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Silicidation Properties of Atomic Layer Deposited Nickel Film using by Rapid Thermal Process

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$MoSi_2$ as a contact barrier material was used for DRAM in early 1980s. Then, WSi2 was popularly used for the gate electrode of logic LSIs from the middle of the 1980s due to low sheet resistance. $TiSi_2$ was popularly introduced into mass production, because the sheet resistance is further smaller than WSi_2. However, $TiSi_2$ was eventually found to be relatively difficult material to treat depending on thermal process. Thus, $TiSi_2$ has been eventually replaced by $CoSi_2$ from the late 1990s making the process more suitable towards deep-sub micron CMOS. However, these materials have been reported to cause some problems such as the increasing series resistance of the device at the technology node of less than 65 nm. Nickel silicide is considered to be one of the most suitable materials for aggressively scaled structure. This material has many advantages such as low process temperature, mid-gap work function, and one step annealing process. Silicon consumption during the silicidation is the smallest among Ti, Co, and Ni. This is suitable for ultra shallow S/D junction formation for scaled CMOS. There are many formation methods for nickel silicide such as e-beam evaporation and radio frequency sputtering etc. However the methods are not suitable for low sheet resistance, high thermal stability and good surface morphology. We adopted atomic layer deposition (ALD) method and rapid thermal process for high quality film properties.

In this work, nickel silicide film was obtained from nickel by rapid thermal process(RTP). Nickel was deposited by ALD with Bis-Ni precursor and H_2 reactant gas at 220℃. We investigated silicidation properties of ALD nickel by using RTP with temperature range from 400℃ to 900℃ in nitrogen ambient. The crystalline properties of the films with various annealing temperature was analyzed by using XRD and HRTEM. The atomic concentration of the nickel silicide was analyzed by using Auger depth profile and the surface morphology of the film was measured by using atomic forced microscopy.