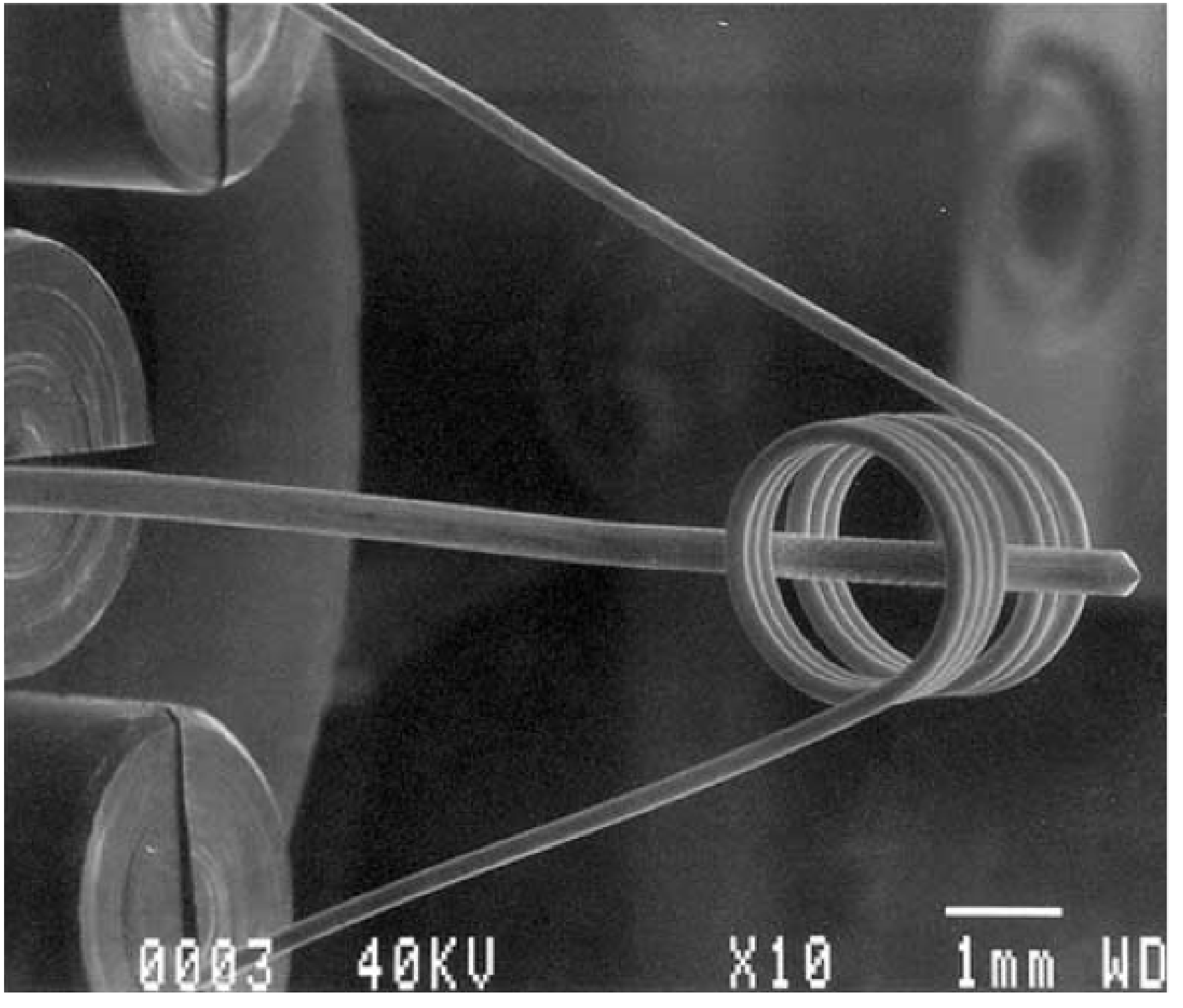
