Study on the Deposition Rate Depending on Substrate Position by Using Ion Beam Sputtering Deposition

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1. Introduction

Ion beams have been used for over thirty years to modify materials in manufacturing of integrated circuits, and improving the corrosion properties of surfaces [1]. Recently, the requirements for ion beam processes are becoming especially challenging in the following areas : (i) ultra shallow junction formation for LSI fabrication, (ii) low damage high rate ion beam sputtering and smoothing, (iii) high quality functional surface treatment for electrical and optical properties[2]. Ion implantation method is world-widely used for high quality semiconductor production [3,4]. Ion implantation has emerged as a powerful surface engineering technology in recent years. Ion beam sputtering is an attractive technology for the deposition of thin film coatings onto a broad variety of polymer, Si-wafer, lightweight substrates. Demand for the decoration metal is increasing. In addition, lightweight of parts is important, because of energy issues in the industries. Although a lot of researches have been done with conventional PVD methods for the deposition of metal or ceramic films on the surface of the polymer, there are still adhesion problems [5]. In this paper, Cr deposition and SUS deposition on the Si-wafer using Ion Beam Sputtering Deposition (IBSD) are discussed.

2. Methods and Results

Ion beam sputtering deposition apparatus was used in this study. Both ion sources were bucket-type.

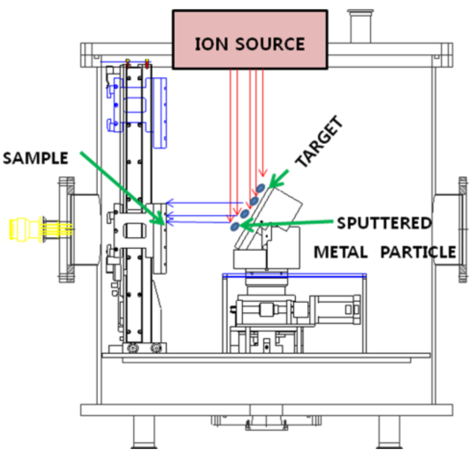


Fig. 1. A schematic diagram of the ion beam sputtering deposition system. The line indicates the flow of argon ions.

In Fig. 1. The red lines indicate argon beams with an energy of 20 kV and a current of 50 mA. When the energetic high current argon beams bombarded the SUS 304 target, a little amount of the target material were detached from the target and ejected onto the Si-wafer substrate. Target holder located at 50mm, 100mm positions from chamber ground. Target angle was 45 degree. The distance between target and sample holder was 80mm.The process conditions are work pressure of 2.4E-4 torr, voltage of 20KeV, current 50mA, and 5N argon gas, respectively. And implantation time was 15minute at room temperature.

2 inch Si-wafer substrates were used with Cr, Stainless steel 304(SUS 304) target.

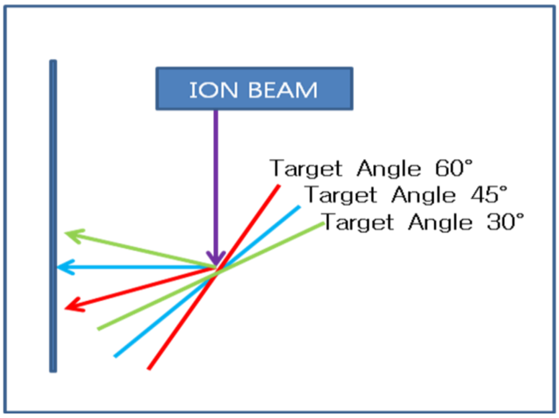


Fig. 2. Transmission lines to the incident angle of a metal target.

