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1960s

Using thin films of evaporated aluminum to form electrodes and wiring

~ Process Technology ~

In terms of electrical resistivity, Al is lowest after silver, copper, and gold, and taking into consideration to the cost, resistance to oxidation, good adhesion to SiO_2, and the absence of adverse effects on Si characteristics (lifetime etc.), it was the optimum material for the electrode of semiconductor devices. Besides electrode material application in bipolar silicon transistors, it was also used as a gate electrode material of MOS transistors. And it continued to be used as the interconnect material in IC and LSI which evolved afterwards. In the latter half of the 1990s, Cu based materials started to be used as the interconnect metal in advanced LSIs, but Al-based materials are still used in many semiconductor devices.

Resistive heating evaporation method and electron beam evaporation method were used for film formation of Al. In the 1960s, a resistive heating vapor deposition method using a tungsten heater/crucible was used, but in the 1970s, the mainstream of production shifted to the electron beam evaporation method. In this method, Al placed in a crucible is irradiated with an electron beam and heated, and the evaporated Al is deposited on a wafer placed in the same chamber. There was a problem that the threshold voltage of the MOS transistor shifted due to the X ray emitted when the electron beam was irradiated to Al, but this could be solved by applying a low temperature heat treatment process.

As the miniaturization progressed, problems were encountered such as Al penetration through the diffusion layer at the Al-Si contact area by the inter-diffusion of Si and Al, and migration of Al interconnect layer, and the countermeasures were taken by mixing trace amount of Si or Cu. The controlled mixing of these impurity could not be realized in vapor deposition method, and film formation by sputtering became mainstream in the late 1970s.

Reference:

1）S. M. Sze “VLSI Technology” 1983

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