Roadmap for Focused Ion Beam Technologies

Katja Hoeflich
Ferdinand-Braun-Institut gGmbH, Leibniz-Institut für Höchstfrequenztechnik, 12489 Berlin, Germany

Gerhard Hobler
Institute of Solid-State Electronics, TU Wien, 1040 Vienna, Austria

Frances I. Allen
Department of Materials Science and Engineering, University of California, Berkeley, California 94720, USA

Tom Wirtz
Advanced Instrumentation for Nano-Analytics (AINA), MRT Department, Luxembourg Institute of Science and Technology (LIST), 4422 Belvaux, Luxembourg

Gemma Rius
Institute of Microelectronics of Barcelona, IMB-CNM-CSIC, 08193 Cerdanyola del Vall

Gregor Hlawacek
Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany

This roadmap document comprises a review of the current state-of-the-art of advanced focused ion beam (FIB) processing and technology followed by an outlook on required future developments curated by a diverse group of stakeholders.
FIBs play an important role in scientific research in fields ranging from health and biology to quantum technology and nuclear fusion research. However, usually FIBs are perceived as tools for the preparation of samples for other methods such as transmission electron microscopy or atom probe tomography. The intention of this document is to show that this is a clear underestimation of the method by showcasing current and past applications as well as providing a guideline for academia, industry and funding agencies on necessary future developments. The roadmap starts with presenting the state-of-the-art of the FIB technology and instrumentation. The working principle of the FIB is described and an overview of additional instrumentation and detectors who widen the applicability of the method is given. In the second section the available instruments for the simulation and prediction of the focused ion implantation and milling process is given. This includes advanced simulation techniques such as DFT and MD but also computational efficient methods like BCA which can be used in the every day lab work by FIB users. The core part of the review

describes the various applications which go beyond the preparation of TEM samples and include in addition to the above mentioned applications also the fields of spintronic and magnonics
super conductivity, photonics, micromechanics, MEMS/NEMS and many more. In the last part the authors comprising the relevant stake holders give an overview of the required future development which will enable FIB technology to stay at the forefront of research in the discussed fields. This outlook part is partly based on a survey conducted within the European COST Action CA19140 FIT4NANO which unites more than 200 users, developers and manufacturers of FIB technology. The intention of this part is to act as a guideline for academic and commercial developers as well as funding agencies to steer the future developments in a direction agreed upon by the community. It is this aim supported by the divers group of contributors to the review which makes this roadmap relevant and timely for many fields of research

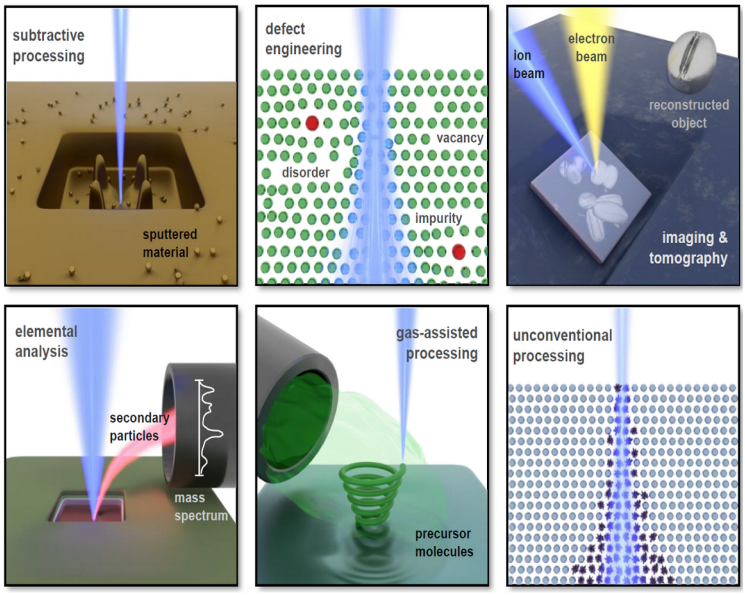

Figure 1: Schematic overview of the different advanced FIB techniques.

This publication is based on the work from the COST Action FIT4NANO CA19140, supported by COST (European Cooperation in Science and Technology) https://www.cost.eu/ and http://www.fit4nano.eu/.

Reference: K. Höflich et al., "Roadmap for focused ion beam technologies," Applied Physics Reviews, vol. 10, no. 4, 041311 Dec. 2023, doi: 10.1063/5.0162597.