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Advanced Ti Silicide Technology with Buffer Thin Al Layer

A. Kishi, T. Doi, S. Ohnisi, K. Iguti, K. Sakiyama*,
Jer-shen Maa**, and S.T.Hsu**

VLSI Development Laboratories,IC Group,SHARP Corporation,2613-1,Ichinomoto,Tenri,Nara 632,Japan
*) Process Development Center,IC Group,SHARP Corporation, 1 Asahi Daimon,Fukuyama,Hiroshima 632,Japan
**) Sharp Microelectronics Technology,Inc.,5700 NW Pacific Rim Boulevard,Camas,Washington 98607
Phone: (07436)5-4037,FAX:(07436)5-2774

1. Introduction

The self-aligned silicide (Salicide) process is a key technology to decrease the parasitic resistance of gate and source/drain region for 0.25μm devices and beyond. The suppression of silicide reaction with a narrow line width cause the rapid increase of sheet resistance , especially for As+ implanted region. The mechanism to suppress the silicidation is not understood well, however, it is believed the native oxide grown on As+ implanted layer and the oxygen atoms knocked into Si substrate suppress the silicidation. [1]

Considering from the thermodynamic property shown in Table. I . Al is easy to produce the metal oxide compared with Ti , that is , SiO_2 is smoothly reduced by Al during the heat treatment. In this study, the new technology to improve silicidation has been proposed with the use of Al/Ti bilayer films.

Table. I The thermodynamic property of Ti and Al oxide.

Oxide	Δ Hf kj/mol
TiO_2	-940
Al_2O_3	-1660

2. Experimental procedure

As+ions(50KeV,$3x10^{15}$/cm²) or B+ions (10keV, $2x10^{15}$ /cm²) were implanted through oxide film(20nm), then the samples were annealed at 1000°C for 10sec. After removing the oxide film in HF solution, thin Al films(1 ~ 5nm) and Ti films(55nm) were continuously deposited in vacuum by DC magnetron sputtering method and the samples were annealed at the temperature of 650°C in N_2 ambient. After removing Al films in H_2SO_4, 2nd anneal was performed at the temperature of 850°C.

3. Result and Discussion

Fig.1 shows the sheet resistance of the silicide layer as a function of Al thickness. The sheet resistance decreased

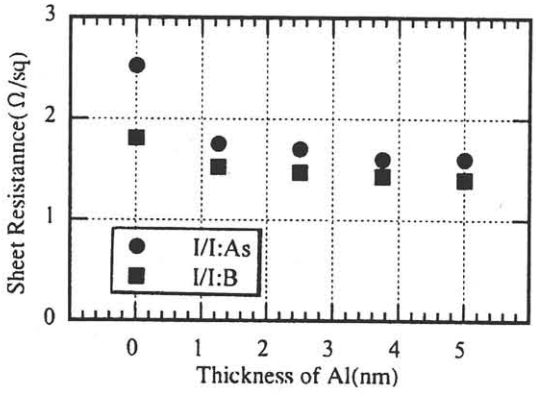


Fig.1 Sheet resistance dependance on Al thickness.

with the increase of Al thickness, especially for As+ implanted samples and indicated 63% value of Ti films at the thickness of 5nm. The morphology of $TiSi_2$ film was very smooth, and the voids or Al spikes were not observed at the interface between $TiSi_2$ and Si, as shown in Fig.2.

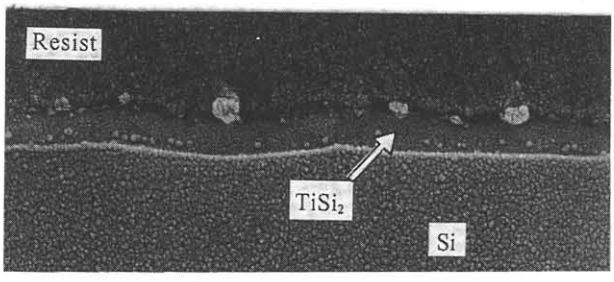


Fig.2 Crosssectional SEM micrograpf of silicide layer.

