The Study of Nickel Silicide film on Dielectric by Nickel and Tantalum Alloy.

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Self-aligned silicide (SALICIDE) is one of the most indispensable techniques for high-performance CMOS fabrication. The Ni-silicide has several advantages for this application. They are low temperature silicidation process, low silicon consumption, smaller contact resistance for both n- and p-Si, no bridging failure property, no adverse narrow line effect on sheet resistance and smaller mechanical stress. Because of these advantages, Ni-silicide has become the promising candidate for the CMOS process. In order to apply to the further use, the silicide formation and thermal stability of Ni film and Ni-Ta alloy films were investigated.

The p-type (100) Si wafer was used as substrates, and this wafer was cleaned by standard RCA cleaning method and diluted HF dipping. Ni single film and Ni-Ta alloy film were deposited on the substrate by DC magnetron sputter. Silicide formation process has been performed by using RTP(Rapid Thermal Process). After silicidation process as increasing RTP temperature (500°C ~ 900°C), we measured sheet resistance and analyzed the microstructure of the interface by using TEM and phase transition with XRD. And post annealing was performed in the furnace to investigate thermal stability of two different systems. We compared the silicide formation on the dielectric materials with silicidation on Si substrate. After depositing $Ni_{1-x}Ta_x$ alloy film on SiO_2 and Si_3N_4 thin film, Ti capping and RTP process was performed. Subsequently, wet etching was done to confirm the existence of unreacted metal.

We measured sheet resistance of pure Ni/Si and $Ni_{1-x}Ta_x$/Si system with different composition of Ta as increasing RTP temperature. It is observed that addition of Ta is effective to keep lower sheet resistance than pure Ni silicide in higher RTP temperature range. Corresponding to the results of sheet resistance, Ni-Ta/Si system shows an improved thermal stability and microstructure than Ni/Si system in higher RTP temperature. After first annealing by RTP at 500°C, After first annealing by RTP at 500°C, post anneal were performed at the different temperature to examine thermal stability on Si substrate. In case of Ni-Ta/Si system has a stable and low sheet resistance of about 5Ω/sq. and silicide is still NiSi layer for 120min long time annealing at 600°C. But, the sheet resistance of Ni/Si system goes up as increase of annealing time due to formation of $NiSi_2$ in Ni/Si system. We investigated the interface reaction between Ni-Ta alloy film and dielectric materials for the application to silicide process. After annealing of $Ti/Ni_{0.95}Ta_{0.05}/SiO_2/Si$ and $Ti/Ni_{0.95}Ta_{0.05}/Si_3N_4/Si$ systems at 500°C, wet etching at 85°C was done by H_2SO_4+H_2O_2 solution. After metal strip, sheet resistance goes up rapidly about 10E7~10E8 Ω/sq. It is noticed that there is no formation of silicide. Corresponding to the results of sheet resistance, it was confirmed that unreacted metal films on dielectric materials can be etched off through the SEM image. Therefore, it was established that addition of Ta can improve thermal stability and Ni-Ta salicide can be applied to CMOS due to selectivity of growth on poly-Si lines and bulk Si. In addition, thermal stability and salicide formation of pure Ni and Ni-Ta alloy films on poly-Silicon will be discussed.

REFERENCE

1. Karen Maex and Marc Van Rossum, “PROPERTIES OF METAL SILICIDES”, INSPEC, the institution of Electrical Engineers, London, United Kingdom, (1995).

2. J.F.Lin, H.B. Chen, J.Y.Feng and J.Zhu, “Improvement of the thermal stability of NiSi films by using a thin Pt interlayer”, Appl. Phys. Lett., 77 2177 (2000)