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Generation of an energy and mass selective hyperthermal ion beam for investigation of ion-assisted thin film growth processes

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Apart from the widely applied chemical vapor phase epitaxy and conventional molecular-beam epitaxy (MBE) there exist other methods to prepare thin epitaxial compound (nitride) films or nanostructures like the ion-beam assisted deposition (IBAD) technique. IBAD is a hybrid physical thin film deposition technique which on the one hand offers the opportunity to investigate fundamental processes involved in ion-assisted film growth and on the other hand provides manifold possibilities to intentionally modify the properties of the prepared thin films. The technique is characterized by simultaneous irradiation of the growing thin film with energetic ions during deposition. By this, a ballistic enhancement of the adatom mobility can be achieved, leading to an enhanced crystalline quality even for thin and ultra-thin films. Additionally, the technique is defined by the separability of the material fluxes that are directed towards the sample, as well as by the accurately adjustable parameters vapor flux and ion flux, the latter generated in form of a broad ion beam. In the case of nitrogen ion beams however, nitrogen plasma based ion-beam sources counteract the demand to chose the ion-beam parameters as freely as possible, because the resulting ion beam consists of a blend of both molecular and atomic nitrogen ions. Particularly in the case of hyperthermal ion energies ranging from several 1 eV to a few 100 eV this creates great difficulties in assessing the dissemination of the ion energy to the growing film surface. In this contribution, a custom setup is presented which allows generating a hyperthermal nitrogen ion beam with variable ion energy and selectable ion mass. This was realized by combining a plasma based ion source with a quadrupole mass filter system, equipped with entry and exit ion optics, ion-beam deflection, as well as ion-beam current monitoring. The key features of this setup are demonstrated and discussed regarding ion-assisted thin film growth.

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