Cl_2/Ar 분위기에서 GST 박막의 ICP 에칭

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Inductively Coupled Plasma Etching of GST Thin Films in Cl_2/Ar Chemistry

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Abstract - $Ge_2Sb_2Te_5$(GST) thin film at present is a promising candidate for a phase change random access memory (PCRAM) based on the difference in resistivity between the crystalline and amorphous phase. PCRAM is an easy to manufacture, low cost storage technology with a high storage density. Therefore today several major chip manufacturers are investigating this data storage technique. Recently, A. Pirovano et al. showed that PCRAM can be safely scaled down to the 65 nm technology node. G. T Jeonget al. suggested that physical limit of PRAM scaling will be around 10 nm node. Etching process of GST thin films below 100 nm range becomes more challenging. However, not much information is available in this area.

In this work, we report on a parametric study of ICP etching of GST thin films in Cl_2/Ar chemistry. The etching characteristics of $Ge_2Sb_2Te_5$ thin films were investigated using an inductively coupled plasma (ICP) of Cl_2/Ar gas mixture. The etch rate of the GST films increased with increasing Cl_2 flow rate, source and bias powers, and pressure. The selectivity of GST over the SiO_2 films was higher than 10:1. X-ray photoelectron spectroscopy (XPS) was performed to examine the chemical species present in the etched surface of GST thin films. XPS results showed that the etch rate-determining element among the Ge, Sb, and Te was Te in the Cl_2/Ar plasma.

1. Introduction

$Ge_2Sb_2Te_5$(GST) thin film at present is a promising candidate for a phase change random access memory (PCRAM) based on the difference in resistivity between the crystalline and amorphous phase. PCRAM is an easy to manufacture, low cost storage technology with a high storage density. Therefore today several major chip manufacturers are investigating this data storage technique. Recently, A. Pirovano et al. showed that PCRAM can be safely scaled down to the 65 nm technology node[1]. G. T Jeong et al. suggested that physical limit of PRAM scaling will be around 10 nm node[2]. Etching process of GST thin films below 100 nm range becomes more challenging. However, not much information is available in this area.

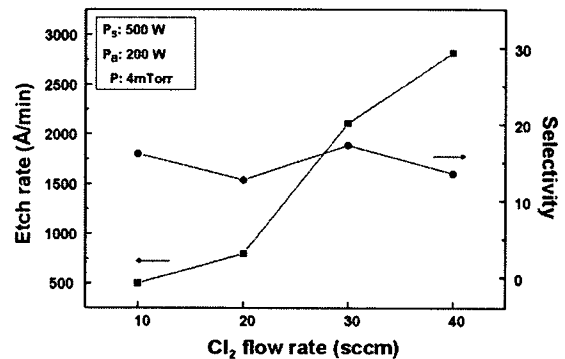
In this work, we report on a parametric study of ICP etching of GST thin films in Cl_2/Ar chemistry.

2. Experimentals

GST films were deposited on Si(100) substrates by RF magnetron sputtering process using $Ge_2Sb_2Te_5$ target. The thickness of GST films was approximately 3000 Å. Etching experiment were performed in an ICP system which utilize a rf(13.56MHz)-powered sample chuck and a 13.56MHz, 1200W ICP source. Four variable parameters were chosen, namely, pressure, bias power, source power, and Cl_2 gas flow rate. The process pressure(P) was varied from 4 to 10 sccm, the bias power(P_B) from 50 to 300 W, the source power(P_S) 400 to 700 W, and the Cl_2 gas flow rate(CF) from 10 to 40 sccm.A surface profiler (Alpha-step 500 surface profiler) was used to measure the etched depth of GST films. The compositional analysis of the GST surface was performed using an XPS (ESCALAB 220-IXL) with Mg Kα radiation (1253.6 eV) at 300 W.

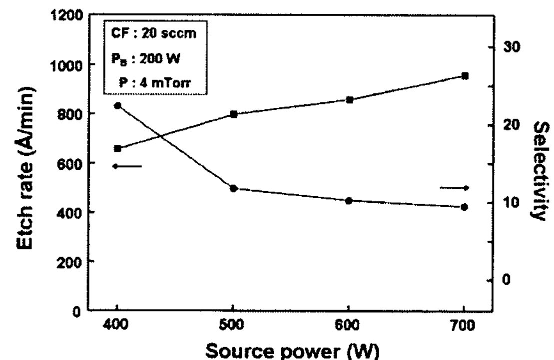
3. Result and discussion

Fig. 1 shows the etch rates of GST films and theselectivity over SiO_2 film as a function of Cl_2 flow rate. The etch rates increase with increasing Cl_2 flow rates. At the Cl_2 flow rate of 40 sccm, an etch rate of 2815 Å/min was obtained. High GST/SiO_2 selectivity more than 12:1 was extracted and remained constant over a broad range of Cl_2 flow rates.



