Progress in Cluster Research toward Novel Functionality

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Since the discovery of clusters in a molecular beam 40 years ago, a plenty of specific properties originating from many-body nature of the tiny system have been unveiled. Considering the quality and the quantity of the specificities elucidated so far, it is the time to educe novel functions from the clusters so as to expand the world of the science. In pursuit of cluster-specific functions, one should amplify the many-body characters by putting the cluster on/in an appropriate surface/interior of a solid material, a solution and a gas atmosphere. Furthermore, they could be tuned precisely by internal electric charges, spins, atomic dopants and ligands as well as external electric and magnetic fields.

We have discovered, in our STM measurements [1-4], two-dimensional charge polarization in a subnano-space. This is due to electron accumulation at the interface between the cluster and the substrate in a similar manner as the Schottky barrier junction [3,4]. The subnano-space polarized charge can be controlled precisely through one-by-one doping of an electron-donor or acceptor atom into the cluster [5].

We are focusing on catalysis as a global key issue we are confronted with to overcome in the material and energy sciences [6]. It is straightforward that catalytic activity is significantly promoted by the charge polarization, because the reduction and oxidation defined as the capture and release of electrons by a molecule, respectively, prefer rich charges. Indeed, it has been found that the Pt cluster disk on the Si substrate has a high-performance catalytic activity of thermal oxidation of CO. Furthermore, this is promoted by doping only a single Ag atom into the cluster disk as the electron donor. It has appeared that clusters in an appropriate environment have higher catalytic activity than a corresponding bulk material. This indicates the way for the cluster-based functional materials in practical use.

[1] H. Yasumatsu, T. Hayakawa, S. Koizumi and T. Kondow, *J. Chem. Phys.* **123**, 124709 (2005); *Virtual J. Nanoscale Sci. Technol.* **12** (2005).
[2] H. Yasumatsu, T. Hayakawa and T. Kondow, *J. Chem. Phys.* **124**, 014701 (2006).
[3] H. Yasumatsu, T. Hayakawa and T. Kondow, *Chem. Phys. Lett.* **487**, 279 (2010).
[4] H. Yasumatsu, P. Murugan and Y. Kawazoe, *Phys. Stat. Solidi* B **249**, 1193 (2012).
[5] H. Yasumatsu, *Euro. Phys. J.* D, **63**, 195 (2011).
[6] H. Yasumatsu, M. Fuyuki, T. Hayakawa and T. Kondow, *J. Phys. Conf. Ser.* **185**, 012057 (2009).