MATERIAL \ DEGREE	30	45	60
Fe	4.413	5.074	7.716
Cr	4.741	5.086	8.211
Ni	4.341	5.317	7.519

Table 1. Sputtering yield depending on incident angles of a metal element. (Argon gas, 20KeV)

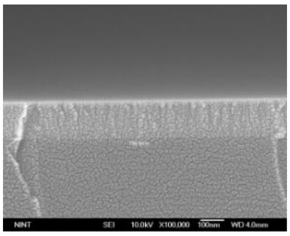
The sputtering yield is calculated under the Sigmund model. The separation of the cascade into two distinct stages has the consequence that two characteristic depths are important for the qualitative understanding of the sputtering process. The scattering events that eventually lead to sputtering take place within a certain layer near the surface, the thickness of which depends on ion mass and energy and on ion-target geometry. In the elastic collision region, this thickness is a sizable fraction of the ion range.[6]

In 1942, Fetz noticed that the sputtering rate of Mo wires by Hg ions increased as the diameter of the Mo wire decreased [7]. This effect was attributed to an increase in the sputtering rate when the ions strike the sample at oblique angles [7]. The loss of material was measured, during sputtering, by recording the change in wire resistance [7]. The change in wire resistance was correlated with the measured weight loss after removing the sample from the sputtering system [8].

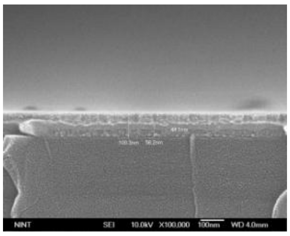
In Fig. 2. The scattered metal (Cr, SUS 304) particles are incident on the target is perpendicular to the ion beam. The scattered metal (Cr, SUS 304) particles are deposited, depending on the angle position which is changed. When the angle is small, metal particles deposition position is increased.

MATERIAL	SAMPLE POSITION	TOP (nm)	MIDDLE (nm)	BOTTOM (nm)	AVERAGE (nm)	DEPOSITION RATE (Å/sec)
Cr	50mm	125.6	156.6	121.9	134.7	1.50
	100mm	74.1	100.3	122.8	99.1	1.10
	150mm	97.5	102.2	92.8	97.5	1.08
SUS 304	50mm	94.7	110.6	88.1	97.8	1.09
	100mm	51.6	73.1	89.1	71.3	0.79
	150mm	68.4	76.9	95.6	80.3	0.89

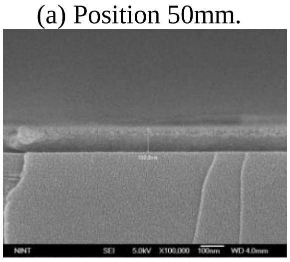
Table 2. Shows the Cr and SUS 304 coated Si-wafer thickness and deposition rate according to position



(a) Position 50mm.

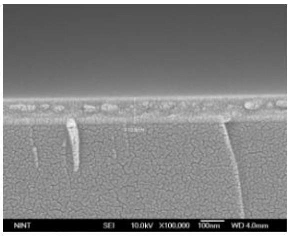


(b) Position 100mm

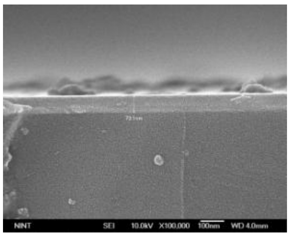


(c) Position 150mm

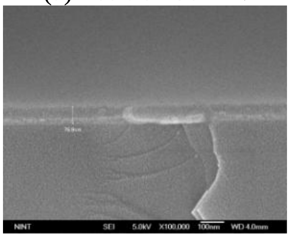
Fig. 3. Show the Cr coated Si-wafer cross section images (FE-SEM).



(a) Position 50mm.



