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Selective Chemical Vapor Deposition of Aluminum

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The selective deposition of tungsten has lately become of major interest for use in VLSI metallization systems.[1] However, aluminum has never been deposited selectively until now. The technology for realizing the selective chemical vapor deposition of aluminum onto silicon substrates and polysilicon patterns is described here.

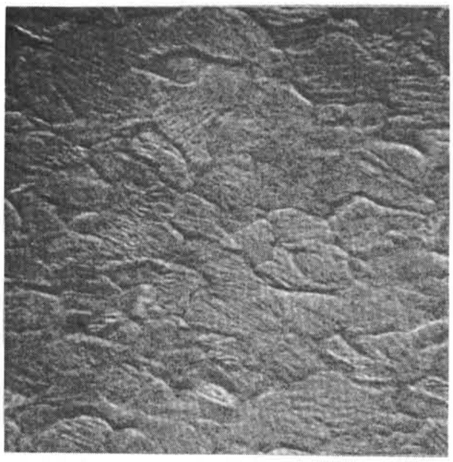
Aluminum films are deposited selectively onto silicon substrates with silicon dioxide patterns using a cold wall-type low pressure chemical vapor deposition (LPCVD) apparatus and a tri-isobutyl aluminum (TIBA) source. Substrate temperature should be low for successful selective deposition. Aluminum is deposited only onto silicon substrates and not onto silicon dioxide patterns. Typical substrate temperature and TIBA gas pressure are 250 °C and 0.5 Torr.

Figure 1 shows the surface topography of a 3000 Å aluminum film deposited on a silicon substrate. It can be seen that the film has a smooth surface and large, 5-10 μm grains. AES depth profiles of an aluminum film on a silicon substrate are shown in Fig.2. They indicate that the film is pure aluminum without detectable impurities such as oxygen or carbon. Also, interdiffusion between aluminum and silicon has hardly occurred. Figure 3 shows thickness dependence of deposited aluminum film resistivity. Film resistivities are approximately the same as the ideal bulk resistivity value for films thicker than 500 Å. Conventional CVD aluminum films have rough surfaces because of island formation in the initial stage of film growth.[2] Films in this work are not as rough as conventional CVD films. They are continuous and uniform even as thin as 500 Å.

Aluminum has been selectively deposited in via-holes on silicon substrates and polysilicon patterns. As shown in Fig.4, via-holes 0.5 μm in depth and 2 μm in diameter are completely filled with aluminum. Thicker films are needed for via-hole filling in multilayer metal systems. Aluminum nucleation is not observed on silicon dioxide even when aluminum thicknesses in via-holes are over 1 μm. Figure 5 shows 1000 Å thick aluminum films selectively deposited on polysilicon lines 1 μm wide. For shunt applications, aluminum should be thin to prevent aluminum-silicon reactions.

Selective deposition of aluminum has advantages over tungsten because the deposited films consist of a material widely used as interconnections. Also, film resistivity is less than 1/3, and selectivity is high. As a result, selective deposition of aluminum has many applications including planarization of multilayer systems and realization of MOSLSI polysilicon gate or source/drain shunts.

References
1) T.Moriya et al.,1983IEDM Tech. Dig. p550.
2) R.A.Levy et al.,J.Electrochem. Soc.Solid-St.Sci.and Tech.,131 (1984)2175.



5 μm
Fig.1 SEM micrograph of aluminum film deposited on a silicon substrate.

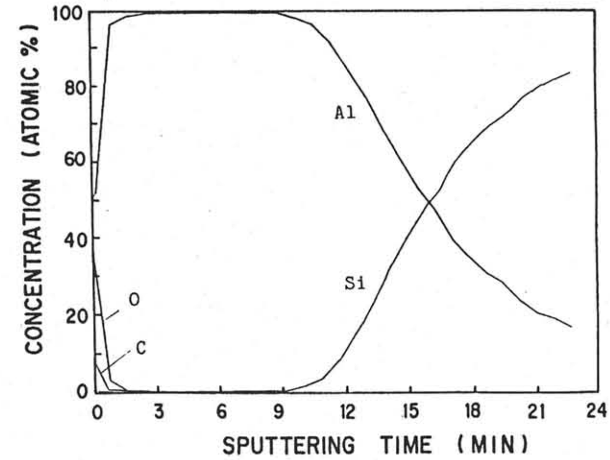


Fig.2 AES depth profiles of aluminum film deposited on a silicon substrate.

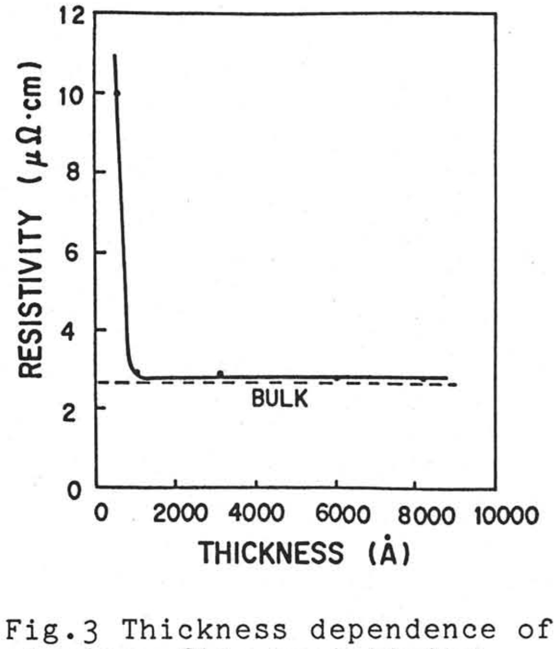
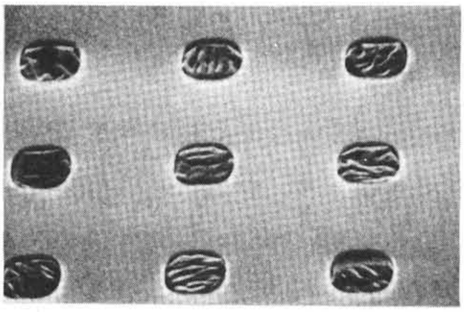
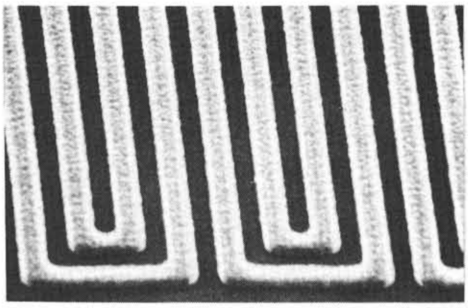


Fig.3 Thickness dependence of aluminum film resistivity.



5 μm
Fig.4 SEM micrograph of via-holes filled by selective aluminum.



5 μm
Fig.5 SEM micrograph of aluminum deposited on polysilicon lines. (Aluminum thickness: 1000Å)