Annealing Reaction for Ni Silicidation of Si Nanowire

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Abstract

Silicidation of Si Nanowire (Si NW) has been investigated. In order to estimate the activation energy for Ni silicide of Si NW, the encroachment length of Ni silicide from the edge of exposed Si NW was measured by SEM images. The activation energy of Ni silicidation into 12nm x 17nm (110) Si NW was 0.95eV. Similarly, the activation energy of Ni silicidation into 8nm x 12nm (100) Si NW was 0.90eV. They are smaller than 1.23eV [1] which is the activation energy of Ni silicidation for (100) bulk Si.

Introduction

Si NW FET is one of the promising candidates for enhancing MOSFET performance in the future. In order to reduce parasitic resistance, the silicidation of source /drain regions is a very effective method [2]. Silicidation has been performed on Si Nanowire FET [3-5], however it is still not clear whether the mechanism of the silicidation of Si NW is different from that of bulk Si. We investigated Ni silicidation of Si NW by reacting them with Ni films with the thickness around 10nm.

Experiments

Si NW was fabricated by lithography and thermal oxidation. Oxide around Si NW was partially removed by HF solution. 10nm Ni film was deposited on exposed Si NW by magnetron sputtering in an Ar ambient. Rapid thermal annealings (RTA) at various temperatures were performed. Unreacted Ni film was removed by SPM (mixed H_2SO_4 and H_2O_2). Ni silicide encroachment into Si NW was observed and measured by SEM.

Results

We fabricated <110> and <100> Si NW with the diameter of approximately 10nm~30nm. Figure 1 show cross-section TEM views of Si NW after thermal oxidation.

Figure 2(a) shows the temperature dependence of Ni silicide encroachment length after RTA. The annealing time duration was 30s. As temperature increases, the length of Ni silicide λ increases, irrespective of the NW orientation. Figure 2(b) shows Arrhenius plot of NWs with both orientations. We estimated the activation energy of Ni silicide into Si NW by this plot. Calculated activation energy of <110> and <100> Si NW were 0.95eV and 0.90eV. The cross-sectional areas were 204nm^2 and 96 nm^2, respectively. Dependence of cross-section area respectively activation energy was small.

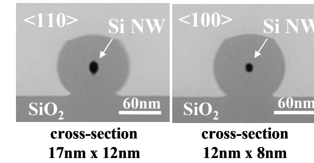

Fig. 1 <110> and <100> Si NW after thermal oxidation.

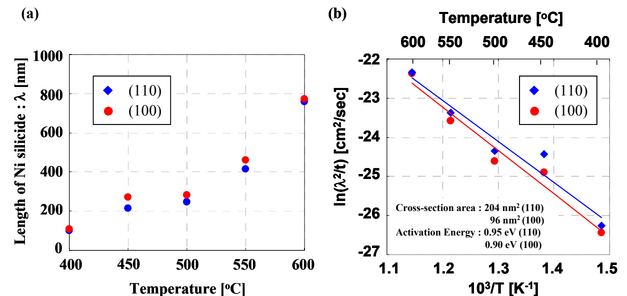

Fig. 2 (a) Ni silicide Encroachment length dependence on annealing temperature. The annealing time duration was 30s. (b)Arrhenius plot of Ni silicide into Si NW.

Conclusions

Ni and Si NW react to form Ni silicide at temperatures around 400 °C~600°C. Activation energy of <110> and <100> Si NW were estimated to be 0.95eV and 0.90eV, respectively. They are smaller than that for bulk Si silicidation. This difference revealed that the microscopic silicidation mechanism of NW differs from that of the bulk. It may come from the difference of the strain imposed in NW by the thermal oxidation process.

Acknowledgement

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