Suppression of Lateral Encroachment of Ni Silicide into Si Nanowires using Nitrogen Incorporation

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Abstract

Full silicidation of source/drain (S/D) for Si nanowire metal-oxide-semiconductor field effect transistors (MOSFETs) has been investigated[1]. It has been reported that the full-silicidation leads to excessive Ni diffusion into Si Nanowires（NWs） covered by oxide films[2]. In order to suppress the lateral encroachment of Ni silicide, we incorporated nitrogen in Ni films prior to the silicidation.With this method, it is confirmed that the encroachment of Ni silicide was successfully suppressed.

Introduction

Si NW FET is one of the promising candidates for high-speed LSI devices in the future. In order to reduce the parasitic resistances of Si NWs, the silicidation of the S/D regions is a very effective method [1]. However, it has been reported that the full-silicidation leads to excessive Ni diffusion into Si NWs [2] and this phenomenon may lead some adverse issues such as excessive Ni silicidation encroaches the channel region. Therefore, it becomes impossible for the gate to control when becoming a conduction state. On the other hand, there is a report that the diffusion of Ni could be suppressed by nitrogen incorporation into the Ni film prior to the silicidation. [3].We applied this method for Ni full-silicidation of Si NW and investigated the reasons for the suppression.

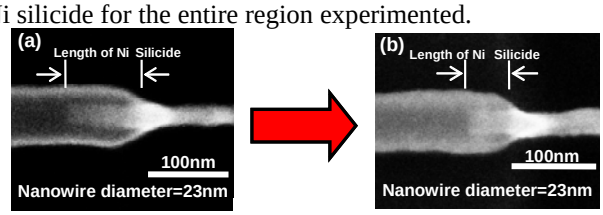
Experiments

Si NWs were fabricated by the formation of Si narrow islands in the SOI layer followed by the thermal oxidation. Oxide around Si NWs was partially removed by HF solution. 6nm Ni films were deposited on exposed Si NWs by magnetron sputtering in an Ar or Ar/N_2 (Ar: N2=1:1) mixed ambient. Rapid thermal annealing (RTA) at 400°C for 30 sec was performed for the silicidation. Unreacted Ni films were removed by SPM (mixed solution of H_2SO_4 and H_2O_2). Ni silicide encroachments into Si NWs were observed and measured by SEM.

Results

Fig.1 shows SEM images of the encroachment of Ni silicide in Si NWs. Bright portions of Si NWs, which correspond to Ni Silicide encroachment. Ni Silicide encroachment could be suppressed in Si NW for the nitrogen incorporation.

The length of Ni silicide encroachment on NWs diameter is shown in Fig.2.The length decreases, as NWs diameter decreases possibly due to the strain in NWs, however, the nitrogen incorporation suppressed lateral encroachment of Ni silicide for the entire region experimented.



(a)Without N_2 **(b)with N_2**

Fig. 1 SEM images of Si NWs after Silicidation. Encroachment length of Ni Silicide decreased in the nitrogen incorporation method.

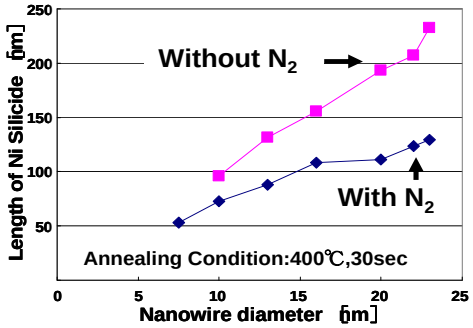


Fig. 2 Encroachment length dependence on the NWs diameter. Ni silicide with and without nitrogen incorporation in Ni films prior to the silicidation is compared.

Conclusions

The encroachment length of Ni silicide into Si NWs was dramatically suppressed by the nitrogen incorporation into Ni film prior to the silicidation. This effect may come from the retardation of the silicidation by the formation of Si nitride layer at the Si NWs surface or by the creation of Ni-nitrogen bonding in the Ni film.

Acknowledgement

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References

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