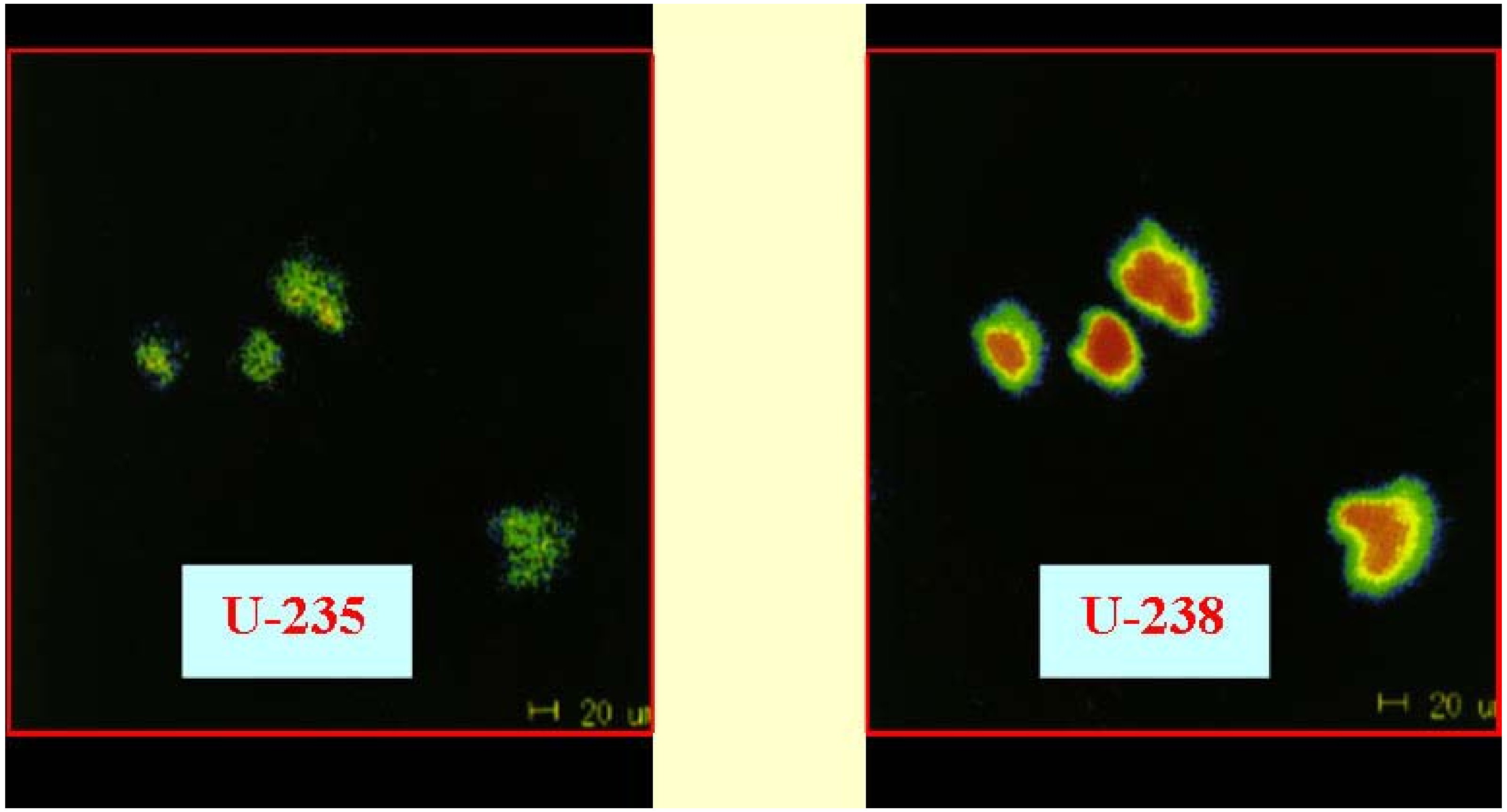
Liquid Metal Ion Sources (LMIS):



