

Comparison of Silicides

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Silicides are highly conductive materials formed by alloying silicon with selected metals. They are commonly used in Si integrated circuits to form ohmic contacts. For instance, ohmic contacts to source and drain in Si CMOS ICs are made almost uniquely using silicides. Silicide contacts are typically formed by the deposition of metal thin-film (thickness x) on Si surface in the contact area (Fig. 1a). Then, wafer is subjected to the sintering (annealing) process in the course of which Si-metal alloy (silicide) is being formed (Fig. 1b). Subsequently, the unreacted metal remaining on top of the silicide is removed and the process of contact formation is completed (Fig. 1c).

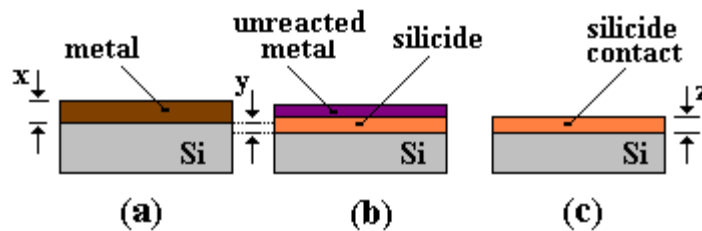


Fig. 1

The advantage of silicides over some metals (e.g. Al) lies in their superior resistance to temperature. On the other hand, very low resistivity of silicides is their advantage over the polycrystalline Si. Several metals form alloy with silicon. The first order criteria for selection of metals to form a silicide are based on the resistivity of silicide, sintering temperature (lower the better), depth of alloy penetration into Si, thickness y in Fig. 1, (shallower the better considering drastically scaled down depth of S and D regions), and the amount of metal needed to form a silicide (thickness x in Fig. 1).

The most frequently used silicides in advanced ICs are silicides of titanium (TiSi_2), cobalt (CoSi_2), and nickel (NiSi). **Table** below compares key characteristics of these three silicides. As numbers shown suggest (*Note: numbers shown are approximate*), in most applications the NiSi is likely to be a preferred choice due to the lowest sintering temperature and shallowest penetration of Si by the alloy formed. This last feature makes NiSi compatible with Fully Silicided (FUSI) gate process in advanced CMOS ICs.

SILICIDE	Thin Film Resistivity ($\mu\Omega\text{-cm}$)	Sintering Temp. ($^{\circ}\text{C}$)	Max. Thermal Stability on Silicon, ($^{\circ}\text{C}$)	nm of Si/ nm of metal
TiSi_2	13 - 16	700 - 900	~ 900	2.25
CoSi_2	14 - 20	700 - 900	~ 950	3.65
NiSi	14 - 20	400 - 700	~ 650	1.85