Scanning Tunneling Microscopic Analysis of Highly Phosphorus-Doped Si(111)-(7x7) Surface

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The structure and the applications of Si(111)-(7x7) surface have being investigated extensively due to its notable high stability and large unit cell size. Si(111)-(7x7) surface acts as a natural template to obtain desired self-assembled nanostructures under controlled environment. Highly doped n-type Si has metal like properties which can affect the self-assembled nanostructures on the surface of Si wafer.

Highly phosphorus-doped Si(111)-(7x7) surfaces have been investigated by scanning tunneling microscopic techniques (STM). Diffusion doping process was carried out to prepare heavily doped n-type Si(111) wafers at 950 °C for 10 min. Dopant concentration was determined by obtaining resistivity of Si(111), calculated from four-probe measurements and diffusion length, and comparing the values with Irvin Curves.

STM measurements were carried out on the doped Si (111)-(7x7), after the cleaning process, under UHV conditions (~ 1 x 10^-8 Pa) using electrochemically etched tungsten tip.

A filled state STM image of a pristine Si(111)-(7x7) surface is shown in Figure 1(a) and the faulted half of the 7x7 unit cell appears brighter than the unfaulted half due to the difference in conductance. Obtained STM image after the reconstruction of P-doped Si(111)-(7x7) surface is shown in Figure 1(b) and demonstrates that P atoms are favored to occupy faulted half atom positions of the unit cell. Filled-state STM images shows bright maximum spots which indicates the presence of P atoms or effect of those on other Si adatoms in unit cells. Another interesting fact is that these bright spots often appears as triplets on the images. P atoms can occupy rest-atom positions in the faulted half of the unit cell, affecting the electronic states of nearby Si adatoms giving bright triplets. The preferential selection of P atoms in the faulted half of the unit cell may be due to its electronegativity and chemical concept of local softness.

References