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14. ABSTRACT
Two instruments have been developed to soft-land species with less than 10eV. First is the laser ablation-coupled drift tube. The chamber was developed with the idea of using an inert gas, helium, to thermalize ions. This allows us to reduce the clusters KE from 40 eV to about 1 eV by producing thermal collisions between the gas and our sample. The drift chamber was assembled using a 6” four-way cross coupled with a 6” reducing cross housing the ion drift cell. Nd-YAG 532nm was utilized to ionize the sample. The clusters formed were then discriminated by cross-section and transported through the drift cell with a potential from -100 to -500 V to our mica surface. The isolated sample was then characterized using AFM and electrochemistry. The second instrument is a rectilinear ion trap with integrated ultra fast pulse valve. This instrument has some novel electronics to allow complete shut-down of the applied RF in 2 cycles. This coupled to the high pressure acquisition makes it an ideal mass filter for preparative mass spectrometry. Though the ion current is an order of magnitude less than the drift tube, the resolution is 2 orders of magnitude greater, making the two instruments complimentary.

15. SUBJECT TERMS
Softlanding, Preparative Mass Spectrometry, Coatings

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Annual Progress Report for FA9550-08-1-0158 – YIP - Development of novel preparative mass spectrometry instrumentation for the advancement of new materials and nanofabrication. (Year 2)

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Brief

A preparative material instrument utilizing Soft Landing Ion Mobility (SLIM) to deposit and comb through the various ionized species formed using front end chemistry (figure 1.) was developed in our lab. This novel instrument has allowed us to deposit selected ions onto unmodified substrates with kinetic energies (KE) ranging from 1 eV to sub-eV. The instrument is unique in that surfaces can be created at pressures spanning from 1 – 100 Torr rather than usual UHV conditions. This method with low kinetic energies allows the soft-landed ions to remain intact, retaining structure for self-assembly followed by the characterization of novel materials. Recently research in the field of carbon containing clusters and nanostructures have experienced a wealth of novel research and development about these complexes from diamond like coatings for wear resistant materials to semiconductor type material seen with graphene. We have investigated the deposition and surface characteristics of small carbon clusters ($C_{n,}$ n = 1-5) formed from the laser ablation of bulk graphite.

Methods.

A graphite target used in these investigations was of high purity form and composed of 99.99% graphite. A pulsed 532 nm Nd:YAG laser ablates the graphite target in the presence of Helium gas which helps cool the sample and promote the formation of ionized clusters. Clusters formed during this event enter the drift tube and are separated based on the mobilities of the clusters. High mobility species (small molecules) exit the drift tube first followed by clusters with low mobilities. A unique pulsed ion optic at the end of drift tube allows for the selection of a specific cluster to be actively detected or deposited on our surface. This process then continues for each of the clusters present until we have created surfaces and combed through the entire drift spectrum. Characterization of these novel surfaces is done primarily with AFM and Raman spectroscopy, but other surface characterization techniques (SEM, XPS, LA-ICPMS) have been employed as well. The delivery force behind this specific soft-landing technique is the drift tube where the ions are thermalized from 1eV to sub-eV kinetic energies via collisions with the buffer gas at

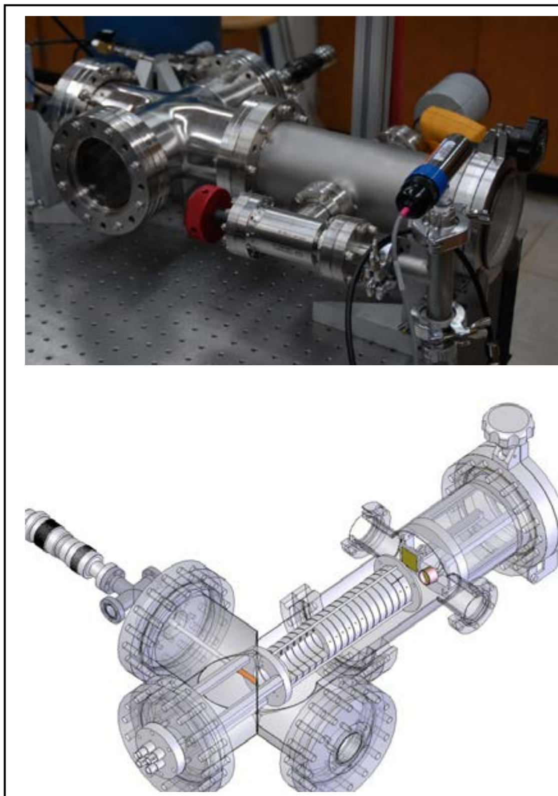

Figure 1. Soft-Landing Ion Mobility Instrument.

pressures between 1-10 Torr.

Carbon Deposition using Soft-landing Ion Mobility.

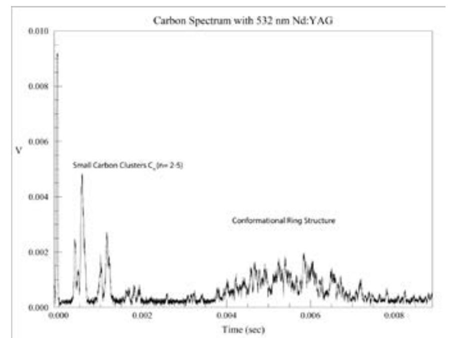

Figure 2. Laser ablated Carbon Spectra at 2 Torr with 532 nm Nd:YAG .

