Mechanism and conditions on the atomic-interchange lateral manipulation

Seizo Morita
(Osaka University, Engineering Department, Professor)

【Outline of survey】

Atom manipulation can be considered as one of the ultimate goal in nanotechnology. The precise positioning of atoms on a surface has been realized, so far, only at cryogenic temperatures. We, however, have recently demonstrated room-temperate lateral manipulation of atom and engineering of nanostructures on a surface - that remain stable for a relatively long periods of time using an atomic force microscope. A novel manipulation method - the atomic-interchange lateral manipulation method - has been identified. This method is based on the interchange of the atomic positions of different types of first neighboring atoms embedded on a surface. In principle, the technology could be also applied to insulating materials, thereby broadening the range of applications.

There are, on the other hand, still many factors yet to be solved in terms of the phenomenon. In this study, we intend to clarify physical phenomenon of the interchange atomic manipulation method, and set guidelines for providing nanomaterials and nanodevices having new functions. Specifically, we are aiming at achieving the following;

1) Quantification of the atomic bonding forces required for the atom interchange.
2) Differences in the forces required depending on the crystallographic directions during the atom interchange.
3) Studying the effects of the thermal energy on the atom interchange.
4) Control on the atom interchange conditions depending on the difference in the atom species.
5) Study on the atom interchange mechanism and conditions for an optimum control of the manipulation process by means of comparison with first principles theoretical calculations.
6) Clarification on the atom interchange phenomenon using various types of substrates including insulating materials.

【Expected results】

Although the atomic-interchange lateral manipulation can be performed at room temperature on semiconductors, it could also be applied to insulating materials. The more progress in the knowledge on the physics of the process is made, the more it will be clear under what conditions atoms could interchange on different types of materials. As a result, the technique could be applied for nanostructuring on metal alloys comprised by different types of elements, and other complex materials such as mixed crystals, impurity semiconductors, and ceramics. Furthermore, the creation of high-performance multi-functional nanomaterials and nanodevices will be made possible; it will lead to innovate and progress for the development of the bottom-up technology.

【References by the principal researcher】

Y.Sugimoto, M. Abe, S. Hirayama, N. Oyabu, O. Custance, and S. Morita : “Atom inlays performed at room temperature using atomic force microscopy”, Nature Materials Vol.4, pp.156-159 (Feb 2005).

N. Oyabu, Y. Sugimoto, M. Abe, O. Custance, S. Morita: “Lateral manipulation of single atoms at semiconductor surfaces using atomic force microscopy”, Nanotechnology, Vol.16, No. 3, pp.S112-S117 (Mar. 2005).

【Term of project】 FY 2005 - 2009	【Budget allocation】 84,500,000 yen

【Homepage address】 http://www-e2.ele.eng.osaka-u.ac.jp/index.html