HIGH RESOLUTION INVESTIGATION OF ATOMIC INTERDIFFUSION DURING Co/Ni/Si PHASE TRANSITION

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Cobalt disilicide is now replacing titanium in the silicon technology to form highly conductive narrow lines on the gate stack of modern Metal-Oxide-Semiconductor devices (MOS). Nevertheless, further scaling down of device dimensions is giving as a critical concern the consumption of silicon on the active area and the process window for the silicide to be formed[1]. Silicides formed by Co/Ni/Si reaction are the future challenge for CMOS technology due to the low thermal budget and the expected lower silicon consumption[1,2] with respect to conventional systems. Nevertheless, in largely scaled systems compared to what is known on thick Co/Ni bilayers[3,4] , phase transformation could return to be a main concern. In this work we studied the phase transition of Co/Ni thin films on amorphous silicon using a novel approach based on *in situ* sheet resistance analyses during isothermal annealing processes, and on *ex-situ* microscopy analyses using Energy Filtered Transmission Electron Microscopy (EFTEM) and Selected Area Electron Diffraction (SAED).

Compared to conventional Co/Si systems, Co/Ni/Si reaction produces a double-peak in the resistance curve versus time at a fixed temperature of annealing (Fig.1) The occurrence of this double peak has clearly indicated some critical stages during silicide formation. At the beginning, cobalt atoms remain confined at the surface while nickel reacts with silicon hence producing the occurrence of the first resistance peak. The second peak is instead related to the cobalt atoms diffusing through the grain boundaries of the underlying Ni_2Si layer, converting Ni_2Si in a continuos CoSi film and forming pipelines through the underlying NiSi downwards the substrate. As a result, a ternary compound nucleates in contact with silicon as it is shown in Fig.2 by the atomic maps of cobalt and nickel. The final structure at the plateau of the resistance curve is a multilayer of CoSi/NiSi/$Co(Ni)Si_2$, differently from the case of Co/Ni thick-layer reaction.

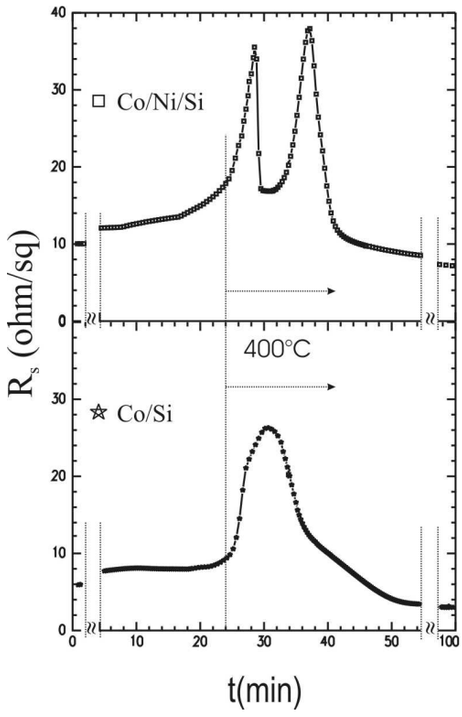

Figure 1 Sheet resistance vs annealing time during silicide reaction. Co/Ni/Si phase transition produces a double peak in the transition curve.

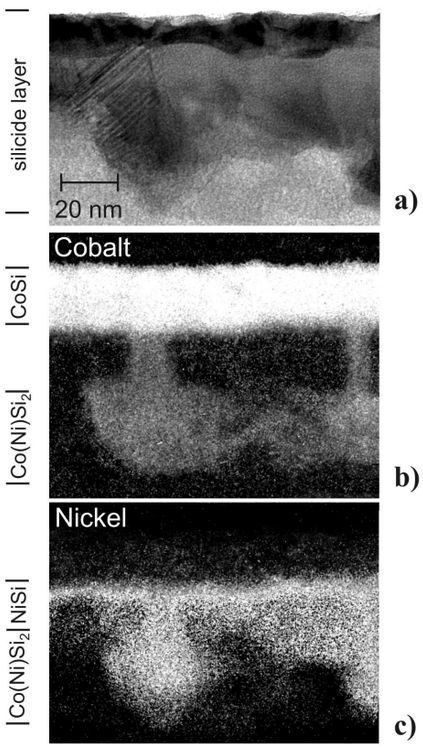

Figure 2 Silicide formed at the plateau of the Co/Ni/Si resistance curve after 220 min annealing at 400°C: a) TEM cross sectional view b) the corresponding cobalt and b) nickel map by EFTEM. Cobalt atoms move through pipelines towards the substrate.

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