A drift tube spectra (Figure 2.) of carbon exhibited multiple peaks which corresponded to the small carbon clusters of C_n (n = 2-5). A broad peak that ranges from 4 – 7 ms is attributed to a ring structure and its corresponding conformers. The active soft-landing of C_2^+ on a mica substrate was carried out over 3 hours after deposition the sample was characterized using AFM and Raman. AFM images of the substrate showed a unique growth on the substrate where soft-landed C_2 clusters stacked on top of one another forming a multi-layer surface. This type of deposition can potentially be used for lubrication in MEMS fabricated devices (Figure 3). Soft-landing deposition of C^+ at1 Torr for 1hour and 10 mJ laser energy leads to the formation of an sp^3 fibrous deposition on the surface. This fibrous deposition was characterized using SEM as the deposition was too soft for contact and tapping modes of the AFM. SEM electron micrographs showed a network of interconnected sp^3 hybridized carbon atoms linked to one another randomly. Raman spectroscopy of this fibrous material showed a highly disordered and amorphous nature of the sample. Depositing under different condition mainly adjusting the laser power <10 mJ a significant change in deposition was seen fibrous carbon was no longer deposited but instead a crystalline growth was seen on the surface Raman spectra showed that this deposition corresponded to an amorphous sp^3 type deposition similar to ta-C (diamond like carbon). Crystalline formations of the area were large and visible through a microscope subsequent AFM and SEM images were unsuccessful due to charge build up and size of the structures. Deposition of the of broad ring structure lead once again to build up of large structures visible optically through a microscope with the structure taking a graphitic shape. AFM images of the structure were unsuccessful but alternate SEM micrographs of the area showed the formation of small clusters and a buildup of particles on the surface. Raman spectroscopy verified the structure to be graphitic in nature as the structure had pronounced G characteristics with a peak 1585 cm^{-1}. The SLIM deposition of these novel materials (Figure 4) is a new and emerging field of stoichiometric controlled deposition through characterization and identification of these deposited materials we can begin to utilize these materials for real world applications.

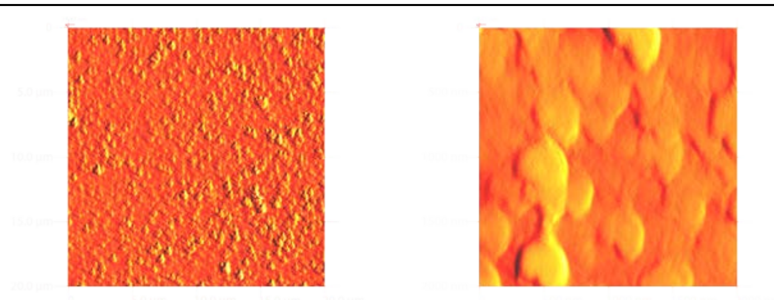

Figure3. Mica disc soft-landed with C_2 at 2 Torr He (left)

Magnified surface image (right).

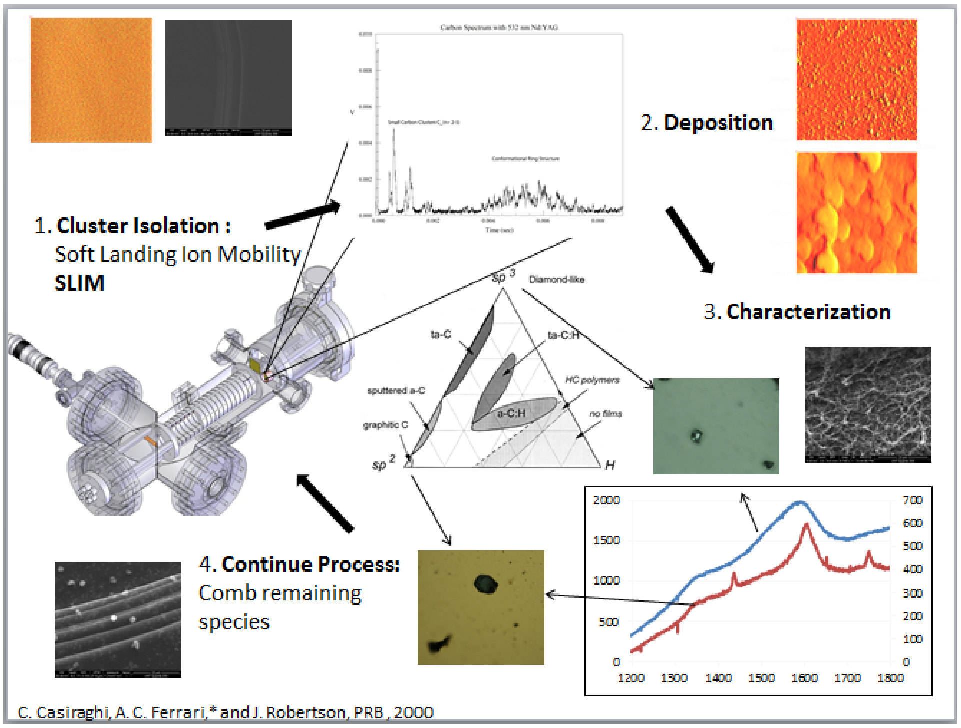

Figure 4. SLIM Process