AFM/STM Investigation of pn Junctions Formed by Ion Implantation

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To accurately determine the shape of the lateral part of pn junction, the applied analysis techniques should have a two dimensional resolution in the 10 nm range, and it should also be able to discriminate between the pand n-type material in the $10^{15} \sim 10^{16}$ cm⁻³ range. At the present time the conventional analysis techniques; angle lapping and staining, angle lapping and etching, and spreading resistance, all do not satisfy both of these criteria.

With its extremely high lateral resolution, scanning tunneling microscopy (STM) and atomic force microscope (AFM) may offer powerful new tools for device analysis. Several researchers have reported work involving the use of STM to delineate pn junction. An atomic force microscope (AFM) was also used to measured the tip-sample capacitance over a pn junction.

In this paper, by using the scanning force/tunneling microscope (AFM/STM)¹⁾ under the constant force mode, we investigate the ion-implanted pn junction. We obtained the topographic and the conductance images separately and simultaneously at the same area of the surface with high resolution. We clearly observed the inhomogeneity of the surface conductance, which directly reflected the differences in the electric properties of the implanted and substrate regions. We further investigate the variation of the inhomogeneity of the surface conductance as a function of the bias voltage. As a result, it has been demonstrated that the AFM/STM is an efficient and precise tool for delineation of electrically dissimilar surface structures such as pn junctions.

Reference:

1) Y.Sugawara et al., Jpn. J. Appl. Phys., Vol. 29, 1990, p. 1539.



(a)



Fig. 1 (a) ATM topographic and (b) STM conductance images of the pn junctions, formed by the implantation of arsen into Si $\langle 100 \rangle$ wafer. The substrate was doped p type with boron at a concentration of 10^{15} cm⁻³. Doses of 3×10^{15} atoms per cm² were implanted at an energy of 60 keV. Bias voltage of the conductive lever was V_T =-100mV.