

Attractive interaction of Mn Atoms on the GaAs(110) Surface Observed by Scanning Tunneling Microscopy/Spectroscopy

Eiko Hayaki, Atsushi Taninaka, Shoji Yoshida, Ken Kanazawa,
Osamu Takeuchi and Hidemi Shigekawa

Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Ibaraki 305-8573, Japan

Diluted magnetic semiconductors (DMSs) have been energetically studied to provide prospective materials for application to spintronics, because they are compatible with general semiconductor devices. Control of the spatial distribution of transition-metal atoms in a DMS is a key factor in realizing desirable magnetic characteristics. (Ga, Mn)As is one of the fundamental and well-studied ferromagnetic DMSs. The magnetic interactions between Mn atoms in (Ga, Mn)As, which depend on the atom arrangements, has been experimentally studied by scanning tunneling microscopy and spectroscopy (STM/STS) [1]. However, the observed structure were artificially fabricated at 4 K. It is necessary to understand the the natural structure of (Ga, Mn)As and the interaction between Mn atoms in it for the future applications. Here, we present the STM/STS results obtained for the Mn structures deposited on a GaAs(110) surface at room temperature, which showed attractive interaction between Mn atoms aligned in the <110> direction.

Figures 1(a) and (b) show STM images of Mn-deposited p-type (Zn-doped, $1\sim5 \times 10^{17} \text{ cm}^{-3}$) and n-type (Si-doped, $1\sim5 \times 10^{17} \text{ cm}^{-3}$) GaAs(110) samples, respectively. Single, pair, and trimer Mn structures are labeled as S, P, and T, respectively, and their magnified images are shown in the right column. Figure 1(c) shows the histogram of the Mn structures obtained from the total count of 300 structures for each of the p- and n-type samples. The ratios of Mn pairs to single Mn atoms were 20 % and 29 % for p- and n-types, respectively, which are higher than those expected from the random distribution, 0.8 % and 1.4 % for p- and n-types, respectively. These results indicate that there exists an attractive interaction between Mn atoms on the GaAs(110) surface at room temperature. STS studies on these structure are also presented at the conference.

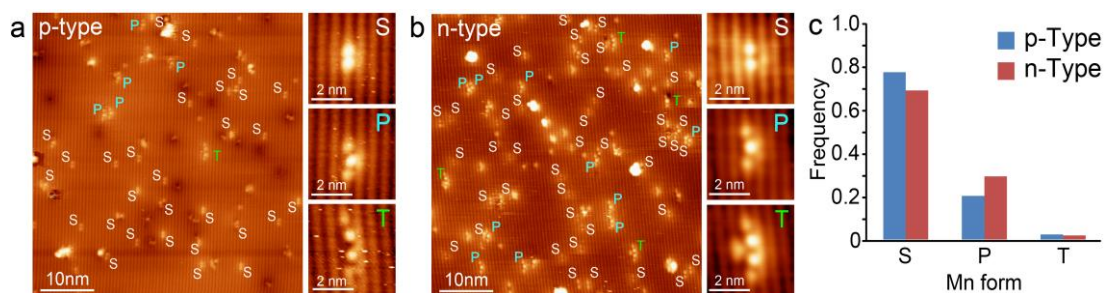


Fig. 1 STM images of Mn atoms deposited on (a) p-type and (b) n-type GaAs(110) surfaces at room temperature. (c) Histogram of ratio among structures labelled S, P and T in (a) and (b).

[1] D. Kitchen, et al., *Nature*, 442, 436-439, (2006).