Reversible atom manipulation by tunneling carrier injection

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Strong excitation of local vibration can induce the motions of atoms and molecules in various materials. The most effective way to realize the highly excited vibration is to convert electronic excitation to vibrational one through electron-phonon coupling. Moreover, the electronic excitation at extended states enables a remote manipulation of the atoms and molecules. I will discuss microscopic processes of the remote atom manipulation by excitation of surface electronic states on the Ge(001) surface [1]. Electrons and holes are injected into the extended surface states using scanning tunneling microscopy (STM), and reversibly alter the tilting orientation of the surface Ge dimer which is not always at the injection point. The electron-phonon coupling in this system is studied by density functional theory (DFT). Two rocking modes of the dimer-pair vibration, out of phase and in phase, strongly couple with the surface electronic states. We can also change the tilting orientation of heterogeneous surface dimers of Ge-Sn and Ge-Si. Simultaneously, the scattering amplitude and phase of the surface electrons at the heterogeneous dimer are modified. The scattering was experimentally detected as standing waves in STM, and theoretically studied using DFT. These results give a microscopic basis for an atomic switch for the surface state conduction on the same surface [2].

[1] K. Tomatsu *et. al.*, Phys. Rev. Lett. **103**, 266102 (2009).
[2] K. Tomatsu *et. al.*, Science **315**, 1696 (2007).