SUPER-EXCHANGE CONTROL BY OFF-STOICHIOMETRY IN YTTRIUM IRON GARNET MAGNETIC OXYDES THIN FILMS

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Off-stoichiometry in Yttrium Iron Garnet ($Y_3Fe_5O_{12\pm\delta}$ or YIG) thin films induced by the Pulsed Laser Deposition (PLD) technique allows the control the super-exchange properties : increase of the Curie temperature and of the value of saturation magnetisation. These effects are explained by the changes of the iron valence toward the 2+ and 4+ states.

PLD as a « non thermodynamic » thin films technique, opens the way of growing off-stoichiometric materials that exhibit new properties. Here YIG poly-crystalline films of typical thickness of 200nm are deposited on fused silica substrates with varying the oxygen partial pressure (in respect to the oxygen + nitrogen atmosphere) during the growth from 15 to 400 mtorr. Bulk properties of stoichiometric YIG (structure and magnetism) are found for an oxygen pressure (P_{O2}) of 30 mTorr and referred as P_{stoich}) [1]. The single phase XRD scans show in figure 1, respectively, a expansion (compression) of the cubic Ia3d lattice in respect to bulk value for $P_{O2} > P_{stoich}$ ($<P_{stoich}$). Figure 2 present the consequently increase of the Curie temperature (up to 10% with respect to the bulk $T_c = 555$ K) as a signature of the change of the super-exchange coupling. Increase of the saturation magnetization (up to 120 % for 100 mtorr) is measured by Faraday rotation and by FMR [2]. The composition measurements by RBS allow to give a coherent picture of these results in term of oxygen vacancies for $P_{O2} < P_{stoich}$ (and formation of 2+ valence iron cations) and in term of iron vacancies for $P_{O2} > P_{stoich}$ (and formation of 4+ valence iron cations preferentially in tetrahedral sites) : computation of the induced magnetisation of what we can say a “new” off-stoichiometric YIG material in PLD thin films.

NB : Ce travail a été soutenu par le contrat Region Ile-de-France SESAME-E1314

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