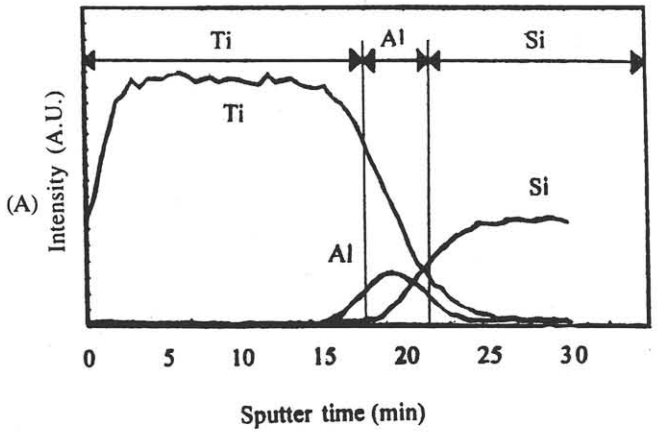
Table Ⅱ summarize the values of the sheet resistance, film thickness and the specific resistivity.

Table. Ⅱ The values of the sheet resistance, film thickness and the specific resistivity.

sample		Sheet	Silicide	Resistivity
Implantation	Film structure	Resistance (Ω/sq)	Thickness (Å)	($\mu\Omega$cm)
As	Al/Ti bilayer	1.62	880	14.3
	Ti monolayer	2.63	760	20.0
B	Al/Ti bilayer	1.49	920	13.7
	Ti monolayer	1.83	870	15.9

In the case of As+ implanted samples, the film thickness increased to the value of 16%, while the specific resistivity decreased to the value of 30% in comparison with the sample without Al film(Table. Ⅱ), indicating the value of 14 μΩcm which is close to the value of bulk $TiSi_2$ films. These results indicated that the silicide reaction was accelerated and also the film quality was improved by using the Al/Ti bilayer film.

Fig.3 shows the AES(Auger Electron Spectroscopy) spectra of as-deposited



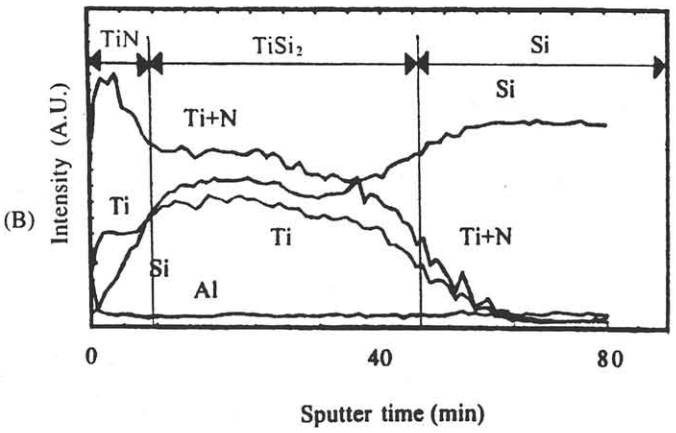


Fig.3 The AES profiles of as-deposited and after annealing samples
(A):as deposited
(B):after annealing

Al/Ti film and after annealing at 650°C. It was found that all of the Al layer on Si substrate moved to the surface of $TiN/TiSi_2$ film during annealing. From these results, the following mechanism is considered to improve the silicidation. At the initial stage of the reaction, the native SiO_2 film is reduced by Al films and simultaneously the Si atoms are absorbed from Si substrate to Al layers. The chemical affinity between Ti and Si is stronger than that between Al and Si, so the $TiSi_2$ is formed and Al layer are pushed up at the surface of TiN films.

4. Conclusions

The new technology to improve the Ti silicidation has been proposed by using Al/Ti bilayer film. The native oxide on n+Si substrate was easily reduced by thin Al layers. This effect enhanced the silicidation reaction and improved the film quality of $TiSi_2$ films. This technology may be applicable for the salicide process for 0.25μm process and beyond.

References

1. H. Kotaki,et al.: Jpn. J. Appl. Phys. 35(1996)1090.