

ME-652 Advanced Additive Manufacturing

Micro-Manufacturing by Additive
Manufacturing Practices

- Kalpak Hedawoo



Micro-Manufacturing

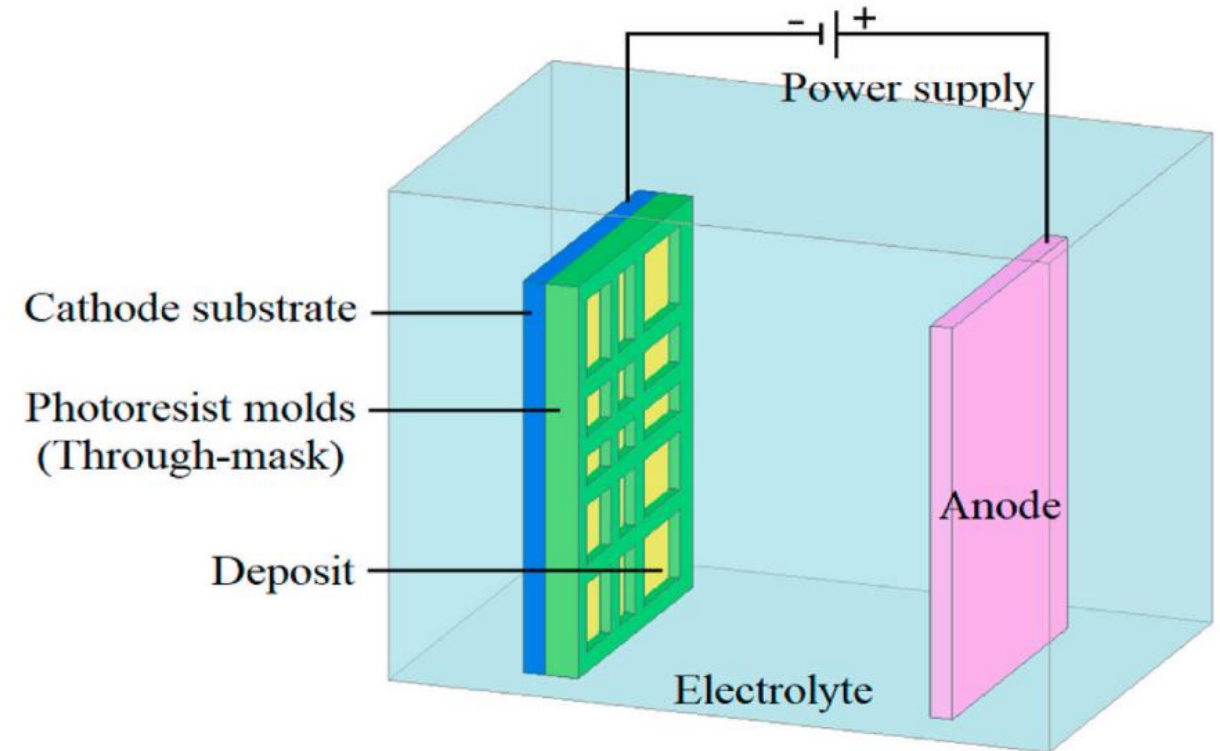
- Microfabrication (Micro-Manufacturing) technologies originate from the microelectronics industry, and the devices are usually made on silicon wafers even though glass, plastics and many other substrate are in use. Micromachining, semiconductor processing, microelectronic fabrication, semiconductor fabrication, MEMS fabrication and integrated circuit technology are terms used instead of microfabrication, but microfabrication is the broad general term.
- I will be majorly focusing on electro-chemical manufacturing process. Depending on the deposition methods this manufacturing is bifurcated in various types
 1. Thermal oxidation
 2. Local oxidation of silicon
 3. Chemical vapor deposition (CVD)
 4. Physical vapor deposition (PVD)
 5. Epitaxy



