Ion Beam Injector based on High Current LMIS

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One of the major advantages of Liquid Metal Alloy Ion Sources (LMAIS) is the capability to emit a broad spectrum of ions from doubly and singly charged ions of nearly the half of the periodic table up to molecular ions or small clusters, consisting of a few atoms and different charge stages. These ion sources, characterized by a high brightness of about 10^6 A/cm2 sr, low energy spread of some eV and a very compact design are dedicated mostly for focused ion beam (FIB) applications [1] or field emission electric propulsion (FEEP) thrusters in space technology [2]. Normal ions in a wide spectrum of parameters can be provided also by other ion sources. The very special of LM(A)IS are the formation of heavy polyatomic ions from metallic or semiconducting elements, which is of great interest for self-organized surface patterning. So with Bismuth di- and trimer ions regular hexagonal dot structures were obtained after room temperature irradiation of Germanium at normal incidence using a FIB instrument induced by the enormous energy deposition by the heavy projectiles [3,4]. To employ these heavy ions also for other ion beam systems and especially for larger areas an ion source injector module based on a high current LM(A)IS will be presented. Total emitted ion currents of more than 100 µA can be reached using different types of field emitter in particular porous needles from Tungsten and Rhenium or capillaries, 50 µm inner diameter of Tantalum. Source materials like Ga for tests, Gold (from $Au_{82}Si_{18}$ alloy), Lead or Bismuth (Bi or $Ga_{38}Bi_{62}$ alloy) were investigated. The I-V characteristic of a porous W-emitter compared to a classical tip is shown in Fig. 1.
In the injector a nearly parallel ion beam of about 2 mm diameter can be obtained by means of an asymmetric ion-optical Einzel lens. A section of the source and lens design is presented in Fig. 2. The cluster ion fraction for a certain ion species is in the range of per mil up to a few percent dependent on the emitted elements. A mass separation system (Wien filter) selects the desired ions while a quadrupole is used for beam adjustment and astigmatism correction. High cluster ion currents enable the formation of various nanostructures or even smooth surfaces over an area in cm²-range depending on ion species, energy, fluence and angle of incidence. The LM(A)IS preparation and the performance of the ion beam module at certain experiments will be presented and discussed.

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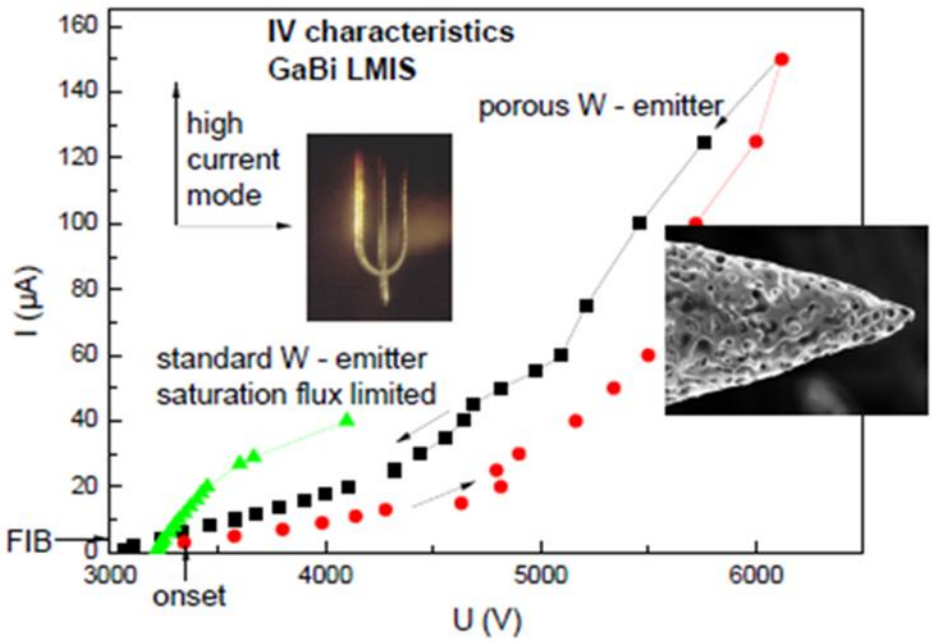

Fig. 1: I-V characteristics of a porous tungsten emitter for GaBi alloy (SEM image right), compared to a standard W emitter which is saturation flux limited (green points), see photo left.

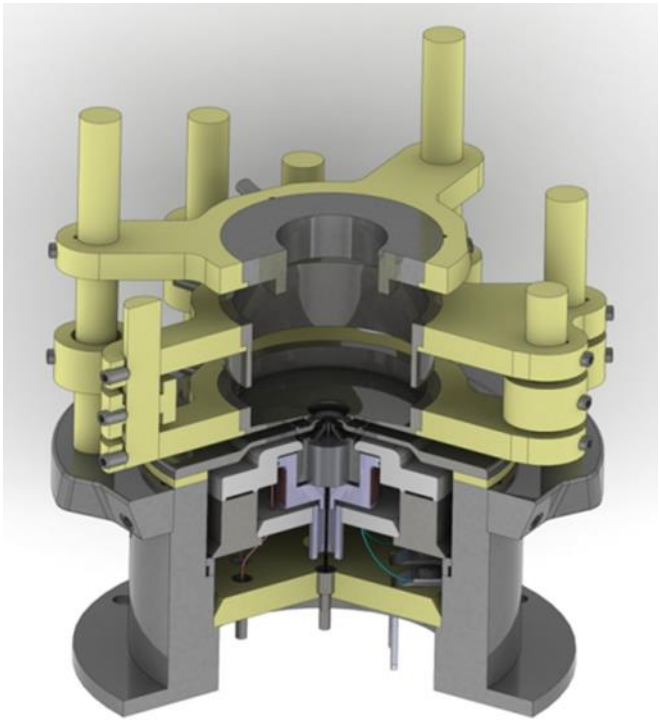

Fig. 2: Section of the design of the source module combined with the asymmetric Einzel lens