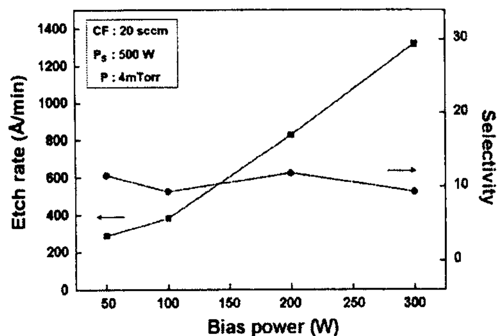
<Fig. 1> Variations of GST film etch rates and selectivity over oxide films with Cl_2 flow rate.

The effect of source power at fixed bias power is shown in Fig.2. As ICP source power is increased, producing higher ion fluxes, there is a general tendency for etch rates to increase, but more slowly compared to Fig. 1.



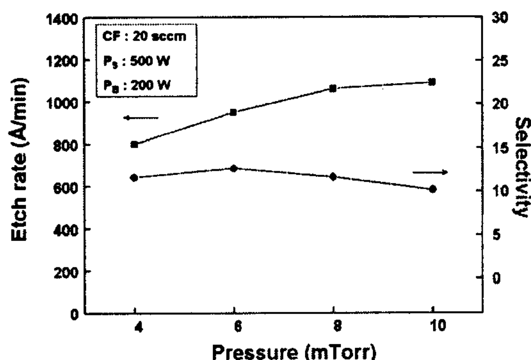
<Fig. 2> Variations of GST film etch rates and selectivity over oxide films with source power.

Fig. 3 shows the variations of the etch rates of GTS films and selectivity.As expected, the etch rate rises linearly, while the selectivity is not changed. This is due to the increase of DC bias.



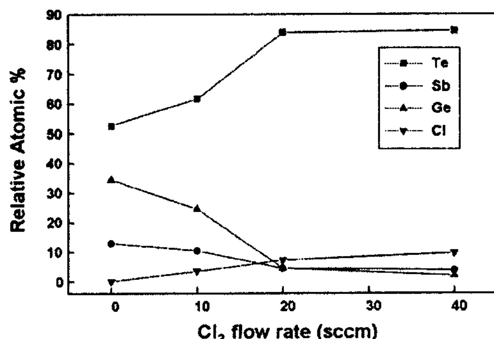
<Fig. 3> Variations of GST film etch rates and selectivityover oxide films with bias power.

Fig. 4 shows the changes of etch rates and selectivity as a function of pressure. As the pressure increases, GST etch rate goes up gradually but GST/SiO_2 selectivity decreases slightly.



<Fig. 4> Variations of GST film etch rates and selectivityover oxide films with pressure.

XPS analysis was performed to examine the chemical species present in the surface of as-etched GST films. Fig. 4 shows relative atomic percentages of GST films as-deposited and etched with various Cl_2 flow rates. As shown in Fig. 5, the relative atomic percentages of Ge and Sb rapidly decrease and Te increases as the Cl_2 flow rate increases to 20 sccm. Meanwhile, over thisflow rate, Ge, Sb, and Te are saturated. This result means that the surface composition of GST film changes and Te is mainly detected on the etched surface. This phenomenon seems to be related to the vapor pressure of each element. The vapor pressure of tellurium chloride(233℃)is lower than that of germanium chloride(-15℃) and antimony chloride(61.8℃)[3]. As a result, tellurium compounds remain on the etched surface while etching GST films. This result implies that the etch rate-determining element among Ge, Sb, and Te is Te.



<Fig. 5> Relative atomic percentages of as-deposited and etched GST films with Cl_2 flow rate.

4. Conclusions

Under various etching conditions GST thin films were etchedwith ICP system in Cl_2/Ar plasma. The etch rate of the GST films increased with increasing Cl_2 flow rate, source and bias powers, and pressure. The selectivity higher than 10:1 over the SiO_2 films were obtained. XPS results indicated that the etch rate-determining element among the Ge, Sb, and Te was Te in the Cl_2/Ar plasma. As a result, the etch rates were controlled by the content of Cl radicals as well as the ion energies.

[References]

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