Controlling Nickel Silicidation Process of Si Nanowires by Ar^+ Ion Irradiation

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Introduction Si nanowire(Si-NW) FET is attractive device structure owning to their immunity to short channel effect. Series resistance due to their small geometry should be solved. Replacing the doped source/drain(S/D) with metal silicides, e.g. Ni silicides, is a candidate solution. However, surface diffusion of Ni in the vicinity of Si/SiO_2 interface[1] and excess growth of Ni silicides into NWs[2] are the bottleneck in device fabrication. Controlling Ni silicidation process of Si-NWs is one of the most important issues. We have reported that Ni silicidation rate in Si-NW is likely to be affected by crystallinity of Si-core[3]. In the paper, we investigate the impact of Si crystallinity on Ni silicidation rate of Si-NWs, using Ar^+ ions irradiation process.

Experiment <100> oriented Si-NWs are fabricated on lightly p-type doped (100)SOI substrates. NWs are fabricated by EB-Lithography, ICP-RIE and thermal oxidation in dry O_2 ambient at 850°C for 3h. After oxidation, Ar^+ ions are irradiated at 25kV with a dose of $1.0\times10^{14}cm^{-2}$. A part of samples are annealed at 950°C for 10min, and we refer the process as recovery annealing in the discussion later. Then, the oxide layer is partially removed by BHF and TiN(20nm)/Ni(20nm) are deposited by ion sputtering. Ni silicide is formed by annealing at 410°C for 15min. The unreacted residual TiN/Ni are removed by SPM. Process A does not include the Ar^+ ions irradiation process. Process B includes the Ar^+ ions irradiation without crystal recovery annealing. Process C includes the Ar^+ ions irradiation and crystal recovery annealing.

Results and Discussion Figure 1 shows SEM image of silicided NWs. The yellow dotted line is Ni silicide/Si interface. The Si/Ni_xSi_y interface fabricated by process A and B has a parabolic shape, and the interface fabricated by process C has flat shape. From these results, it is considered that the atomic disorder in the vicinity of Si/SiO_2 interface is repaired by crystal recovery annealing after Ar^+ ions irradiation.

Figure 3 shows the result of measured Ni silicidation length(λ) versus inverse of NWs width(1/W). The Ni silicidation length of NWs fabricated by process B is increased, which is attributed to the enhancement of the lattice disorder induced by the Ar^+ ion irradiation. The Ni silicidation rate of process C is suppressed because crystallinity of Si lattice is recovered by the post annealing. Thus, the Si/Ni_xSi_y interface shape and Ni silicidation rate of NWs can be understood by the crystallinity of Si-NWs.

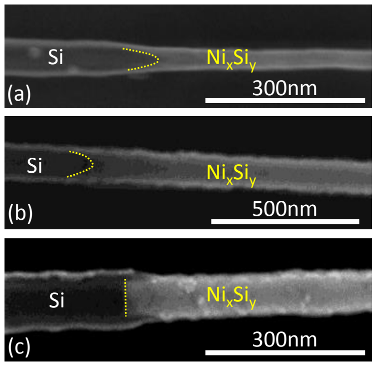

Figure 1 SEM image of silicided NW of (a)Process A, (b)Process B, (c)Process C and (d)schematic of silicide NW.

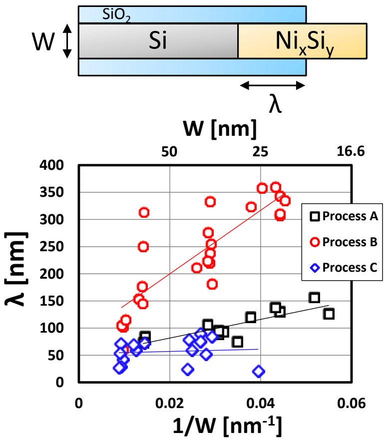

Figure 2 Schematic of silicided NW and Silicidation length λ versus inverse of NW width 1/W for three types of processes.

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Reference: [1]A. Katsman et al., J. Electro. Mater., **39.4**, 365-370(2010). [2]H. Arai et al., ECS Trans., **25(7)**, 447-454(2009). [3]S. Hashimoto et al., 27th International Microprocesses and Nanotechnology Conference(2014).