Where are LMIS found?:

- Focused Ion Beam (FIB)
- Secondary Ion microscopy equipment.



http://ec.europa.eu/dgs/jrc/site_images/hi-res_10030.jpg

Common Metals Used for LMIS & Properties:

Table 1

Percent beam composition at $I_T = 5\ 0\ \mu A$ for several pure metal LMIS

	M^+	M^{++}	M_2^+	M_3^+	Other
Al	100 0	0 0012	0 00099	0 00009	0 00004
Ga	99 92	0 0014	0 060	0 016	0 006
^{69}Ga (isotopic pure)	^{69}Ga 99 27	0 0018	0 080	0 021	0 008
	^{71}Ga 0 61				
In	100 0	n	n	n	n
Au	68 9	16 0	6 0	9 0	nm
Bi	64 9	4 0	10 3	8 3	Bi_3^{++} 10 4
					Bi_5^{++} 2 0

nm – not measured

n – not present

Common Metals Used for LMIS & Properties:

Table 2

Summary of various pure metal LMIS properties

	Sub-strate	Melting point (K)	Vapor pressure [a] (Torr)	Calculated efficiency (μA h/mg)	Experimental efficiency (μA h/mg) [b]
Al	Ti/C	933	$4\ 9\times10^{-9}$	993	–
Ga	W	303	$2\ 0\times10^{-40}$	383	375
In	W	429	$1\ 9\times10^{-21}$	233	200
Au	W	1336	$6\ 4\times10^{-6}$	145	–
Bi	NiCr	544	$6\ 1\times10^{-11}$	137	–

[a] Vapor pressure is at melting point

[b] For total current 2 0 μA

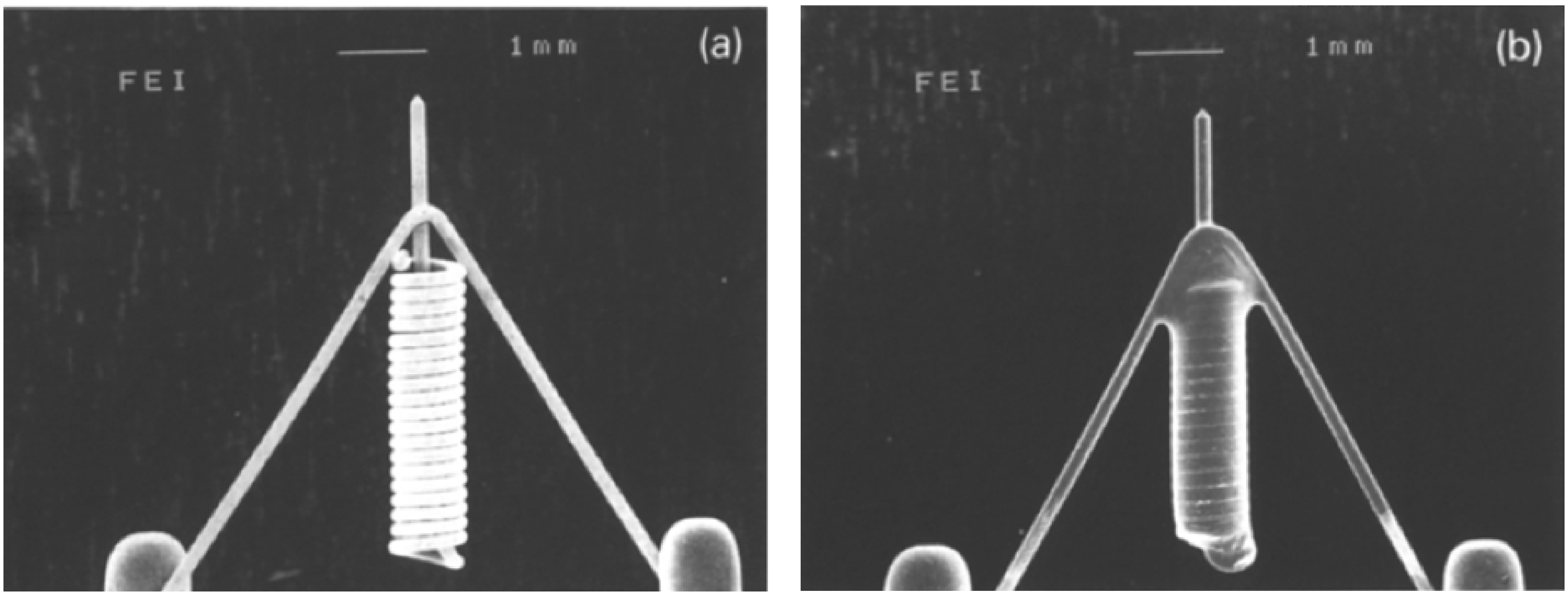
$$\frac{\mu\text{A h}}{\text{mg}} = 2\ 66 \times 10^{4} A^{-1} \sum \frac{mX(\text{M}_n^m)}{n}$$

How do we extend the LMIS lifetime?

