a-Si:H Photosensor Using Cr silicide Schottky Contact

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Abstract—Amorphous silicon is a kind of optical to electric conversion material with current or voltage type after generating a numerous free electron and hole when it is injected by light. It is very effective technology to make schottky diode by bonding thin film to use optical diode. In this paper, we have fabricated optical diode device by forming chrome silicide film through thermal processing with thin film(100Å) having optimal amorphous silicon. The optimal condition is that we make a thin film by using PECVD(Plasma Enhanced Chemical Vapor Deposition) to improve reliability and characteristics of optical diode. We have obtained high quality diode by using chrome silicide optical diode from dark current and optical current measurement compared to previous method. It makes a simple process and improves a good reliability.

I. INTRODUCTION

It is classified by amorphous silicon, poly silicon and crystal according to regularity on array of mutual array with component of atoms. Amorphous is used as electric device in restricted field because amorphous is very disorder. But, there is a interconnection distance between atoms in amorphous. It is used in the field of electron device in specific usage with low quality of electrical characteristics compared to conventional crystal. This kind of work was advanced after 1980. Compared to other materials, specially, amorphous have high quality characteristics in optical to electrical conversion. The new technology of thin film has improved in this kind of field.

Especially, hydrogenated amorphous silicon can be obtained high quality of a-Si:H film by reducing localized states after bonding hydrogen and dangling bond of amorphous silicon. Hydrogenated amorphous silicon has low quality characteristics such as carrier mobility and dark current compared to crystal silicon. But it has a superior to optical absorption coefficient, optical bandgap and optical conductivity. It makes sensor device such as solar cell by using its optical characteristics. Hydrogenated amorphous silicon is first commercial optical diode with thin film type. It is not popular used. Because a-Si changed intrinsic degradation when it is emitted by light. Intrinsic degradation generating in light absorption is limited 20%. In this paper, we have fabricated optical detector by forming chrom-silicide thin film through thermal processing.

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II. FABRICATION OF PHOTO DIODE

CORNING 7059 GLASS (5cm X 5cm) and Si wafer is used as substrate in this experimental condition. Electrode of optical diode has very critical condition in process that forms electrode and characteristics of material because of characteristics of junction with amorphous. Lower electrode of optical diode is generally used by Cr thin film. In experimental, E-beam evaporator is used. It can form high vacuum with 10-6 ~ 10-7 Torr by using low temperature pump. It can heat at 350℃ with IR lamp

Table 1 E-beam evaporator condition of Cr thin film

vacuum	μTorr	1~2
power	mA	30
substrate temperature	℃	30
deposition rate	Å/sec	4
RPM		20
film thickness	Å	2,000

We have fixed the deposition rate of Cr thin film with 4Å/sec in experimental. The thickness of Cr thin film in lower electrode is fixed at 2,000Å. Figure 1 shows the result of measurement with AES(Auger Electron Spectroscopy) of Cr thin film. To make a Cr silicide, amorphous Si was deposited on Cr silicide thin film with about 100Åand has annealed 30 minutes to 1 hour at 250℃under N2 condition. After that, it was formed a-Si:H thin film with 10,000Å thickness by PECVD method over that thin film..

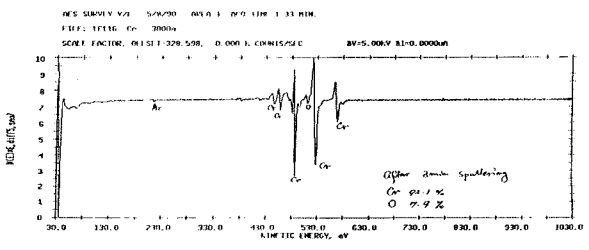

Fig. 1 AES Characteristics of Cr Thin Film

Table 2 shows the deposition condition of amorphous silicon thin film respectively.

Table 2 PECVD deposition condition of amorphous Si thin film

	unit	a-Si:H for Cr silicide	a-Si:H
SiH4	sccm	4	4
pressure	torr	0.3	0.3
temperature	℃	250	250
time	min	0.4	40
power	watt	4	4
thickness	Å	100	10,000

The process of photodiode is as follows. First, it was deposited 1000□ thickness of ITO with vacuum process by using sputtering equipment over surface. Second, it is patterned ITO by optical etching process and removing a-Si:H by RIE process. Third, photodiode is formed. ITO thin film equipment used in experimental is DC magnetron sputtering, HSD-662M. The density of magnetic can be affected in electron and is not affected in ion, it is very helpful to form an plasma in equal. The main vacuum system use Turbo molecular pump and circle target of 8 inch. It can be fabricated thickness uniformity with ±5% on glass substrate of 300*300㎟. Optical transparency and resistivity are important on transparent electrode and are inverse proportional to quality of O2 gas. In this experimental, the composition rate of In203:Sn02 is 90:10wt%

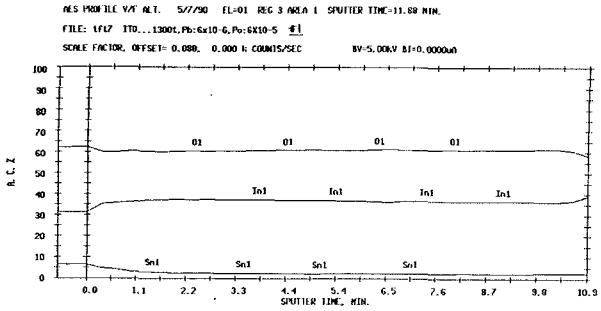

Fig. 2 Measurement result of AES of ITO thin film

Table 3 shows the sputter condition of ITO thin film.

