(P1-20)

Observation of elastic softening associated with vacancies in crystalline silicon

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Silicon monocrystalline includes fewest impurity and is known as ideal crystal. Small amount of vacancies and silicon intersticial, however, are included in silicon monocrystalline. These defects prevent from miniaturization of devices in semiconductor device developing which is required high completeness in silicon monocrystalline.

The defect molecular orbitals of the vacancy at a tetrahedral T_d symmetry site split into a node-less singlet ground state with Γ_1 (A_1) symmetry and an excited triplet state with Γ_5 (T_2) symmetry.[1] In non-doped FZ silicon, charge state V^0 with paired spin shows non-magnetism. But, in B-doped silicon, two of the three electrons occupy the ground state Γ_1 with anti-parallel spin orientation. The third electron occupies one of triply degenerated Γ_5 state with unpaired spin orientation. The charge state V^+ with unpaired spin in B-doped silicon shows a magnetism.

In the present investigation, we have carried out low-temperature ultrasonic measurements of elastic constant of non-doped FZ silicon and B-doped FZ silicon down to 20 mK. We observed softening of elastic constants which is thought that it originates from the Jahn-Teller effect due to the coupling of the quadrupole of vacancy orbitals with elastic strains of ultrasounds.[2] Furthermore, we investigated the charge state of vacancy in applying magnetic fields. In this paper, we describe the elastic softening due to the vacancy using quadrupole susceptibility of vacancy orbitals.

[1] C. A. Coulson and M. J. Kearsley, Proc. R. Soc. London A 241 (1957) 433.
[2] T. Goto, H. Y. Kaneta, Y. Saito, Y. Nemoto, K. Sato, K. Kakimoto and S. Nakamura, J. Phy. Soc. Jpn. 75 (2006) 044602

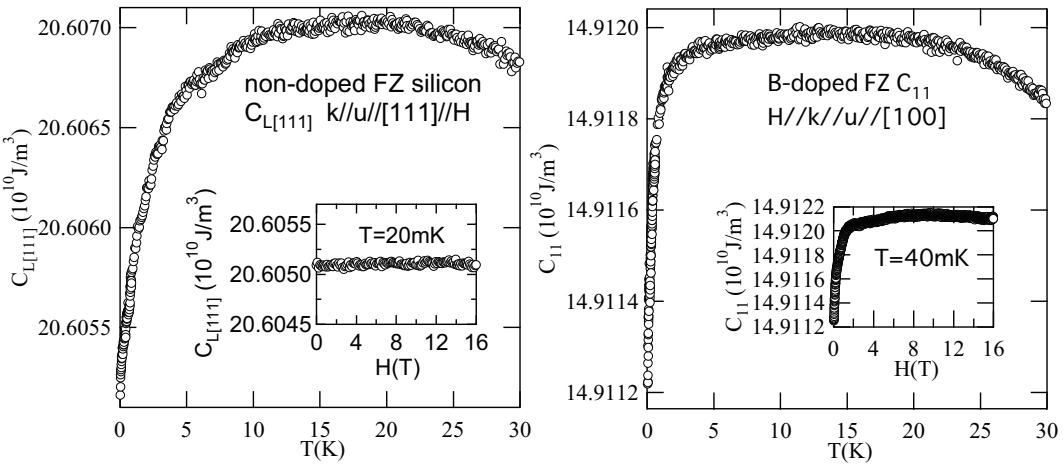

Figure 1: Temperature dependence chart of elastic constant of non-doped FZ silicon (left) and B-doped FZ silicon (right). Inset; Magnetic field dependency