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Sputtered Lead Silicate Glass Film for Multilevel Interconnections

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The use of multilevel interconnections is playing an important role for high density LSI's. The discontinuity and photofabrication difficulty of upper level metal layers are a formidable problem in fabrication of multilevel interconnections because of step height increasing. It is necessary to introduce a planarization which relieves step height and inclination. This paper describes a new sputtering in Ne ambient for bubble-free lead silicate glass film formation which is required for glass flow planarization, and a fabrication of 4-level interconnection on MOS devices using this glass film.

1. Sputtering for Lead Silicate Glass Film Deposition

The sputtering gives capability for multicomponent film deposition and improved controllability of film thickness. However, it was found on examination that under the practical condition, sputtering in Ar ambient is unable to form lead silicate glass film of about 1μm thickness required for multilevel interconnections, without bubble formation in the glass flow process. The reason assumed is that Ar introduced into the glass film in the sputtering process is unable to diffuse away from the glass film and, as a result, expands thermally in the glass film, because the diffusion constant of Ar in glass is very low.

He and Ne, on the other hand, have a higher diffusion constant, therefore preventing bubble formation. However, He is of no practical use because the glass deposition rate in He ambient is below 1/10 of that in Ar. Ne ambient with about 0.7 times the glass deposition rate of Ar is the most appropriate one for glass film deposition. Fig.1 shows experimental results for manifesting the sputtering ambient effect.

Lead silicate glass film sputtered in pure rare gas ambient has a lower Pb ratio than the target glass. It is necessary to bring the Pb ratio in the glass film close to that in the glass target for sufficient planarization. Mixing O_2 in the sputtering ambient is effective to increase the Pb ratio in the glass film[1] Because O_2 has the same order of magnitude of diffusion constant as Ar in glass, more O_2 mixture than 7.2% causes bubbles in the glass flow process. Table 1 shows the glass film deposition and flow conditions.

2. Fabrication of 4-Level Interconnections

The 4-level interconnection shown in Fig.2 was fabricated to verify the suitability of the lead silicate glass flow planarization for multilevel inter-

connections. The glass film thickness as deposited was about 1μm. As shown in Fig.2, the lead silicate glass film provides excellent planarization.

The 4-level interconnection similar to Fig.2 was fabricated on n-channel MOS devices with phosphorus doped polysilicon gate to evaluate the effects of this multilevel interconnection on active devices. Alkaline content of the glass target used was below 100 ppm, but no serious difference between this 4-level interconnection device and a single-level Al interconnection one has been observed on V_{FB}'s, junction leakage currents and junction breakdown voltages. The reason assumed is that the gettering action of conventional phosphosilicate glass under the lead silicate glass is effective.

Dielectric constant of the lead silicate glass film was about 8 and resistivity was over $10^{14}\Omega\cdot$cm.

3. Conclusion

A new sputtering in Ne ambient has been developed for lead silicate glass film deposition, preventing bubble formation in the glass flow process. A 4-level interconnection using this sputtered glass film has been observed to have no serious influence on active device characteristics.

Reference (1) P.D.Davidse and W.A.Pliskin, IBM Technical Disclosure Bullitin 12(1970) 1792.

Table 1. Lead silicate glass film deposition and flow conditions

Item		Content
Deposition	Sputtering System	RF Planar Magnetron
	Target Composition	PbO 45wt%, SiO_2 40wt% B_2O_3 10wt%, Al_2O_3 5wt%
	Sputtering Ambient	Ne 96.4%, O_2 3.6%, 0.23Pa
	Substrate Temp.	260°C
Flow		at 850°C for 30min in N_2

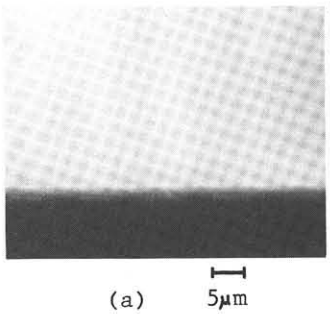

Fig.1. Sputtering ambient effect.
(a) Sputtered in Ne ambient and flowed. Glass thickness tg =1.36μm.
(b) Sputtered in Ar ambient and flowed. Glass thickness tg =0.96μm.

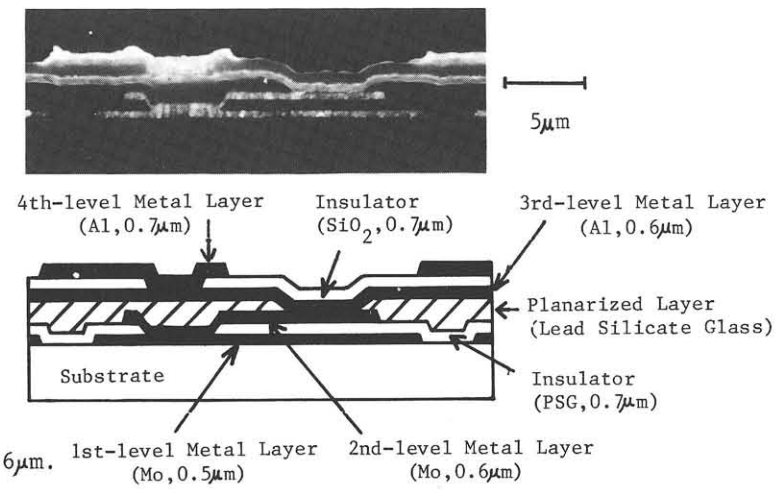

Fig.2. 4-level interconnection.