

Technology and Recent Improvements of LMIS for FIB patterning and FIB nanofabrication

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In this presentation we will review some fundamentals of the Focused Ion Beam (FIB) technique based on scanning finely focused beams emitted from Electro Hydrodynamic Emitters (EHD) to perform direct writing [1]. It is widely assumed that the spatial extension of the phenomena induced by FIB irradiation represents a severe drawback, presumably limiting the use of this method for the realization of highly localized structures. At the light of advanced experiments and analysis techniques we will review these limitations and thus explore FIB for patterning sensitive devices such as III-V heterostructures, thin magnetic layers, artificial defects fabricated onto graphite or graphene, engraving nanopores into thin Si-based and atomically thin suspended graphene membranes. This includes the aspect of short ion penetration ranges and high localization of ion-deposited energy for localized damage generation showing the ultimate potential of this technique with respect to spatial resolution and ion doses.

We will introduce the principle and mechanism of liquid metal ion source (LMIS) operation and explain achievements for its performance in particular for Ga. Moreover the technology and range of available ion species of alloy sources (LMAIS) are presented and discussed [2]. We will conclude in presenting the instrumental routes we are exploring aiming at higher resolution, better stability and various ion species as well as turning FIB processing "limitations" into decisive advantages. Such new routes for the fabrication of devices or surface functionalities are urgently required in some emerging nanoscience applications and their developing markets.

[1] J. Gierak, R. Jede, and P. Hawkes "Nanolithography with Focused Ion Beams", in Nanofabrication Handbook S. Cabrini and , S. Kawata ed., 2012 CRC Press

[2] L. Bischoff, P. Mazarov, L. Bruchhaus, J. Gierak "Liquid metal alloy ion sources - An alternative for focused ion beam technology", Appl. Phys. Rev. 3, 021101 (2016)