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MAGNETO-OPTICAL PROPERTIES OF MnBi FILMS PREPARED BY IONIZED-CLUSTER BEAM TECHNIQUE

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Among the many materials suggested for optical memory applications, thin films of MnBi have been most intensively studied,[1)-3)] because a high recording density of about 10^8 bits/in^2 is possible . At present, however, the films prepared using the conventional vacuum evaporation involve many problems, especially a film uniformity over a large area and a stability of the films in writing and erasing over a number of cycles. The ionized-cluster beam (ICB) deposition technique developed by the authors [4),5)] was applied to work out the problem. In the ICB deposition, vapourized-metal clusters (macroparticles consisting of about 10^3 atoms loosely coupled together) are used after ionization instead of atomic or molecular particles. The technique is characterized by (1) extremely low charge-mass ratio, (2) high surface diffusion energy (migration energy) enhanced by breaking up into atoms from a cluster due to the kinetic energy upon impact with a substrate, and (3) remarkable influence on coalescence, nucleation, critical condensation density, etc. during the initial stage of film formation due to the presence of ions. Good quality crystalline state films with high packing density and adhesion strength can be obtained by these advantages.

Film formation of MnBi by the ICB technique was made by the depositions of the accelerated Mn and Bi clusters onto a glass substrate. In this study a multi-crucibles method was used, where two crucibles for both materials were heated at 1520 °C and 580°C, respectively, to obtain a stoichiometric composition. Then, an acceleration voltage (V_a) and an electron current for ionization (I_e) of each cluster beam were controlled separately. Schematic diagram of the ICB technique is shown in Fig.1.

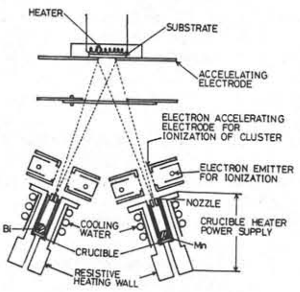

Fig.1 Schematic diagram of the ICB technique.

Fig.2 shows typical magnetic domain configurations of MnBi films prepared by using (a) the ICB deposition at V_a=0 and I_e=100 mA and (b) the conventional vacuum evaporation without ions. For the case of the ICB deposition, uni-

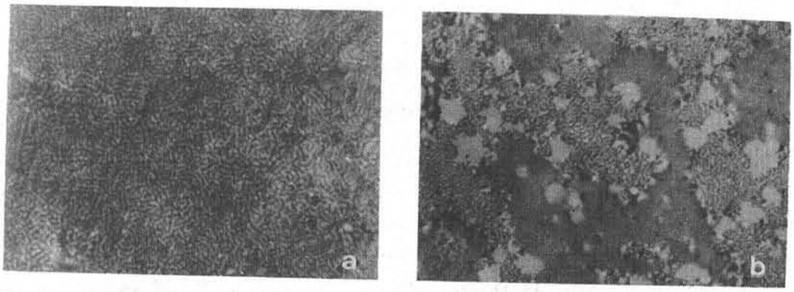

Fig.2 Magnetic domain structures of MnBi films prepared by using (a) ICB deposition and (b) conventional vacuum deposition.

form stripe domains appear all over the glass substrate (5 x 5 cm^2), where the magnetic easy axis of the material is successfully oriented along the c-axis perpendicular to the film plane. For the conventional vacuum evaporation, the domain configurations forming an island-like structure grew, and they remained in the same state even with further annealing. The difference between these domain structures can be attributed to the facts that the presence of ions affects the kinetics of the film growth to stimulate coalescence, and that the kinetic energies of Mn and Bi clusters corresponding to their ejection velocity enhance the crystal growth, even though additional acceleration voltage is not applied.

In general, optimum conditions of epitaxy on a single crystal substrate depend on kinds of source and substrate materials or their combinations. Some materials having a hexagonal structure such as MnBi, CoCr, and ZnO, etc. show inherent properties with preferential orientation to a special axis on amorphous substrates. In these materials, only kinetic energies corresponding to the ejection speed with suitable content of ionized clusters are available to make good quality crystalline state films. The c-axis orientation is weakened with increasing acceleration voltage for MnBi films formed on an amorphous substrate, although the adhesion strength remarkably increases.

Experiments on the thermal writing by a He-Ne laser (maximum output: 50 mW, wave length: 0.6328 μm) were performed to check the material characteristis as a magnetooptical memory. Fig.3 shows the spot patterns written in MnBi thin film, whose thickness is about 1000 Å, with a laser power of 10 mW after focusing the numerical aperture up to 0.25, and with the access time 10 msec. The bright spots, which can be observed under the polarizing a microscope using the magnetooptic Kerr effect, indicate the state of magnetization reversal. High stability of the film after writing and erasing over a substantial number of cycles was maintained, which proves that the adhesion strength of the film on the substrate is prominent.

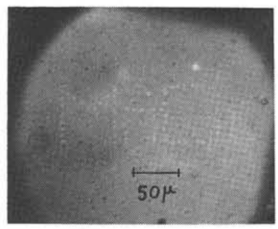

Fig.3 An example of patterns written on MnBi film by means of He-Ne laser.

In order to get some informations about the crystallographic structure of part of the film written with the laser, X-ray diffraction patter was measured. Fig.4 shows the results (a) before and (b) after written, from which the crystal structure after written was found to change from LTP (low temperature phase) to QHTP (quenched high temperature phase).

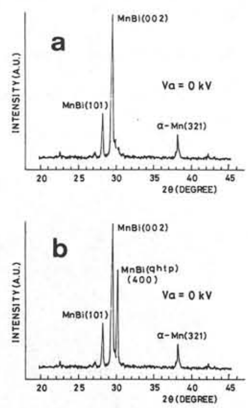

Fig.4 X-ray diffraction patterns of MnBi films (a) before and (b) after written by He-Ne laser.

Reference

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