- Keep the operating current low!

http://www.cartoonstock.com/newscartoons/cartoonists/kmh/lowres/kmhn569l.jpg

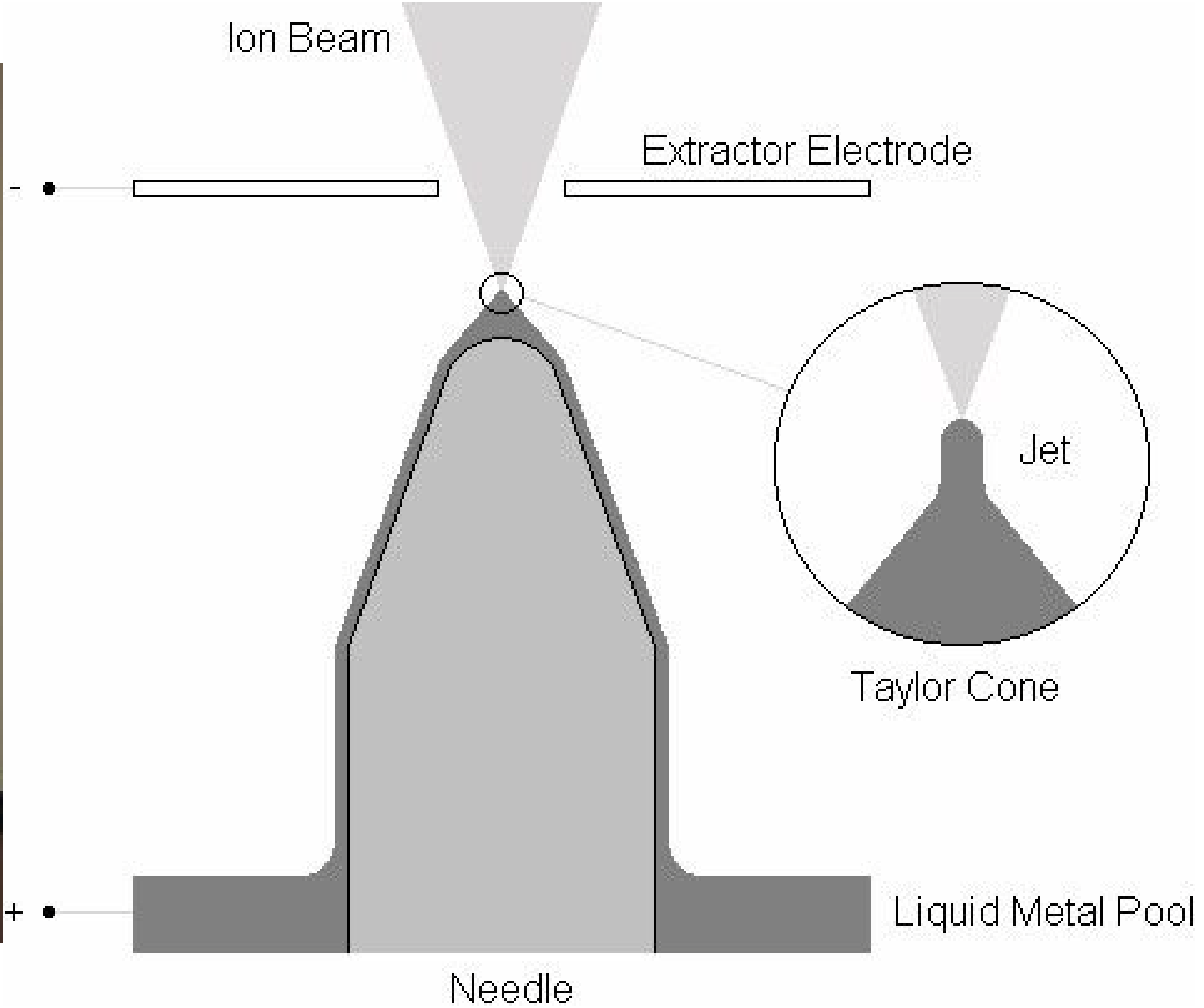
LMIS:



Before dipping After dipping

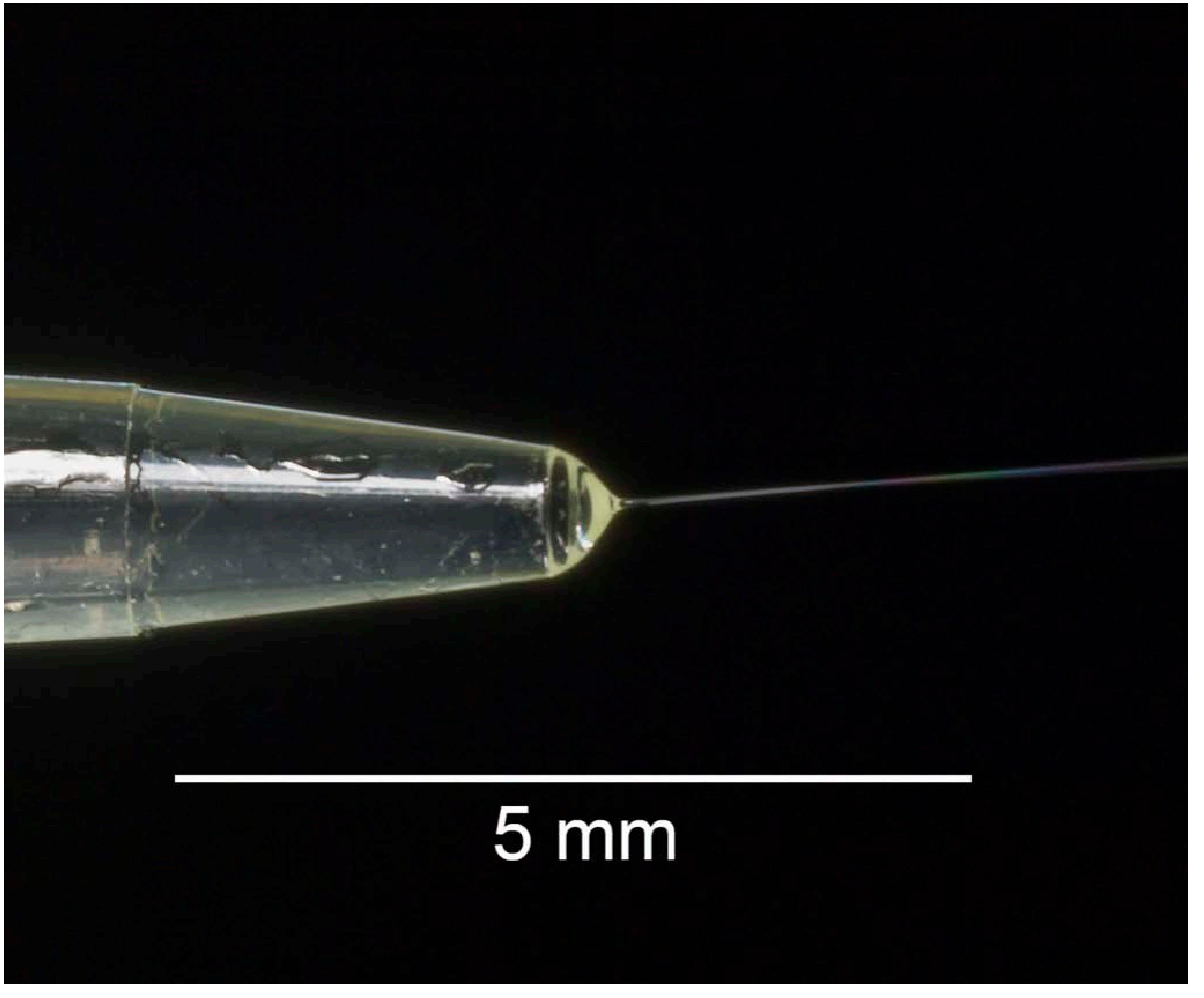
Taylor Cone:

http://www.stehm.uvic.ca/images/installation/IMGP9434.jpg



http://www.advanced-materials.at/images/Bilder%20SPA%5Cliquid%20metall%20ion%20source.jpg

Taylor Cone:



