DOI: 10.1017/S1431927603443857
Microsc Microanal 9(Suppl 2), 2003

Problems Concerning Application of Electron-Holography Observation of P-N Junctions from the Viewpoint of the Semiconductor Industry

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Since two-dimensional electric-potential distributions were successfully observed, application of electron holography to the semiconductor industry has been one of the hottest topics in recent years. However, such application requires high accuracy and consistency of the measurement. Accordingly, the present study investigates some of the problems concerning p-n junction observation from the viewpoint of applying electron holography to the semiconductor industry.

Uniformity of specimen thickness is the first requirement for acurate measurement of electric-potential distributions. For example, since the mean inner potential of silicon is around 12V, 1% of thickness distribution causes a potential error of approximately $\pm$0.1V. This implies that, if the accuracy of potential measurement of silicon should be higher than $\pm$0.1 V, the thickness variation of the specimen must be less than $\pm$1%. This requirement represents a very difficult problem for TEM specimen preparation. The second problem is specimen damage induced by the ion beam bacause ion beams form amorphous layers and electrically dead layers on the surface of a TEM specimen.

In the present experiment, a specimen having a p-n junction was fabricated by arsenic ion implantation into a silicon wafer with a boron concentration of 10^{15} cm^{-3}. Then, wedge-shaped TEM specimens containing Si/Si p-n junctions were prepared by focused ion beam (FIB). Figure 1 illustrates a schematic of such specimen. Figures 2(a), 2(b), and 2(c) show phase maps of the specimen having a wedge angle of 20, 30 and 45 degrees, respectively. Each figure indicates that the junction is 200nm from the original wafer surface. This observed distance does not agree with the theoretically calculated value of 380nm. The reason for this disagreement is unclear at present, but we suspect that a small amount of gallium ions might be working as a p-type dopant in the silicon.

In summary, thickness distribution and ion-beam-induced damage are major problems facing application of electron holography to the semiconductor industry. Further technical development on preparing specimens with uniform thickness and less damaged layers is therefore necessary.

References

[1] W. D. Rau et al., Phys. Rev. Lett. **82**, (1999) 2614.
[2] Z. Wang et al., Appl. Phys. Lett. **80** (2002) 246.
[3] Z. Wang et al., Appl. Phys. Lett. **81** (2002) 478.
[4] Sections of this work were performed as part of the Active Nano-Characterization and Technology Project, using Special Coordination Funds from the Ministry of Education, Culture, Sports, Science and Technology of the Japanese government.

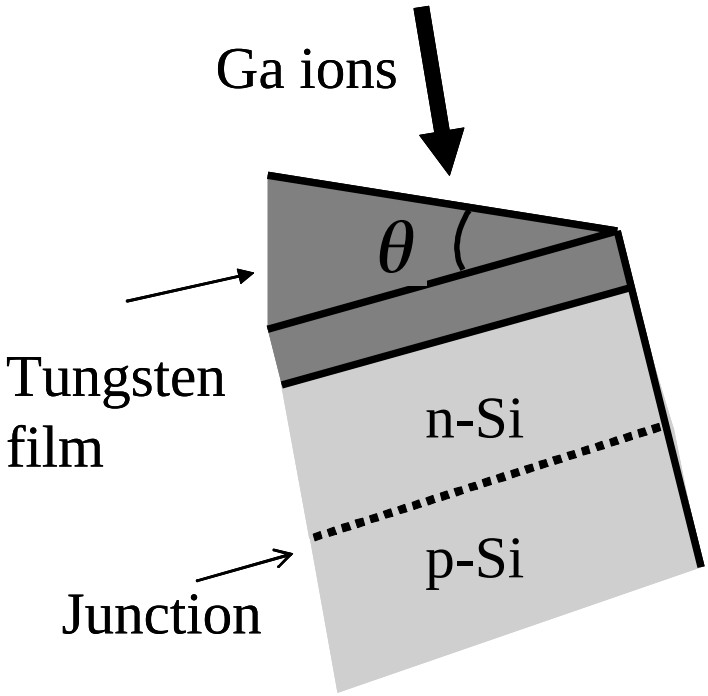

FIG. 1. Wedge-shaped TEM specimen containing a Si/Si p-n junction prepared by focused-ion-beam.

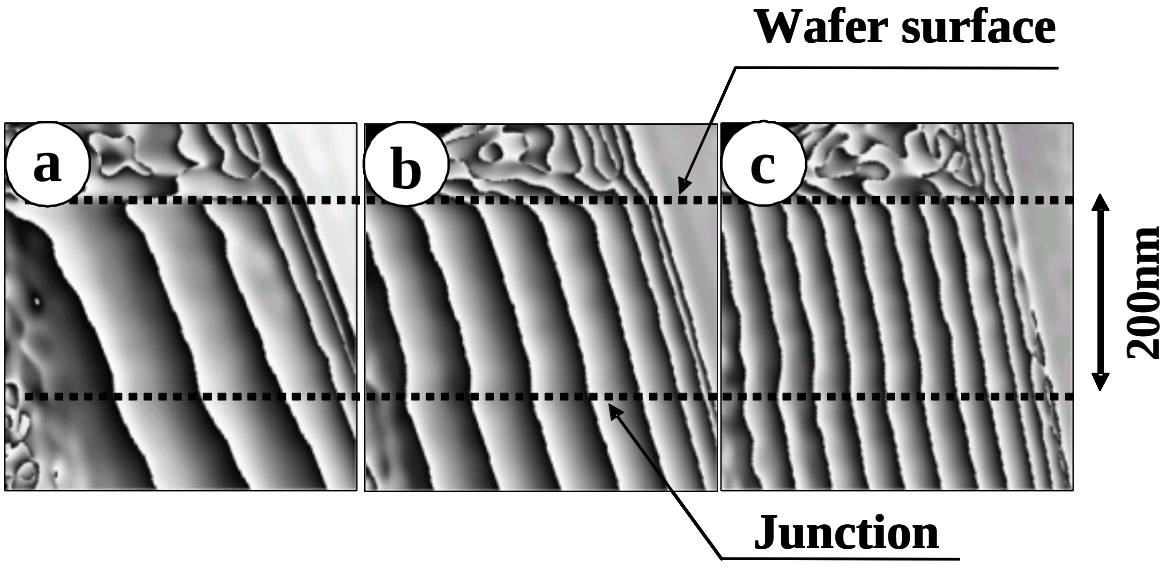

FIG. 2. Phase maps of wedge-shaped specimens containing a Si/Si p-n junction (wedge angles: (a) 20 ° , (b) 30 ° , (c) 45 °).

https://doi.org/10.1017/S1431927603443857 Published online by Cambridge University Press