Screened Coulomb potential around charged defects on GaAs(110) imaged by Light-Modulated Scanning Tunneling Microscopy

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As the size of electronic-devices shrinks to the nanometer scale, the electronic properties of semiconductors are significantly influenced by individual defect and impurity, and understanding their atomic scale electronic property has become extremely important. Scanning Tunneling Microscopy (STM) has an excellent potential in identifying individual defects and impurities, providing opportunity to explore their characteristics.

In this study, we performed "Light-Modulated Scanning Tunneling Spectroscopy (LM-STS)"[1] to investigate the electrostatic-potential variation in semiconductors with a spatial resolution down to the single point defect level. Surface photovoltage (SPV) measured by LM-STS was used to visualize the nanoscale electrostatic-potential variation with respect to point defects and charged steps.

Figure (a) shows an STM image of Ga vacancy on a n-GaAs(110) surface (Si-doped, 2 x 10^{-18}cm^{-3}) and the corresponding SPV image obtained at Vs = +1.7V is shown in Fig. (b). SPV increases as the STM tip approaches to the vacancy due to the screened-coulomb potential (= SCP) around the negative charge trapped at the center of the vacancy. Through the fitting of the cross-sectional profiles of the SPV image using the SCP formula with a parameter of charge state n (Fig. (c), n = -1e to -3e),

$$SPV(r) = \frac{ne}{4\pi\varepsilon_0\varepsilon_s r}\exp(-r/R_s) + SPV_{TIBB}$$

the charge of the Ga vacancy was determined to be -3e. These results are consistent with the result of the recent positron annihilation experiment[2].

Other applications of LM-STS will be discussed together.

Reference:
1) S. Yoshida et al,. Phys. Rev. Lett. 98, 26802 (2007)
2) J.Gebauer et al,. Phys. Rev. B. 67, 235207 (2003)

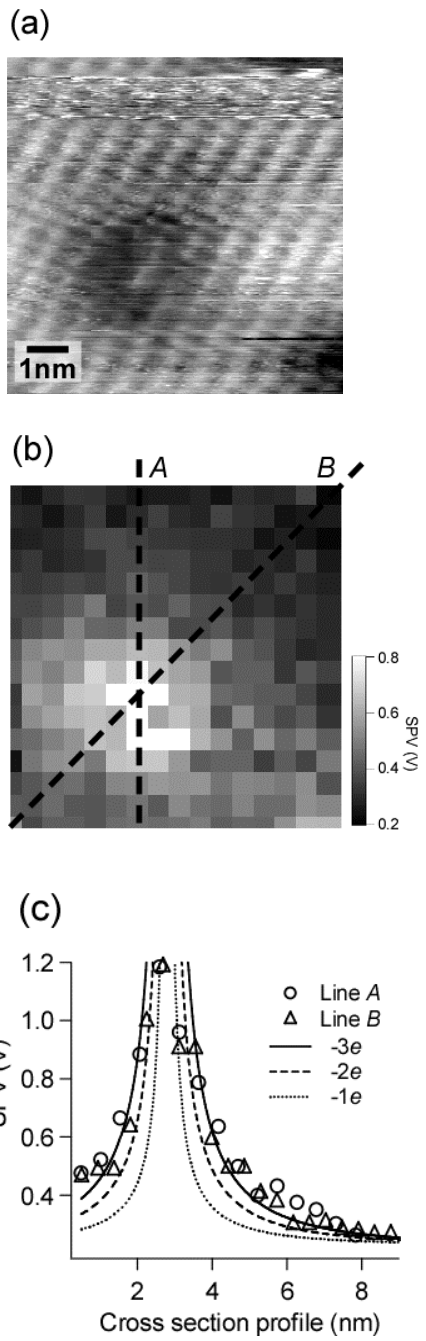

Fig (a) STM image of Ga vacancy (*V*s = -1.8V, *I*t = 80pA) (b) SPV image (Vs = +1.7V) (c) Cross-sectional profiles of the SPV image along the lines A and B in (b), and theoretical distributions of SCP calculated for n = -1e ~ -3e.