Table 3 Sputter condition of ITO thin film

	unit	ITO
Ar	sccm	50
O2	sccm	0.5
temperature	℃	200
Target	(In2O3 : SnO2)	90:10 wt%
power	W/㎠	1.85
thickness	Å	1000

III. STRUCTURE AND CHARACTERISTICS OF OPTICAL DIODE WITH CHROMSILICIDE

Generally, the amorphous optical diode with ITO/a-Si:H/Cr structure uses schottky effect. a-SiH/Cr has a quasi-schottky characteristics and barrier height with 0.55eV. a-Si:H and ITO has a barrier height with ~0.93 eV .. But, Cr and a-Si:H surface has no good condition and it can not meet schottky effect. It makes unstable device. To make a stable schottky characteristics in Cr and a-Si:H layer, we can restrict dark current by inserting shallow Cr silicide between Cr and a-Si:H. It is very important to grow shallow thin film to tunnel optical charge by protecting the flow of optical current. In this paper, we have obtained Cr thin film and thin film below 100Åby annealing process after deposition a-Si:H with about 100Å.

Figure 3 shows that optical diode structure in fabricated

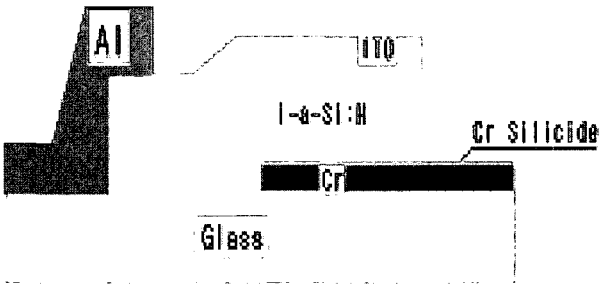

Fig. 3 Structure of Cr Silicide photodiode

Figure 4 shows that energy band structure of Cr - silicide optical diode in fabricated

From this study, we can reduce the process of photo diode formation by making Cr-silicide over Cr considering conventional default. This process improves the operation and characteristics of photo diode. From figure 4, we have shown that the current drives toward Cr in ITO when "-" voltage is applied to chrome and "+" biased to ITO.

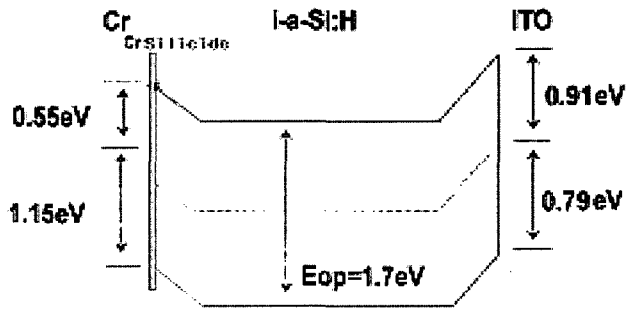

Fig. 4 Energy band diagram of Cr Silicide photodiode

If light is injected to ITO, A lot of optical current flows. Schottky barrier is generated by Cr Silicide. A small current 10-12 A of flows. At this time, the light is injected to ITO, charge is generated in a a-Si:H thin film, a lot of optical current flows. Figure 5 shows the characteristics of optical diode of Cr Silicide.

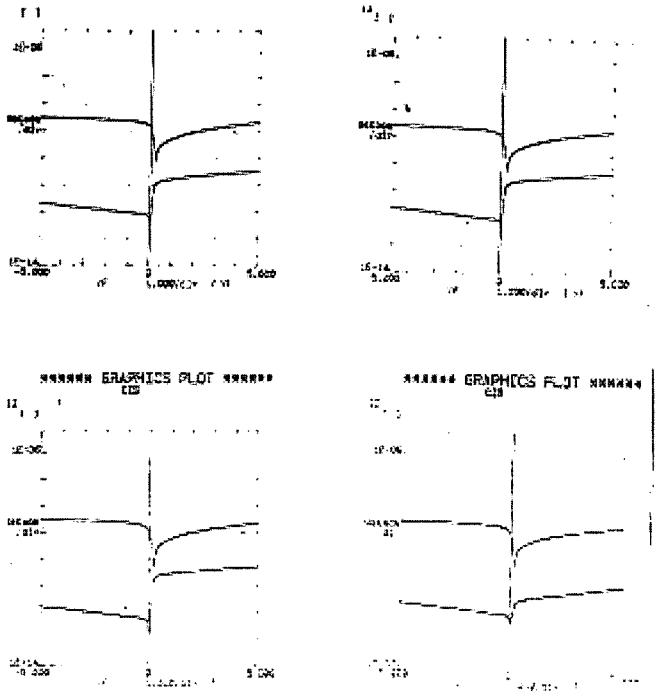

Fig. 5 Characteristics of Cr Silicide photodiode

IV. CONCLUSIONS

In this paper, we have fabricated optical diode device after forming Cr silicide thin film through thermal process. To improve characteristics and reliability of optical diode, we have deposited Cr metal thin film as lower electrode compared to conventional method. Generally, the amorphous optical diode with ITO/a-Si:H/Cr structure uses schottky effect.

From the experimental result, a-Si:H/Cr has quasi-schottky characteristics with barrier height of about 0.55eV. a-Si:H and ITO has schottky characteristics with barrier height of 0.93 eV. But, It makes unstable device characteristics because schottky effect in the layer of Cr and a-Si:H is not satisfied. The main factor is deposition method and process of Cr.

The main idea is that we can control and limit the dark current by inserting shallow Cr silicide layer between Cr and a-Si:H in this paper. We have measured dark current and optical current of Cr silicide optical diode. The performance is superior to conventional method. The process of fabrication is very simple and the reliability has improved.

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