation of strongly oriented films appeared to be complicated for some of the phases. With respect to the ME effect, the Y and Z phases seem to be the most promising.

New Y-ferrite phases were prepared with the composition $BaSrZnCoFe_{11}(Me)O_{22}$ (Me = Al, Ga, In, Sc), and it was found that for Me = Al, Ga the magnetic structure is of noncolinear ferrimagnetic type with an unspecified helical magnetic structure. For Me = Ga this is a new system with potential ME effect. These films could be prepared with good out-of-plane and in-plane orientation directly on STO - SrTiO3(111) substrate, but M-phase seeding layer usually leads to better results.

The ME Z-type ferrite $Sr_3Co_2Fe_{24}O_{41}$ and $Ba_xSr_{3-x}Co_2Fe_{24}O_{41}$ thin films with strong out-of-plane and in-plane orientation were prepared and characterized for the first time [2]. In the former case, the analysis was complicated by the presence of M and S (spinel) phases that were also oriented (aligned with the substrate and with another). Consequently, many weak asymmetric reflections were overlapped and careful selection of reflections suitable for the analysis had to be made. The magnetization data show anomalies in the magnetic behaviour occurring at temperatures close to the room temperature that are characteristic for collinear to noncollinear spin structure transitions. For the latter film, it has been found that the ME effect can be stronger for the oriented film, but still with some disorder, than for a single crystal [3].

XRD studies were performed by a combination of different scans to characterize both out-of-plane orientation and in-plane orientations. Strong out-of-plane orientations were found, and only basal (00l) reflections were available in symmetric scans. Therefore, the lattice parameters, profile analysis (crystallite size and strains), and residual stresses were studied by combination of several asymmetric reflections scanned at specific suitable angles of inclinations [4].

References

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