**DIELECTRIC AlN THIN FILMS WITH HIGH REFRACTIVE INDEX PREPARED BY PLASMA FREE DC SPUTTERING**

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**Abstract** — Dielectric AlN thin films have been prepared by reactive sputtering method, using a facing targets sputtering apparatus with a DC power supply. The AlN films deposited at the ratio in pressure of nitrogen of 21% exhibited refractive index as high as 2.35 and revealed sharp rocking curve of x-ray diffraction pattern with full width of half maximum as small as 5 deg.

**KEYWORDS:** dielectric AlN thin film, facing targets sputtering, magneto-optical recording, multiple reflection, protecting layer

**INTRODUCTION**

Dielectric layers in magneto-optical recording media play some important roles such as, enhancement of Kerr effect by multiple reflection and protection of magnetic layers from oxidation. Some oxide and nitride films were used as dielectric layers in magneto-optical recording media. Most of them were prepared by RF reactive sputtering.

In this study, dielectric AlN films were prepared on substrates at room temperature under stable plasma discharge by using a facing targets sputtering (FTS) apparatus [1,2] with DC power supply. The hexagonal AlN film is one of the promising piezoelectric material and it also have passivation and insulating properties [3-7]. The effects of sputtering conditions to their properties have been investigated in detail, and it also have been attempted to optimize the preparing conditions.

**EXPERIMENT**

The specimen films were deposited on plasma-free substrates by using a FTS apparatus, as illustrated in Fig. 1. The specimen films were

![Fig. 1. Facing targets sputtering apparatus](image-url)
deposited by reactive sputtering method with a pair of Al targets (purity of 99.99 at.%). Pure silicon wafers were used as substrates.

Working gases were pure nitrogen (purity of 99.999 at.%) or mixture of gases composed of argon (purity of 99.999 at.%) and nitrogen. For the mixture gas, the argon pressure $P_{Ar}$ was fixed at 0.5 mTorr and the ratio in pressure of nitrogen $R_{N_2}$ was changed from 10 to 100 % of the total gas pressure. When the $R_{N_2}$ was 100 % the nitrogen pressure $P_{N_2}$ was varied in the range between 0.1 to 10 mTorr.

The specimen films were deposited by using a DC power supply at the constant input power of 500 W. The thickness of dielectric AlN films was fixed about 400 nm.

The crystal structure of AlN films was investigated by x-ray diffractometer. The refractive index $n$ of specimen films was measured by ellipsometer at the wavelength of 633 nm.

RESULT AND DISCUSSION

Figure 2. shows the deposition rate $R_d$ of AlN films. The $R_d$ was drastically decreased with increasing $R_{N_2}$. $R_d$ was conversed to the value of 7 nm/min at $R_{N_2}$ more than 40 % which is 1/7 of pure Al thin films.

Transparent dielectric AlN films were achieved at $R_{N_2}$ in all range of 10 to 100 %. They showed large (002) and (004) peaks of hexagonal AlN crystallite in x-ray diffraction pattern with good orientation of (001) plane, as illustrated in Fig. 3.

Figure 4 and 5 shows the distance of (002) plane $d_{002}$ and the crystal size $<D>_{002}$ of AlN crystalline dependent on $R_{N_2}$. The $d_{002}$ of specimen films was increased from 2.49 Å to 2.52 Å. The $<D>_{002}$ was almost same with the value of 270 Å within the range of $R_{N_2}$ between 10 to 70 %.

![Fig. 2. Deposition rate $R_d$ of AlN films](image)

![Fig. 3. X-ray diffraction pattern of AlN](image)
The degree of crystal orientation $\Delta \theta_{50}$, which was estimated by the full width of half maximum of the (002) rocking curve of AlN films, revealed almost same value of about 5 deg., as illustrated in Fig. 6.

Figure 7 shows the dependence of the refractive index $n$ on $R_{N_2}$. The specimen films exhibited $n$ about 2.05 to 2.10, except the films deposited at $R_{N_2}$ of 21 and 90 % which showed $n$ of 2.35 and 1.95, respectively. This result may
be compared with the results obtained from x-ray diffraction diagram.

They showed almost same distance of (002) planes of about 2.50 Å, but $<D>_{002}$ and $\Delta \theta_{50}$ were a little bit different. The AlN film deposited at $R_{N_2}$ of 21% exhibited small $<D>_{002}$ and small $\Delta \theta_{50}$ of about 270 Å and 5 deg., respectively. On the contrary, the AlN film deposited at $R_{N_2}$ of 90% exhibited large $<D>_{002}$ of about 300 Å with large $\Delta \theta_{50}$ of about 14 deg. Higher $R_4$ of 18 nm and larger $n$ of 2.35 implies the optimum $R_{N_2}$ for depositing AlN films may be 21%.

CONCLUSIONS

Dielectric AlN thin films have been prepared by using a facing targets sputtering apparatus and DC power supply. Results are as follows;
(1) The specimen films prepared at $R_{N_2}$ of 21% revealed $n$ as large as 2.35.
(2) Reactive DC sputtering for preparing transparent dielectric AlN films have been achieved at $R_{N_2}$ in all range of 10 to 100% and the specimen films showed excellent c-axis orientation.
(3) Deposition rate of AlN films were decreased to the value of 14 to 60% of pure Al films because of reactive sputtering.

REFERENCE