Abstract: Cubic anisotropy measurements of ion-implanted layers on magnetic bubble garnets

I. Maartense and C. W. Searle

Department of Physics, University of Manitoba, Winnipeg, Canada

Effective cubic anisotropy fields of 100 keV Ne^+ implanted layers on (111) garnet films can be directly measured by monitoring the in-plane ac susceptibility or loss while a dc in-plane field is varied along the projection of a cubic hard axis. The effective field is defined by the onset of irreversibility in the in-plane rotation of the magnetization. In the presence of various perpendicular bias fields, the effective field boundary can be plotted for magnetization directions from ~10° to 90° out-of-plane, with the 90° orientation defining the uniaxial anisotropy field, as reported previously.[1] The effective fields have been measured as a function of temperature for $(YSmLuCa)_3(FeGe)_5O_{12}$ films subjected to several implantation dosages and annealing temperatures. The measurement technique is described in an accompanying paper.[2] In a uniform layer, the in-plane effective cubic field should vary as $\sin\theta_M \cos^2\theta_M$, with the magnetization angle given approximately by $\sin\theta_M = H_b / H_{ku}$, where H_b is the applied bias field and H_{ku} is the effective in-plane uniaxial anisotropy field of the layer. The effective-field boundary of a lightly implanted film (8×10^{13} ions/cm^2) behaves generally as expected. The maximum in-plane cubic anisotropy occurs near $\theta_M = 35°$, the direction of a ⟨100⟩ cubic hard axis and shows relatively little change with annealing, whereas the uniaxial anisotropy field drops rapidly with annealing. The temperature dependence of the uniaxial effective field clearly reflects the variation of the cubic anisotropy. With an implantation dosage of 2×10^{14}/cm^2, the cubic hard axes are defined only after annealing. In the as-implanted film, the out-of-plane hard axis directions cannot be located. A heavily implanted film (6×10^{14} ions/cm^2) shows completely anomalous behavior: The cubic hard-axis maximum has totally disappeared, as if the out-of-plane structure has been randomized, although the three-fold symmetry of the in-plane hard directions remains well defined. Annealing has little effect on this behavior, except that after a 600 °C anneal the cubic anisotropy shows a large decrease and the in-plane directions are split off from the original ⟨211⟩ directions. Similarly, the uniaxial anisotropy gives evidence of a breakup of the layer into regions as described earlier.[1] Long-range diffusion of neon atoms is presumed to be responsible for this behavior. We plan to present a more detailed account of this work at a later date.

[1] I. Maartense, C. W. Searle, and H. A. Washburn, J. Appl. Phys. 52, 2361 (1981).
[2] I. Maartense, J. Appl. Phys. 53, 2466 (1982).

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Abstract: Comparison of magnetic and crystalline profiles in He^+-implanted Gd,Tm,Ga:YIG

V. S. Speriosu and C. H. Wilts

California Institute of Technology, Pasadena, California 91125

Profiles of magnetic and crystalline properties in He^+-implanted ⟨111⟩-oriented Gd,Tm,Ga:YIG were obtained using ferromagnetic resonance and x-ray diffraction techniques, respectively. Implantation was done at room temperature several degrees off ⟨111⟩ axis. One series of samples was implanted with 140 keV He^+ at 1.5, 3.0, 4.5, and 6.0×10^{15} at. cm^{-2}. Another series consisted of three profiles obtained with single, double, and triple energies and doses in the range 30–140 keV and 9.0×10^{14}–3.0×10^{15} at. cm^{-2}. For the highest dose the maximum changes in magnetic properties were: -3200 Oe in uniaxial anistropy H_k, a 55% decrease in magnetization M, a 65% decrease in exchange constant A, a 20% increase in damping parameter α, and no change in gyromagnetic ratio γ. The maximum perpendicular strain $\epsilon^\perp$ was 1.26% with a corresponding maximum rms random atomic displacement of 0.23 Å. Lateral strain $\epsilon^\parallel$ was zero. No evidence was found for creation of extended defects. The highest dose was, at most, half of that required to produce amorphousness. Both ΔH_k and $\epsilon^\perp$ had a significantly sublinear dependence on dose. The ratio of maximum ΔH_k for the 6.0 and 1.5×10^{15} at. cm^{-2} was 1.8 instead of 4.0. The corresponding ratio for strain was 2.6. The difference in sublinearity indicates that ΔH_k and $\epsilon^\perp$ are not linearly related through magnetostriction. The equation relating ΔH_k, M, and $\epsilon^\perp$ can be preserved only by invoking implantation-induced changes in Young's modulus, Poisson's ratio, or the magnetostriction.

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