Chemical bonding behavior of In, Sn and Sb adatoms on the Si(111)-(7×7)

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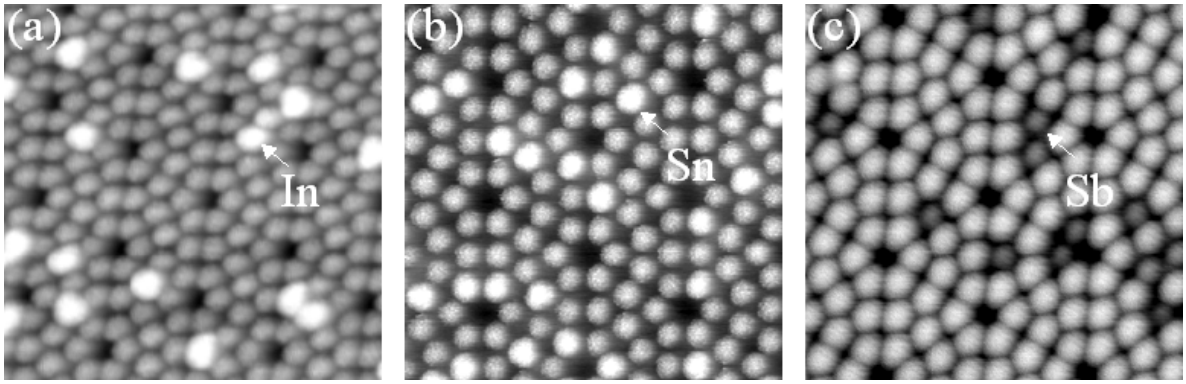
Recently, we have succeeded in constructing two-dimensional nanostructures composed of Sn and Ge atoms by interchange lateral atom manipulation using non-contact atomic force microscopy (NC-AFM) at room temperature [1]. To apply this novel atom manipulation method to construct atom-scale devices utilizing dopant atoms, understanding the chemical bonding behavior of not only group IV elements [2] but also group III (acceptor atom) and V (donor atom) elements is highly required.

In this study, we investigated the chemical bonding behavior of substituted In (group III), Sn (group IV) and Sb (group V) adatoms on the Si(111)-(7×7) surface. The valence electron orbital of In, Sn and Sb are $5s^2 5p^1$, $5s^2 5p^2$ and $5s^2 5p^3$, respectively. These adatoms can be characterized by using the Si adatoms as reference, since they are mixed in common surface. Each surface was prepared by an independent evaporation of each element on the Si(111)-(7×7) surface followed by an annealing. Figures show NC-AFM topographic images of (a) In, (b) Sn and (c) Sb substitutional adatoms on the Si(111)-(7×7) surface. Both In and Sn adatoms are imaged brighter than Si adatoms (figs. (a) and (b)) while Sb adatoms are imaged darker than Si adatoms (fig. (c)). The contrast difference of each element in NC-AFM topographic images could be attributed to the difference of spatial height, chemical bonding behavior and electrostatic behavior of each element. We will discuss in detail the further information obtained from site-specific force spectroscopy to investigate chemical bonding force between the tip-apex atoms and surface adatoms.



[1] Y. Sugimoto, M. Abe, S. Hirayama, N. Oyabu, O. Custance, and S. Morita, Nature Materials **4**, 156 (2005).
[2] Y. Sugimoto, M. Abe, K. Yoshimoto, O. Custance, I. Yi and S. Morita, Appl. Surf. Sci. **241**, 156 (2005).