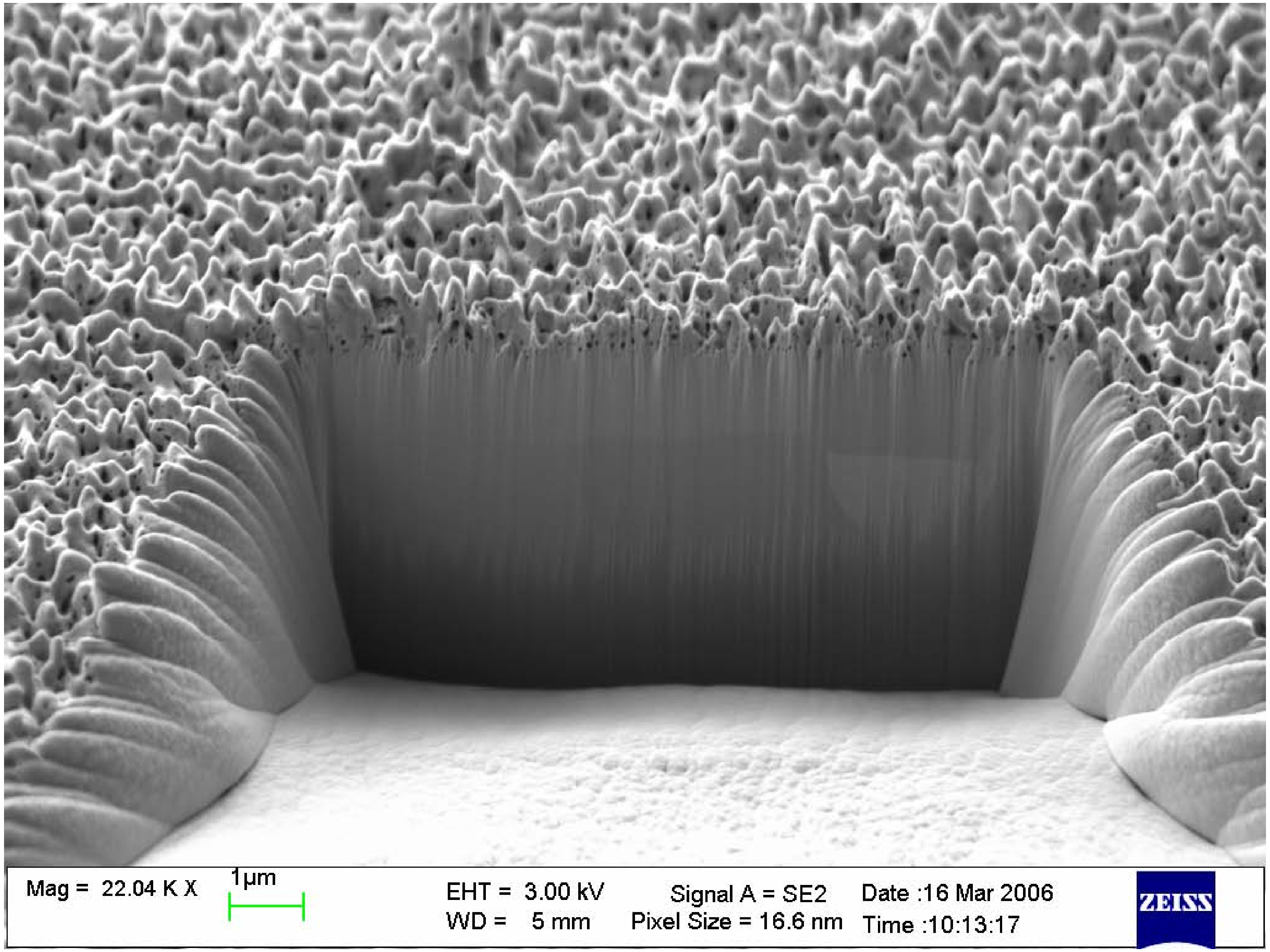
http://upload.wikimedia.org/wikipedia/commons/6/6e/Taylor_cone_photo.jpg

It is important that…

- There be minimal current fluctuations.

