STM/STS study on electronic states of magnetic impurity Cr atoms adsorbed on ZnTe(110) surface

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Study on electronic states of transition-metal (TM) dopants in a semiconductor at single-atom scale is important not only to understand the fundamental mechanism of the magnetic property of the diluted magnetic semiconductor (DMS) but also to progress the new nanotechnology research field combined with magnetism of DMSs. Here, we performed scanning tunneling microscopy / spectroscopy (STM/STS) study on Cr atoms adsorbed on a p-type ZnTe(110) surface, since Cr-doped ZnTe has been regarded as one of the promising DMSs for future spintronic application because of its intrinsic room temperature ferromagnetism observed for $Zn_{0.8}Cr_{0.2}Te$.

We prepared a ZnTe(110) clean surface as a substrate by cleaving a single crystal *p*-type ZnTe(001) wafer (P-doped, ~1×10^{18} cm^{-3}) in a high vacuum (~10^{-5} Pa). We deposited Cr atoms on the surface at room temperature by an electron beam deposition method. All STM/STS measurements were performed in an ultrahigh vacuum (~1×10^{-9} Pa) at 80 K.

After the deposition, a large number of small bright points corresponding to Cr atoms were observed at a negative STM sample bias voltage as shown in Fig. 1(a). Comparing with our previous study [1], we concluded that the shape of the bright points mainly reflected the t^a impurity state induced by Cr atoms substituting for Zn atoms in the first layer of the surface. Furthermore, we also found that STM images observed for a single Cr atom were varied by sample bias voltages in the range of -2.0 V < <V_s < -1.2 V; the brightest region in the images was shifted from the position of the top-most Te atoms neighboring with the substitutional Cr atom to the position of the Cr atom by increase of the bias voltage from -2.0 V to -1.2 V (Fig. 2). This result suggests that the the t^a impurity states, which are triply degenerated in the bulk tetrahedral substitutional site, was resolved by symmetry breaking at the surface. At the conference, we will discuss the impurity states in more detail with the results of STS measurements.

References: [1] K. Kanazawa et al., Nanoscale 6, 14667 (2014).

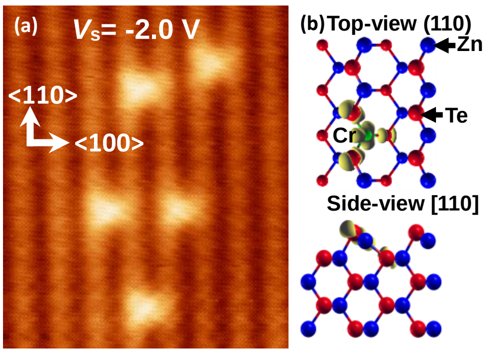

Fig.1 (a) STM image of single Cr atoms. (b) DFT-calculated spatial distribution of LDOS (E_F - 0.1 eV < E < E_F) [1].

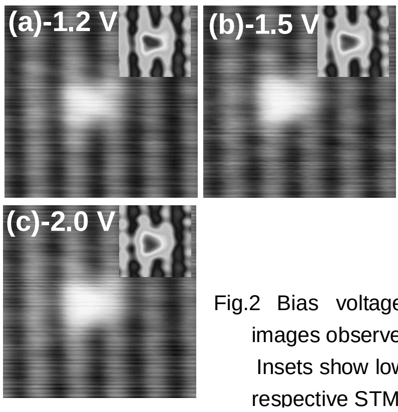

Fig.2 Bias voltage dependence of STM images observed for a single Cr atom. Insets show low-pass-filtered images for respective STM images