Photoelectron spectroscopic studies of free metal clusters using VUV range synchrotron radiation

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The electron spectroscopy research group (ELSP) at the University of Oulu, Finland, focuses its research on the synchrotron radiation excited spectroscopy of atoms, molecules and clusters. The group actively develops experimental and theoretical methods for carrying out studies utilizing synchrotron radiation. The research on the electronic structure and properties of free metal clusters has been recently set to the main focus of the group.

Clusters that are composed of countable number of atoms can be considered as an intermediate state of matter between molecules and solid state. Therefore clusters exhibit properties from the both sides, allowing studies of the evolution and rise of macroscopic observables from the atomic scale. Clusters formed of elements that are metallic in the solid state have been studied since the 1980s. However, challenges in production of sufficient cluster vapour densities for synchrotron radiation experiments have restricted most electron spectroscopic studies to the valence region, that is accessible for conventional lasers. The use of synchrotron radiation however opens up a different and unstudied set of observables for probing the cluster properties. For example, one may study site sensitive core-shell ionization and chemical shifts, cluster fragmentation, (resonant) Auger decay and NEXAFS.

In order to study study these properties the ELSP group has developed in collaboration with Uppsala and Lund Universities (Sweden) a pick-up based EXchange MEtal Cluster (EXMEC) source [1]. The source has been shown to produce free neutral cluster densities that are sufficient for electron spectroscopic studies using synchrotron radiation. The source produces clusters by evaporating metal atoms from solid and can reach temperatures up to ~1800 °C, allowing wide range of elements to be studied. The size-distribution of the clusters produced can be varied from few tens to few hundred. In this so called quantum-size regime the electronic structure of clusters experiences its most drastic changes.

During the last couple years the source has been used to study the properties of a range of different metallic and semi-metallic clusters (e.g. [2-7]). The studies have varied from the alkali metals [2-4] and topological properties of Sb and Bi clusters [5,6] to salt clusters [7]. In the present contribution an overview the ELSP group's recent metal cluster research will be given.

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