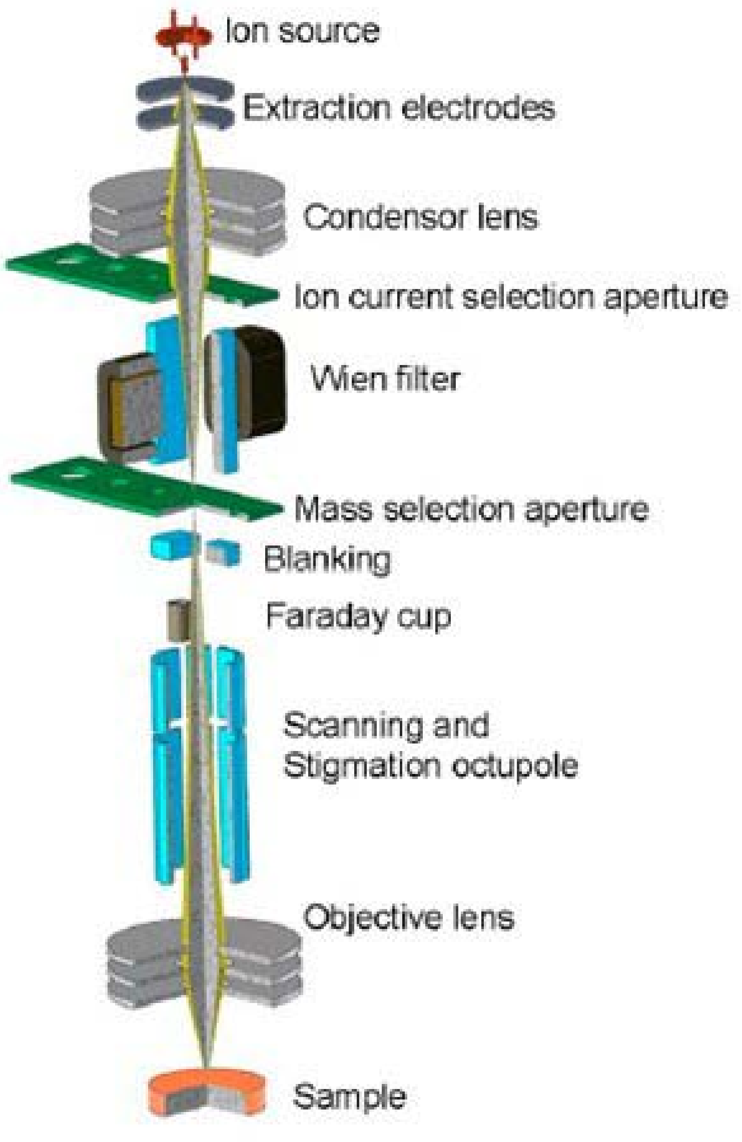
Why the need for minimal current fluctuations?:

- Ensures high resolution for FIB work.



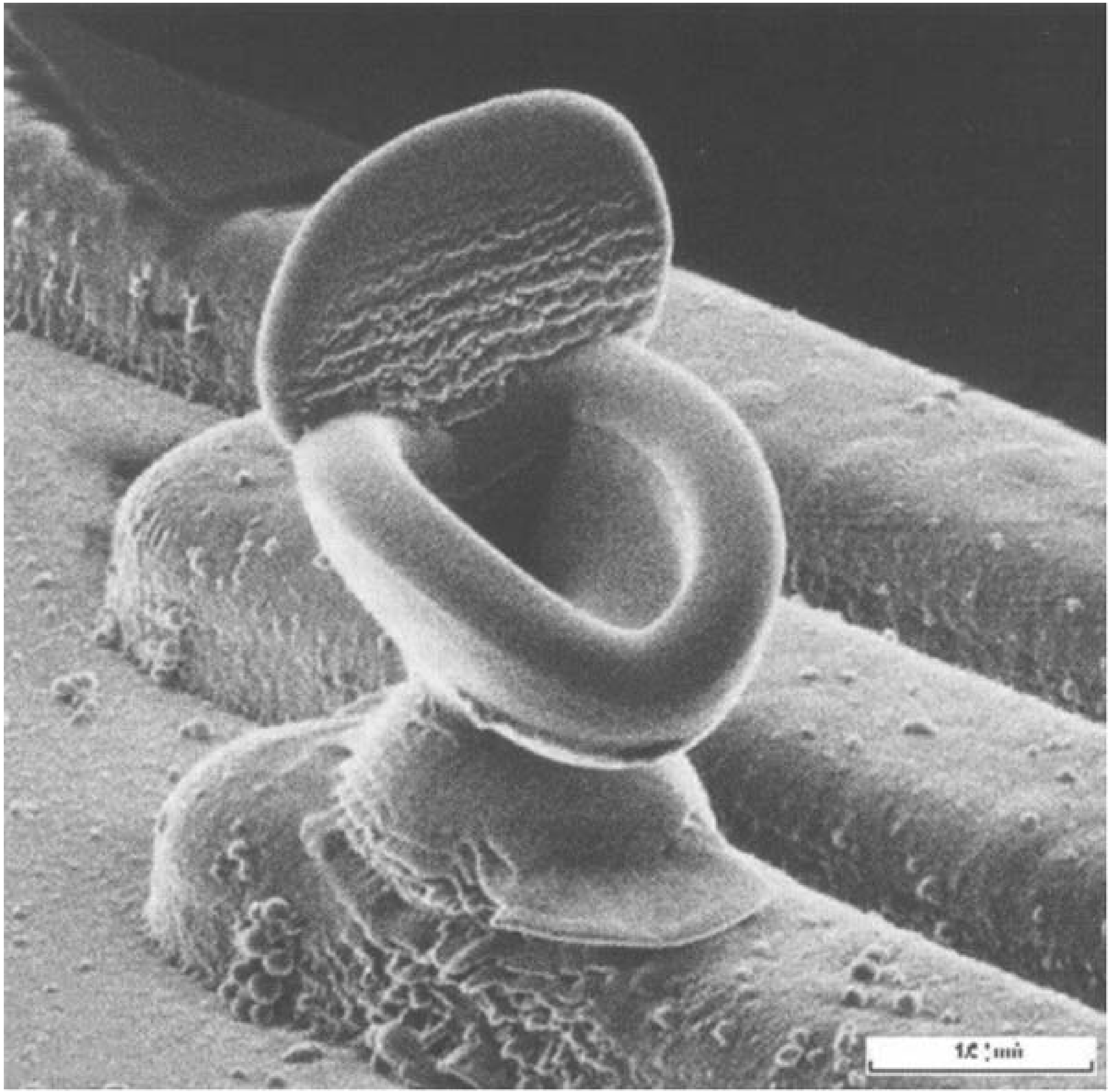
http://iec.neep.wisc.edu/images/fib_pic.jpg

