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Around 1990

Usage of shallow junction and silicide source/drain techniques

Process Technology ~

The CMOS transistor has continued miniaturization following the scaling rule and has achieved high performance. However, as it entered the 0.35μm generation, performance improvement came to be limited even when scaling was done. One of the causes was an increase in the parasitic resistance of the gate electrode and the source/drain diffusion layers. In order to solve this problem, SALICIDE (Self-Aligned siLICIDE) technology came to be used.

Salicide is a technique of forming metal silicide on silicon or polysilicon surface in a self-aligned manner. After forming transistors, a metal is deposited and heat treatment is applied to make it selectively react with the exposed Si surface to form a metal silicide. The metal film on the insulating film is then removed and a self-aligned metal silicide is formed. Historically it was not new, but its practical application started from 0.35μm CMOS generation.

It was first applied to $TiSi_2$, titanium (Ti) and Si alloy. Since the diffusing element is Si, Si diffuses also into Ti on the insulating film, forming $TiSi_2$ after prolonged heat treatment. In order to avoid this, heat treatment at a high temperature for a short period of time, that is, RTP (Rapid Thermal Process) technology, was necessary for the alloy formation.

As the miniaturization progressed, the phenomenon called a thin line effect occurred in which $TiSi_2$ stopped transition to a low resistance phase. Although a high temperature heat treatment was necessary for the phase transition, agglomeration occurred when a high temperature process was used, and there arose a problem that the appropriate process temperature range for the stable formation of $TiSi_2$ was extremely narrow. Although the problem could be alleviated by making the Si surface amorphous, from the 0.18μm generation onwards, $CoSi_2$ alloy of cobalt (Co) and Si which did not have these problems came to be used.

However, there is also a problem with $CoSi_2$. In the reaction between Co and Si, since the diffusion species is Co, Co easily penetrates into Si in a spike shape. It breaks through the shallow junction and leakage current increases in the further miniaturization of processes. As a result, NiSi is adopted in 0.1μm and beyond. As described above, advancement of salicide technology is indispensable for realizing further miniaturization and high performance.

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