Brightness measurements of a Gallium liquid metal ion source

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The virtual source size of a Liquid Metal Ion Source is an order of magnitude larger than the size of the region from which the ions are emitted at the source. This source size has a direct effect on the reduced brightness and, hence, on the performance of these sources. The virtual source size of a gallium Liquid Metal Ion Source has been measured as a function of the ion emission current. This was done by extracting the source image size from images of a carbon pencil lead specimen, in an FEI Focused Ion Beam FIB 200 system. The measurements indicate that the virtual source size, defined as the diameter which contains 50 % of the current (FW50%), grows from about 50 to 80 nm when the emission current increases from 1 to 10 μA (see fig. 1). The experimental data on the virtual source size are compared with the trajectory displacement due to stochastic Coulomb interactions[1] in the accelerating region of the source. In the Holtzmark regime it is expected that the trajectory displacement increases with angular current density according to a 2/3 power law. To verify whether the increase of the virtual source size with emission current follows this power law the results in fig. 1 are plotted as a function of angular current density. The relation between angular current density I_Ω and emission current I is approximately linear: I_Ω (in μA/sr) = 21+1.6*I (in μA). A nice agreement is found indeed. The results are also consistent with numerical-theoretical results of Radlička and Lencová[2]. From these measurements we were able to show that the reduced brightness deteriorates with an increasing angular current density (see fig. 2). The maximum reduced brightness measured is 1×10^6 A/(m^2srV).

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[1] P. Kruit and G.H. Jansen, in *Handbook of Charged Particle Optics*, edited by J. Orloff (Chemical Rubber, Boca Raton, FL, 1997), p.275.
[2] T. Radlička and B. Lencová, Ultramicroscopy (2007), doi:10.1016/j.ultramic.2007.07.004

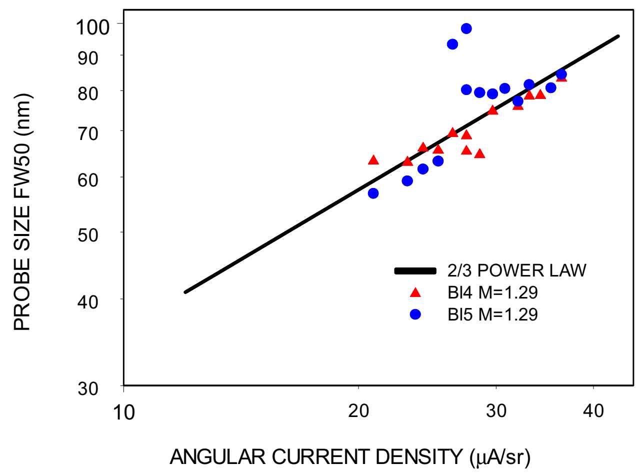

Fig. 1: The measured probe size as a function of angular current density. The magnification M is 1.29. Two similar series of measurements are shown (triangles and dots), and the solid line represents the 2/3 power law of the trajectory displacement caused by the statistical Coulomb interactions in the source region.

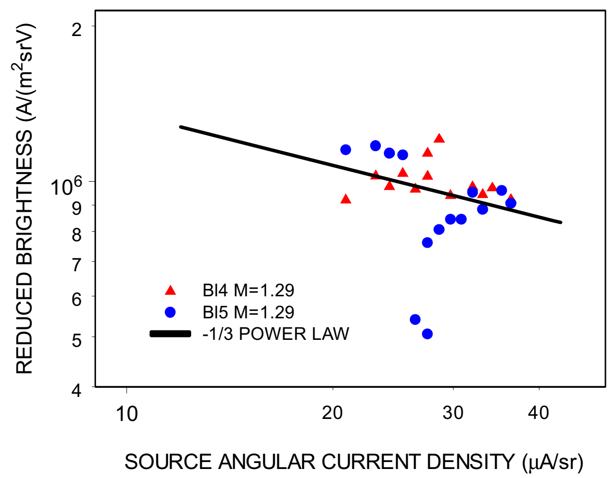

Fig. 2: The reduced brightness as a function of the source angular current density for the measurements of fig. 1. The solid line now is the -1/3 power law that results when the reduced brightness is determined by the trajectory displacement caused by the statistical Coulomb interactions in the source region.