SIMS ANALYSIS OF SPUTTERED SPECIES FROM MIXED OXIDE POWDER TARGETS FOR YIG DEPOSITION

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Introduction

Sputtering is effective to deposit many kinds of materials. Sputtered magnetic garnet (YIG) films are very promising materials for magneto-optical devices. The analysis of the fragments formed in the sputtering process is important to improve the properties of YIG films[1]. Some studies for inspecting the structures of those fragments have been reported by Naoe and others[2,3]. Those studies attempted to identify the sputtered fragments in the plasma. Fig.1 shows a model of the reaction mechanism for generating fragments from a target. Some properties of a sputtered thin film depend on structures and species of deposited fragments. By using a SIMS measurement system, we can estimate the fragments sputtered in an actual film deposition condition. We analyzed the SIMS data of mixed metal oxide powder targets used for the YIG films deposition, using a primary ion beam accelerated at several kV.

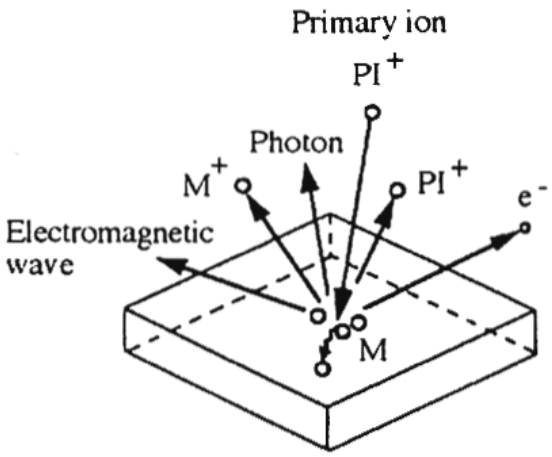

Fig.1 Schematic illustration of a sample surface sputtered by a primary ion beam.

Experimental

Oxide powders of Y, Bi and Fe were fired at 800°C for 4 h and ground with a mill. Then the powders were pressed at 200kg/cm^2 to form a disk[4]. The sample compositions were Y:Bi:Fe=1:2:5 and 2:1:5 in mol ratios. After calcinating at 800°C for 4 h, the samples were measured using an Ion Micro Analyzer (CAMECA IMS-4f).

The SIMS measurement conditions are shown in Table 1. The primary ion was Ar^+ which was accelerated at 5~15 kV. We measured positive ions in all fragments because the as-deposited film is oxygen-deficient and contains excess cations of metals. The measured mass number of cations ranged from 30 to 290.

Table 1 SIMS measurement conditions

Primary Beam	Ar^+
Primary Acceleration Voltage	5~15 kV
Secondary Acceleration Voltage	4.5 kV
Primary Ion Current	0.7×10^{-8} A
Residual Pressure	2×10^{-9} Torr

Results and Discussion

Figure 2 shows the SIMS spectrum of a target having a composition of Y:Bi:Fe=1:2:5. Many kinds of fragment ions were detected. We derived Fig.3 by rewriting Fig.2 from logarithmic to linear scale. Fig.3 shows the mass numbers of measured major fragments as 56, 89 and 105. Other fragments are minor.

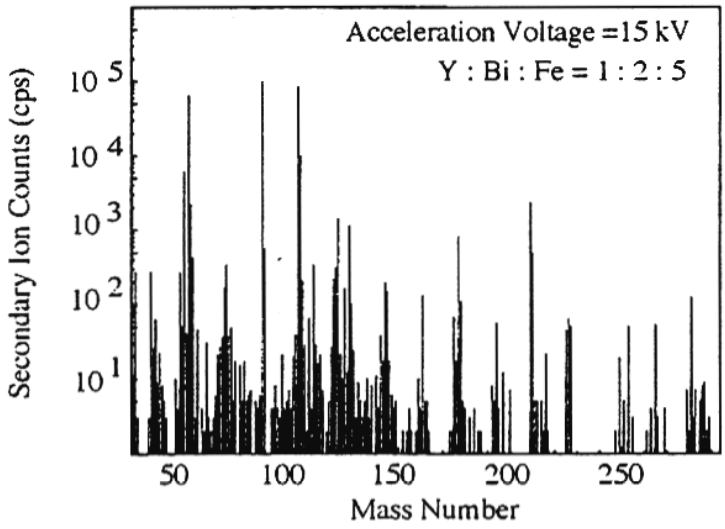

Fig.2 SIMS spectrum of a target for YIG deposition.

Samples used for the measurements were made from Y_2O_3, Bi_2O_3 and Fe_2O_3 powders. The peak appearing points of ionized Y_2O_3, Bi_2O_3 and Fe_2O_3 are shown by arrows in Fig.3. No peaks were observed at these points as m/e=160, 226 and 233. Fig.3 implies the major sputtered fragments in YIG deposition process had more reduced forms. The peaks of mass number 56, 89 and 105 are assigned to Fe^+, Y^+ and YO^+, respectively.