(b) Position 100mm



(c) Position 150mm

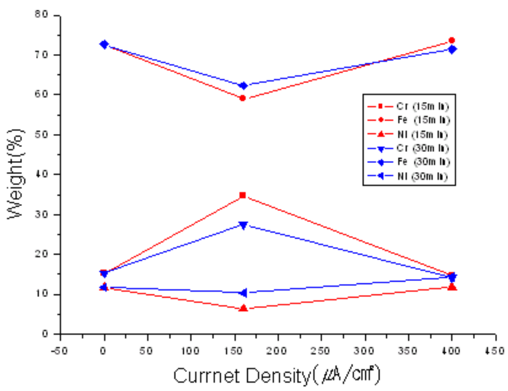
Fig. 4. Show the SUS 304 coated Si-wafer cross section images (FE-SEM).

The specimens were cleaned with alcohol before ion beam irradiation.

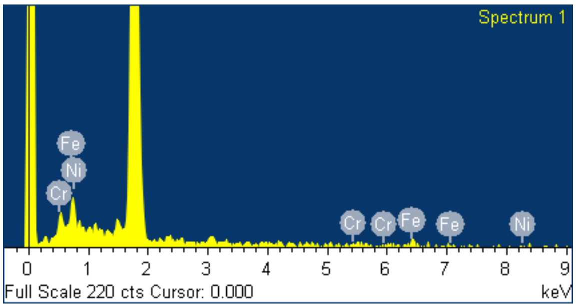
Fig. 3. (a), (b) and Fig. 4. (a), (b) show the FE-SEM cross section image for the Cr and SUS 304 coated Si-wafer, respectively.

The FE-SEM cross section images reveal that the thickness of Cr coating was 156.6nm (position 50mm), 94.7nm (position 100mm), 102.2nm (position 150mm), respectively. And SUS 304 coated thickness was 110.6nm (position 50mm), 73.1nm (position 100mm), 76.9nm (position 150mm), respectively.

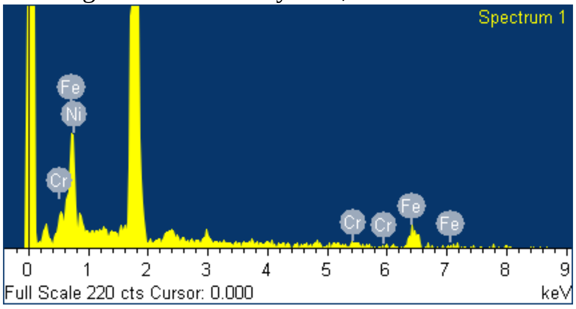
Based on the results of the thickness, rate was 1.26 Å/sec, 1.18 Å/sec, 1.23 Å/sec at 50mm, 100mm, 150mm position, respectively. Also SUS 304 deposition rate was 1.44 Å/sec, 0.812 Å/sec at 50mm, 100mm, 150mm position, respectively.



(a) Cr and SUS 304 deposition metal component ratio according to current density.



(b) Cr and SUS 304 deposition metal component ratio according to current density 160 ㎂/㎠.



(c) Cr and SUS 304 deposition metal component ratio according to current density 400 ㎂/㎠.

Fig. 6. Show the Cr and SUS 304 deposition metal component ratio according to current density.

In fig. 6. When the current density 160 ㎂/㎠, Sputtering yield value high Cr components ratio have increased up to 27.3wt% from 15.3wt%. When the current density 400 ㎂/㎠, Cr and SUS 304 component ratio is similar to the target (15.3wt%) and a deposition thin layer (14.6wt%) because sputtered molecules are clustered into units.

3. Conclusions

In this paper, we find out that the shorter distance between target and substrate makes the higher deposition rate Cr target has higher deposition rate than stainless steel 304(SUS304). We find out when current density increases up to 400 ㎂/㎠ Cr and SUS 304 component ratio is similar to the target and a deposition thin layer.

When current increases up to 100mA from 50mA, the deposition rate is expected to be improved due to high current density.

When light material like plastic are coated by metal using Ion Beam Sputtering Deposition(IBSD), products can be made which have high corrosion resistance as well as lightweight.

We will have more measure of the other target angle (30, 60 degree). And detailed experimental result will be presented.

ACKNOWLEDGMENTS

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