A multipole ion-trap as a cluster-ion source

Noriyuki Uchida[1]; Toshihiko Kanayama[2]; Kaoru Kimura[3]

[1] Inst. of Appl. Phys., Univ. of Tsukuba; [2] ASRC, AIST; [3] Advanced Materials Sci., Univ Tokyo

Atomic clusters have interesting properties never seen in bulk materials resulting from their size effect and peculiar structures. Thus to synthesize clusters with tailored properties, it is necessary to control the elemental composition and the structure of the clusters. To this goal, we are developing a cluster growth technique using an ion-trap method. In this report, we discuss performance of the ion trap and cluster growth in detail.

We first developed a type of ion trap, external quadrupole static attraction ion trap (EQSIT) for the mass-selective synthesis of cluster ions. The EQSIT consists of a linear quadrupole electrode and a surrounding cylindrical cage electrode. Application of both ac and dc voltages to the quadrupole electrodes causes an ion trapping field to arise between the quadrupole and the cage electrode. Actually, hydrogenated silicon cluster ions, SinHx+ were grown from silane SiH4 gas in the EQSIT.Ionization of SiH4 was carried out in the EQSIT by electron irradiation. The resulting SiHy+ ions were confined in the EQSIT and were grown to SinHx+ cluster ions through the reactions with SiH4 and its radicals. The clusters grown to a predetermined mass value are automatically extracted from the EQSIT through the internal region of the quadrupole electrode. This indicates that the EQSIT acts as a cluster-ion source with mass selection.

One of the issues of the EQSIT is that it supplies only a small yield of cluster ion beam; e.g. 11 - 70 pA for the SinHx+ ion beams. This drawback arises from the fact that the ions are confined mainly alongside the linear quadrupole, making it difficult for the ions to enter from the end of the electrodes into the quadrupole internal region. Therefore, to achieve larger yield of clusters, we have improved on the EQSIT by arranging additional pole electrodes surrounding the central quadrupole. This newly designed external multiupole static attraction ion trap (EMSIT) confines ions not alongside but at the front side of quadrupole using the same principle as the EQSIT (Fig.1). The actual EMSIT constructed consists of linear 36 pole electrodes. The simulation results by SIMION 7.0 indicated that the EMSIT can supply about 60 times larger ion yield than the EQSIT. The SinHx+ were also grown from SiH4 gas in the EMSIT and as expected, the resulting SinHx+ (n= 2 - 5) ion-beam current was 10 times larger than that of the EQSIT.

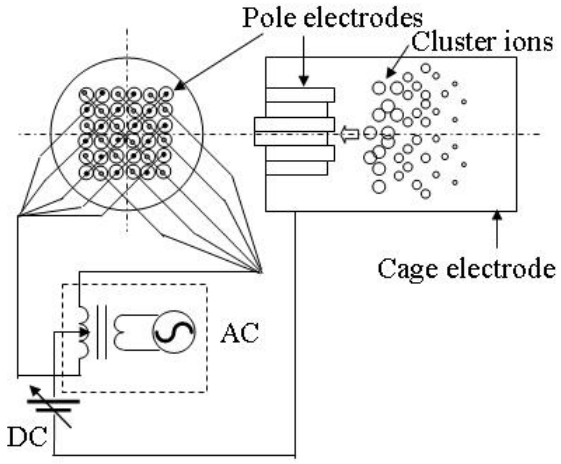

Fig. 1: Schematic of EMSIT trap.