2004A0318-NXa-np-Na BL37XU

Study on the charge dynamics in rare-gas clusters by using site-selective inner-shell excitation

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The de-excitation processes of x-ray absorption on free mixed rare-gas clusters containing krypton have been studied by utilizing the PhotoElectron PhotoIon COincidence (PEPICO) technique. By an irradiation of high energy x-ray, a multiply charged krypton ion is generated in a mixed cluster as a result of 1s electron excitation, then the charges disperse from the absorbing atom to surrounding atoms. The multiply charged cluster become unstable due to Coulomb repulsive force, and fragment ions with various charge to mass ratio are emitted from multiply charged clusters. The charge distribution of fragments and the kinetic energy of fragment ions are expected to reflect the charge mobility and stability of clusters. Then the information of the charge dynamics in the free cluster could be deduced from the precise study on the de-excitation processes of cluster.

The PEPICO measurements were carried out at BL37XU. The neutral mixed rare-gas clusters were produced in a vacuum vessel via expansion of rare gas mixture with fixed composition. The composition, temperature and pressure of sample gas were adjusted to control the composition and size of cluster. The neutral cluster beam has been photoionized with monochromatized synchrotron radiation in the energy regime near the krypton K absorption edge. The photoions are detected by a time of flight mass spectrometer, while the photoelectrons are detected by a channeltron. The electron signal provides a start pulse for for PEPICO measurement and the ion signal gives a stop pulse. The PEPICO measurements were carried out at photon energies of 14.08, 14.319, and 14.50 keV, i.e., on the both side of the krypton K-edge.

In figure 1, the PEPICO spectra for Ne-Kr mixed clusters taken at photon energy of 14.5 keV are shown as a function of the time of flight of photoion. The $Ne_{99}Kr_1$ mixture was used for starting material. <N> denotes average cluster size estimated from empirical scaling law. Clear size dependence was found in the intensity of Ne^+ ion. The appearance of Ne^+ ion is evidence for the charge transfer from krypton to neon atoms in mixed cluster. The broad Ne^+ peak reflects large kinetic energy of fragments due to Coulomb explosion, suggesting the charge localization in the rare-gas clusters. The yields of these ions depend clearly on both the cluster size and the composition of clusters. The PEPICO spectra of Ar-Kr mixed cluster show the several daughter ions due to charge transfer from krypton to surrounding atoms. The size and composition dependence of daughter ion for Ar-Kr system has been different from that for Ne-Kr system. The difference of miscibility between Ne-Kr system and Ar-Kr system gives us informations on the site dependence of de-excitation processes.

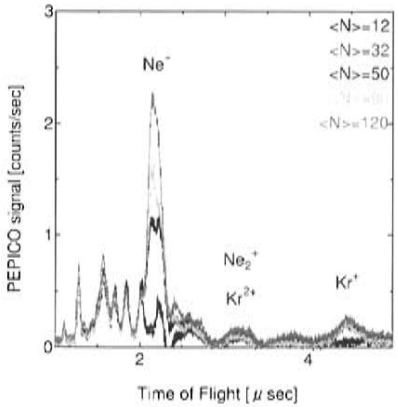

Fig.1. The PEPICO spectra of Ne-Kr(1%) cluster beam recorded at 14.5 keV are polotted as a function of ion flight time. <N> is average cluster size.

2004A0385-NL3-np BL37XU

FLUORESCENCE IMAGING OF TRACE ELEMENTS IN LEC RATS

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In the Long-Evans Cinnamon (LEC) rat, which is known as an animal model of Wilson's disease, copper (Cu) accumulates in lysosomal bodies in hepatocytes. In order to investigate the state of Cu accumulation in a liver tissue of LEC rats, we used the x-ray fluorescence (XRF) imaging technique. Liver tissues from normal Wistar rats were used as a control. The liver tissues were fixed in 10% formalin and embedded in paraffin. Unstained sections with a 4μm thickness were cut from the paraffin blocks and mounted on a mylar film for elemental analysis.

The measurements were done at BL37XU with a microbeam optics. Two-dimensional mapping of elements was done with a step size of 3 μm. Accumulation time at each point was 0.5 - 2 sec. Fe, Cu, Zn were measured simultaneously.

The tissue of the LEC rat liver showed strong x-ray fluorescence, especially of Cu and Fe. The x-ray intensity of the Cu fluorescence was stronger as the age of LEC rat was older, while the x-ray fluorescence of Cu in the normal rats did not exceed the background. These results confirm accumulation of Cu in the hepatocytes in agreement with the results of our measurements using ICP-MS.

Distribution of Cu in a section of liver tissue from a LEC rat.