

Production of Equally Sized Atomic Clusters by a Glowing Wire

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Unexpected behavior is found as the particle size is reduced to the atomic cluster range. For example, clusters of non-magnetic solids are found to be magnetic and clusters of noble metals are found to be strong catalysts. Every atom counts in the cluster regime. Using stable clusters, it will be possible to form cluster assembled materials as demonstrated in the case of the fullerenes. Certain stable species mimic the chemical behavior of atoms. These *superatoms* form a new dimension of the periodic table (Khanna et al., 1995). A major challenge in experimental studies on atomic clusters is to produce *arbitrary pure and well defined samples*. In view of cluster assembled materials, increase of the production rate with respect to existing vacuum technology is desired. The present study, to be published shortly in more detail (Peineke et al., 2009), represents a major step regarding these challenges.

In 2007, Peineke and Schmidt-Ott had shown that charged species emitted from a glowing wire produce spikes in the mobility distribution attributed to clusters of outstanding stability (magic numbers). Improved differential mobility classifiers have been applied to nanoparticles, gas ions and large molecules in the past, but not to metallic atomic clusters, in lack of a suitable source of charged clusters.

A resistively heated metal wire is shown to be such a source. Ag_nK^+ clusters are obtained from wires containing silver, with traces of potassium. They are size classified with a differential mobility analyzer, and their relative abundance is determined as a function of the inverse mobility (Upper curve, fig. 1). First principles calculations yield the stability of Ag_n in terms of the removal energy of Ag (fig. 1 (lower curve)). We assign the first peak of the mobility curve to K^+ and the first prominent one to the first stable cluster, Ag_2K^+ . These species were also observed in a mass spectrum. The pronounced odd-even oscillation of the calculation then agrees well with the mobility distribution. The distance between the peaks decreases with growing number of atoms, n , in agreement with an estimated relation for $Z^{-1}(n)$.

The calculated Ag_nK^+ cluster properties are similar with respect to the pure Ag_n clusters in terms of energetic and electronic stability and cluster structure. Thus K^+ attachment is an ideal, non-

invasive way of charging, which enables mobility classification. Using the heated wire as the source of atomic clusters and simultaneously as the source of K^+ ions leads to selective charging of the clusters, while contaminants in the inert gas remain uncharged. This explains the absence of “gas ion” peaks, which normally occur in mobility spectra in the present size range. As the equally-sized clusters are available for reactivity, coalescence and deposition studies, the method presented demonstrates the power of aerosol technology in the field of atomic clusters.

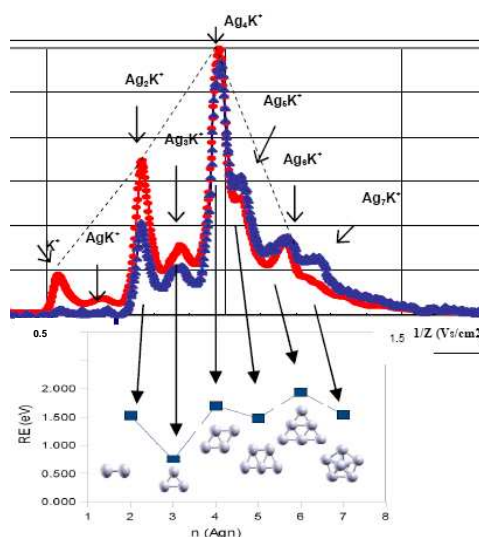


Figure 1. Mobility distribution of Ag_nK^+ (red: Pd wire containing Ag and K; blue: Ag wire containing K) and calculated stability in terms of Ag removal energy.

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