Focused ion beam nanofabrication - new possibilities

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Fabrication capabilities focused ion beam systems based on liquid metal ion sources were first demonstrated in the late 70s and early 80s. However, it took many years for some of the major applications to be identified and exploited. In recent years three radically new developments have emerged in focused ion beam capabilities namely:

- gas field ion source FIB systems, (aka He ion microscope) [1]
- plasma source-based FIB system [2]
- ion multibeam systems [3].

These systems, particularly with further development, will likely enable many new micro/nano applications or alter existing ones. Envisioning the applications often motivates and directs the system development. In this presentation I will examine some of the new capabilities of the systems and point to some possible applications.

The helium ion microscope is mainly seen as an imaging tool because of its ultra small beam diameter, the large depth of focus, the material contrast, and the fact that secondary electrons are emitted only close to the point of incidence. However, the direct fabrication capabilities of the helium ion beam have not widely been explored. Because of beam-solid interaction is more local than either electron beams or gallium ion beams, nanofabrication, particularly gas assisted, may be possible at smaller dimensions.

Plasma-based ion sources are well known and have many applications. Although the brightness of plasma ion sources is about 300 times lower than that of a gallium liquid metal ion source (LMIS), at beam currents above 50 nA a xenon plasma ion source will outperform the LMIS, i.e. higher beam current density for the same beam diameter.

The plasma ion source is also the key element of the ion multibeam system. In applications where an ion dose has to be delivered to a significant sample area the throughput of a multibeam system, determined by the total current, is at least two orders of magnitude higher than for an FIB. The total current in the multibeam system is determined by two fundamental factors the current density that plasma ion source can deliver for a given collimation and the ion-ion scattering in the beam crossovers in the demagnifying ion optics. Another advantage over FIB systems is that the multibeams can be available with a large variety of ion species from a stable source. Moreover, many of the applications one can envision do not require the ultimate resolution so that the collimation and crossover current limitations can be relaxed resulting in a much higher total current. Examples of such applications demonstrated in the past, not put into practice, but worth examining now in light of the new developments, include: flash A/D converters, higher-speed charge coupled devices, and RFID tags.

[1] B.W. Ward, J.A. Notte, N. Economou, JVST, B242871 (2006)
[2] P.Tesch, N. Smith, N. Martin, D.Kinion, Conf. Proc. ,34th International Symposium for Testing and Failure Analysis November 2–6, 2008,Portland, Oregon,
[3] E. Platzgummer, H. Loeschner, G. Gross, JVST- B 26, 2059, (2008)

Overview of novel Ion source,
FIB and ion multi-beam
developments and achievements