General FIB Schematic:



http://upload.wikimedia.org/wikipedia/commons/e/e7/ExB_Column.jpg

The photograph title, Chisai Benjo, means "small toilet" in Japanese.



http://www.zyvex.com/EIPBNuG/05bizarre.jpg

http://www.electronics-lab.com/blog/wp-content/uploads/2008/04/mcmasterhair.jpg

Reference:

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Applied Surface Science 76/77 (1994) 80–88

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Use of the liquid metal ion source for focused beam applications

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Abstract

A review of the liquid metal ion source (LMIS) emission properties as they affect its performance in focused ion beam (FIB) applications is given for several pure metal sources which include Al, Ga, In, Au and Bi. Functional relationships between source emission characteristics such as energy spread, angular current intensity, virtual source size and LMIS properties such as atomic mass, source current and ionic charge are given. Experimental and Monte Carlo results are used to develop these relationships. In general best LMIS performance for FIB applications occurs at low source current and with small atomic mass LMIS. Beam noise characteristics are close to the shot noise limit.

1. Introduction

During the past decade the liquid metal ion source (LMIS) has found extensive use as a high brightness source of ions for focused ion beam (FIB) applications [1]. Reliable, long lived, pure metal sources, such as Al, Ga, In, Au, Sn, Bi, etc., are now available along with alloy sources of B, Si, As, Be and other ions useful for semiconductor device implantation, lithography or related applications. Pure metal sources are finding increasing commercial use in a variety of applications related to semiconductor and microstructure device analysis, modification and fabrication. In the latter applications, three basic features of FIB are exploited. They are: sputtering, imaging and ion-beam-induced deposition of metal or insulating films.

Sputtering or, as it is often referred to, micromachining is one of the most common applications of microfocused ion beams. The ability to form sub-tenth micron beams with current densities in excess of 1 A/cm^2 allows for the formation of a variety of high-aspect-ratio microstructures. Modification and repair of semiconductor devices and the formation of a variety of microstructures by use of micromachining and metal deposition is now a common use of FIB systems.

In addition to its unique ability to modify surfaces, FIB can be used to image surfaces in a scanning ion microscope (SIM) mode of operation. Either secondary ions or electrons can be used to image the surface features, each with unique contrast mechanisms that provide useful image information of surface structure and composition. Through a combination of sputtering and SIM, three-dimensional image information can be obtained from multilayer structures by cross sectioning. Depth profiling of multilayer devices with a high degree of lateral resolution

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