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Cluster Implantation and Deposition Apparatus: Design and Capabilities

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Abstract Aggregates of atoms and molecules (clusters) can be considered to be a distinct form of matter, a "bridge" between atoms on the one hand and bulk on the other. Cluster can be used as models for investigation of fundamental physical aspects of the transition from atomic to macro scale as well as for fabrication of nanostructured materials with unique range of optical, magnetic, mechanical and catalytic properties (Jena and Castleman, Proc Natl Acad Sci U S A 103:10560–9, 2006; Wegner et al. J Phys D Appl Phys 39:R439–R459, 2006; Toyoda and Yamada, IEEE Trans Plasma Sci 36:1471–1488, 2008; Popok and Campbell, Rev Adv Mater Sci 11:19–45, 2006). Clusters kinetic energy is an important parameter which defines the cluster-surface interaction regime. These regimes can vary from soft landing to implantation (see Fig. 46.1). Different approaches can be used for generation of clusters in vacuum offering a wide choice of clusters species and providing a possibility for control of cluster size and energy distribution (Popok and Campbell, Rev Adv Mater Sci 11:19–45, 2006; Popok et al. Surf Sci Rep 66:347–377, 2011). In the current report, a design and capabilities of a cluster implantation and deposition apparatus (CIDA) involving two different cluster sources are described. The experimental setup represents a modified and upgraded CIDA described in detail in (Popok et al. Rev Sci Instrum 73:4283, 2002). Schematic picture of the new apparatus is shown in Fig. 46.2. One of the sources is a new model of a pulsed cluster source (PuCluS-2) based on a high repetition rate Even-Lavie valve. This source can be used for the production of cluster ions from various gas phase precursors. The core part of the other part is commercial gas condensation nanocluster source (NC200U, Oxford Applied Research Ltd.). This source is intended for the production of metal clusters. Both sources are connected to CIDA where the size-selection can be carried out and cluster kinetic energy can

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B. Di Bartolo et al. (eds.), *Nano-Structures for Optics and Photonics*,
NATO Science for Peace and Security Series B: Physics and Biophysics,
DOI 10.1007/978-94-017-9133-5_46,

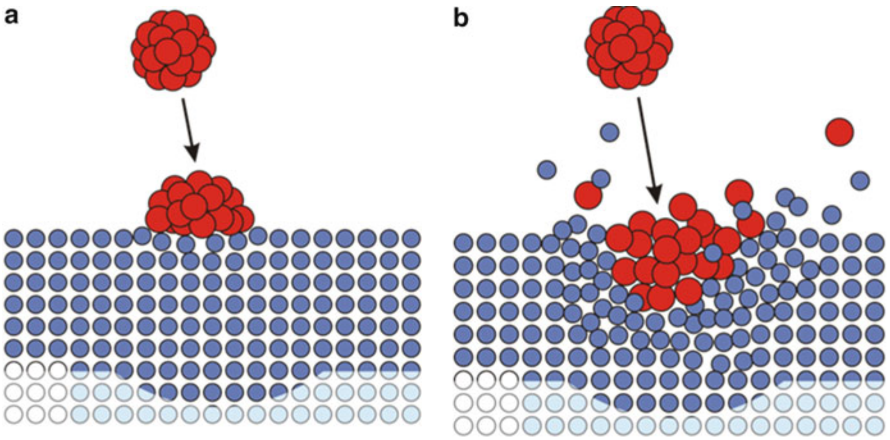

Fig. 46.1 Schematic pictures of (**a**) cluster deposition and (**b**) cluster implantation

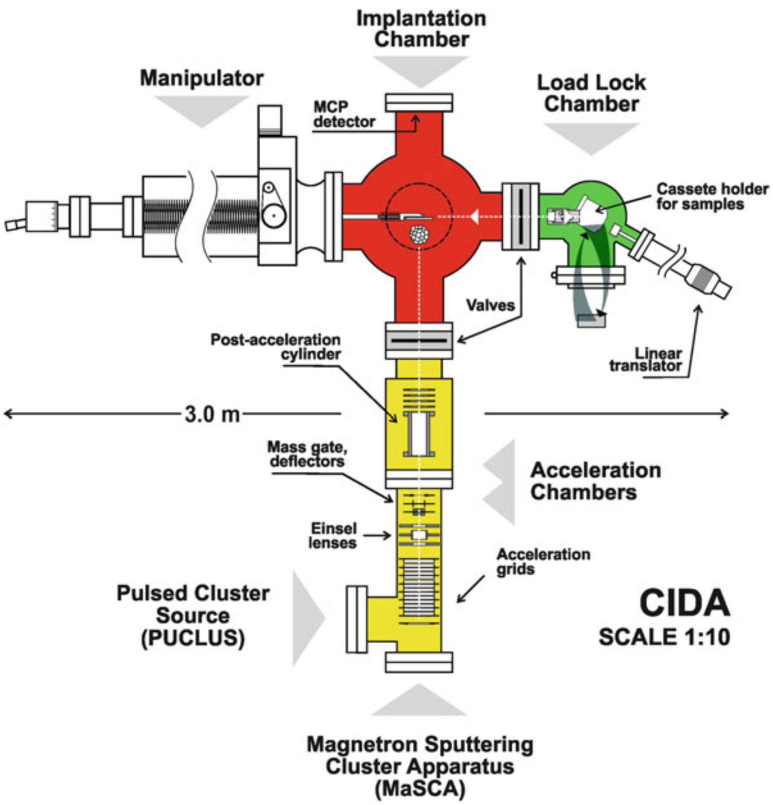

Fig. 46.2 Schematic drawing of CIDA containing a magnetron sputtering source and pulsed cluster source from gaseous precursors

be varied up to ca. 20 keV/cluster. The clusters can be deposited on or implanted in different substrates at ultra-high vacuum conditions. The clusters produced from gas precursors (Ar, N etc.) by PuCluS-2 can be used to study cluster ion implantation in order to develop contributions to the theory of cluster stopping in matter as well as for practical applications requiring ultra-shallow implantation and modification of surfaces on the nanoscale. Metal clusters from the magnetron cluster source are of interest for the production of optical sensors to detect specific biological objects (for instance, enzymes and proteins) as well as for the enhancement of photocatalytic reactions, for example, in hydrogen production. In both cases the phenomenon of localised surface plasmon resonance is utilized. Regime of metal cluster pinning can be used for processing of graphene.

Keywords Cluster beams • Cluster deposition • Cluster implantation • Surface plasmon resonance