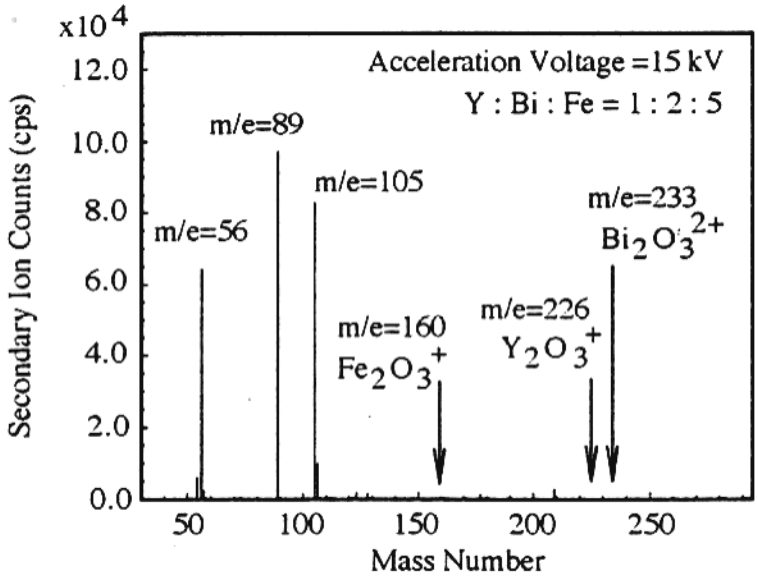

Fig.3 SIMS spectrum of a target for YIG deposition.

Fig.4 shows the SIMS spectrum measured with the primary ion beam accelerated by half voltage on Fig.3 data. The spectrum pattern of Fig.4 is almost the same as Fig.3. The energy of sputtering particles in the actual deposition conditions was several keV. The major sputtered fragments in actual YIG deposition conditions were Fe^+, Y^+ and YO^+.

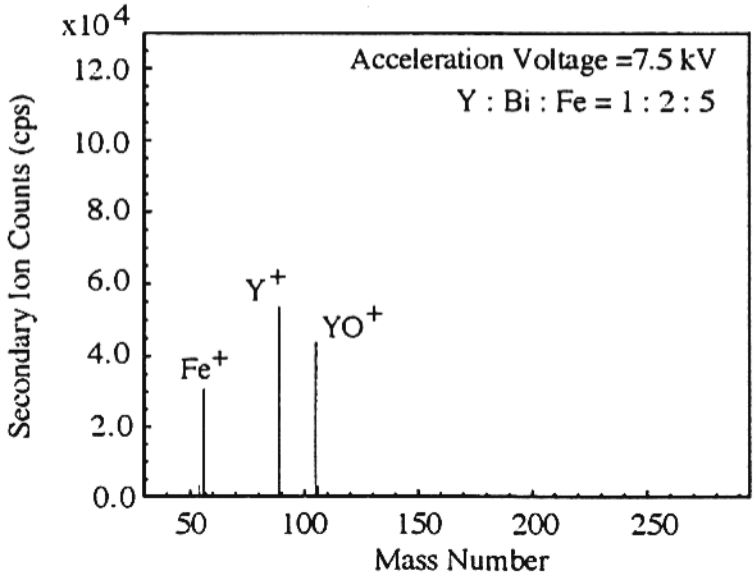

Fig.4 SIMS spectrum measured of low energy primary ion beam.

We measured the kinetic energy distribution (KED) spectra on the major fragments to obtain additional structural information. The profile of KED spectrum contains structural information on the fragments[5]. All fragments having same mass number were measured as a peak in SIMS spectrum. We confirm the structures of major fragments by KED spectrum. Fig.5 shows the KED spectrum of major fragments having mass number m/e=56, 89 and 105. The form of KED spectra of mononuclear fragments like metal ions were wide shape. And the form of KED spectra of polynuclear fragments like MO^+ shows a narrow shape. From Fig.5, the peaks of m/e=56 and 89 in the SIMS spectra are assigned to pure Fe^+ and Y^+. And m/e=105 peak is assigned to YO^+ ion.

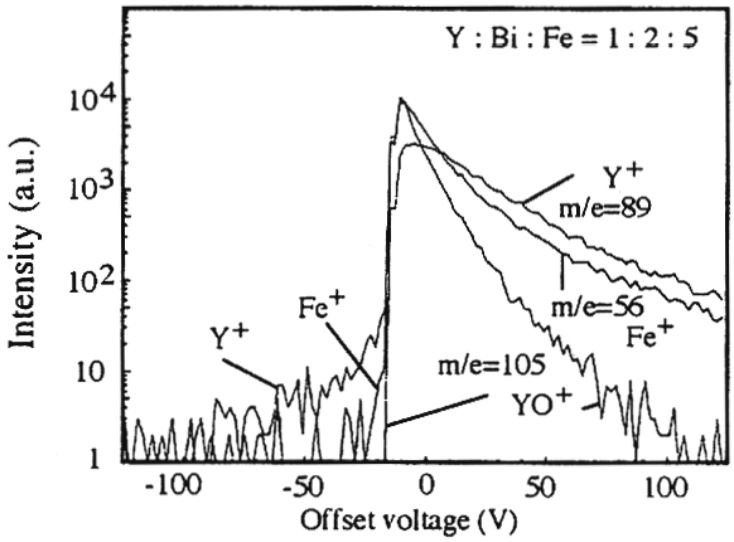

Fig.5 Kinetic energy distribution of secondary ions sputtered from a YIG target.

Conclusions

We measured the SIMS spectrum of oxide targets used for YIG film deposition. SIMS measurements using a primary ion beam accelerated at several kV present valuable information about the fragments sputtered in actual deposition conditions. The analysis of the SIMS data suggests that the major species of sputtered fragments in the deposition condition were reduced ions. These ions are expected to be responsible for the deficiency of oxygen in an as-deposited YIG film.

References

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