My research history - from molecular structure to surface science

Investigation of the molecular structure of $SiCl_4$ using gas electron diffraction (GED) was the topic of my research I picked up when I started my graduate study at Department of Chemistry, the University of Tokyo. However, initial attempts did not work out well, and tried to set up a new apparatus for precise measurements by GED . In the mean time, I succeeded in giving reasonable estimates for random errors from the continuous curve of the scattering intensity using a non-diagonal weight matrix in the least-square fit, for which I received my Ph.D. from the University of Tokyo. I was very fortunate to receive an offer to join Chemistry Department of Gakushuin University in October 1966, so I left the University of Tokyo after accomplishing the construction of the apparatus there.

When I got to Gakushuin Univerity, I decided to engage in the study of surface science, which is emerging at the time as a new field in solid state physics. Surface science was quite a different field from the study of molecular structure, and I had little knowledge of solid state physics at that time. I started to investigate electronic properties and their applications in surface science. Surface plasmon dispersion seemed to explain well the process of initial oxidation of aluminum. We discovered irreversible phase transition in the top layer of atoms on an as-cleaved MgO(001) by using the low-energy electron diffraction Kikuchi pattern at surface state resonance. I had developed a low-energy electron time-of-flight spectrometer , and clarified surface electronic properties of the dislocation on a defective vacuum-cleaved MgO(001) surface. I also studied, briefly, structure of molecular liquid. I hit upon an energy-dispersive method in X-ray diffraction and constructed a diffractometer. A reliable liquid structure for three-dimensional stacking of CCl_4 molecules was obtained by using this apparatus.

I moved to the Institute for Solid State Physics, the University of Tokyo in 1976. I studied one-dimensional metal of potassium overlayer on a Si(001) surface, and succeeded in measuring a characteristic dispersion for the overlayer plasmon. Furthermore, we succeeded in discovering rotational epitaxy of two-dimensional potassium monolayers on Cu(001) and phase transition on a surface-defect-free surface of Si(001). Subsequently, my research switched to the study of dynamical phenomena on the surface. Very-low-energy (1 – 100 eV) reactive-ion scattering yield on metal surfaces as a function of the incident energy was found to contain key information on the repulsive potential between an incident ion and surface atoms. Laser-induced desorption caused by electronic transition of NO and CO molecules from metal surfaces was observed. The desorbed molecules were state-selectively detected by using resonance-enhanced multiphoton ionization technique and we discovered that a desorption mechanism could be discussed through lifetime and critical residence time of the intermediated excited state. The surface hydrogen detection method using a resonance nuclear reaction between ^{1}H and an incident ion of $^{15}N^{2+}$ at an energy of 6.385 MeV was developed. Hydrogen atoms had not been detected by the usual surface analysis method. The depth profile of hydrogen atoms was non-destructively measured by distinct detection

of surface and interface. Then, dynamical hydrogen behaviors were observed.

I moved to the University of Electro-Communications in 1996. I studied very thin single-crystal oxide films on the transition metals. The band gap of the oxide was found to become narrower with decreasing film thickness thinner than 3 nm for Al_2O_3 on Ru(0001) and SiO_2 on Ni(111). Since these results could be interpreted by the many-body effect, I succeeded to make a monolayer Pt film on Al_2O_3 (1 nm) on Ru(0001).

I have tried to look into several different research fields and tried to construct new apparatuses to carry out original research projects in different areas. Although many of my projects ended up in the halfway point when I resigned from my posts at several universities, I am confident and hopeful that my ideas and initiatives are important and meaningful enough for my young colleagues and graduate students to continue and expand them by using their know-how and talents as experimentalists. I am very happy and fortunate to have met many professors who came out of my laboratory to become experts in the surface science and other fields.

Publication

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