Details about Micro-Manufacturing

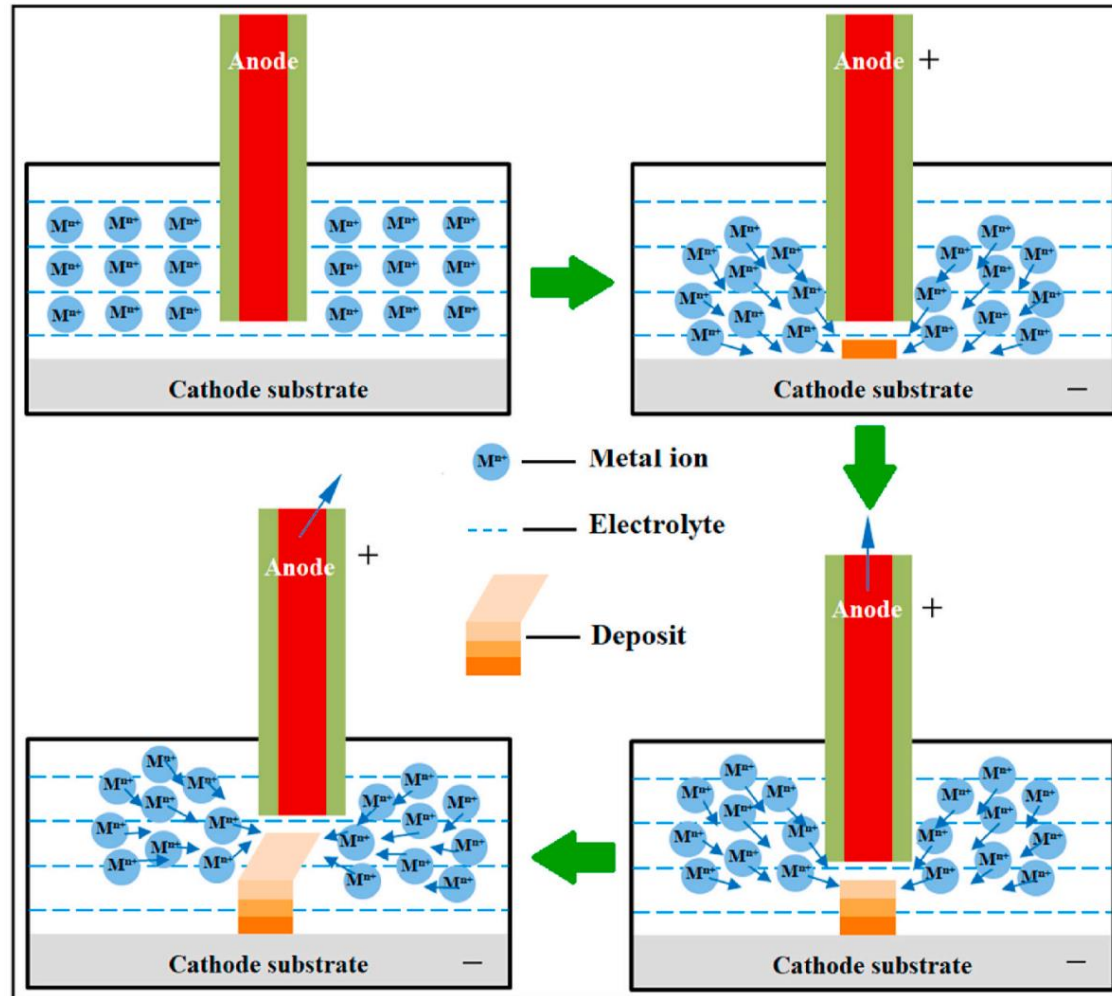
Electro-Chemical

- Electrochemical micromachining is a process in which metal is removed from metallic workpieces by controlled dissolution of surface atoms without direct contact between the tool and the workpiece material. Material removal follows Faraday's law of electrolysis, that is, the amount of material removed is proportional to the time and intensity of an electrical current flow between tool and workpiece. The workpiece is not exposed to mechanical or thermal stress, hence there is no change in the physical or chemical properties of the material.
- The microECM process can produce internal features a few microns deep by 10s to 100s of microns wide, or external features as small as a few microns in some applications.
- A significant advantage of the microECM technology is the ability to machine features in bores. In one application, we were able to put over 40 grooves in a 0.200" (5-mm) diam bore. The machining time to produce these grooves was 3.5 sec.

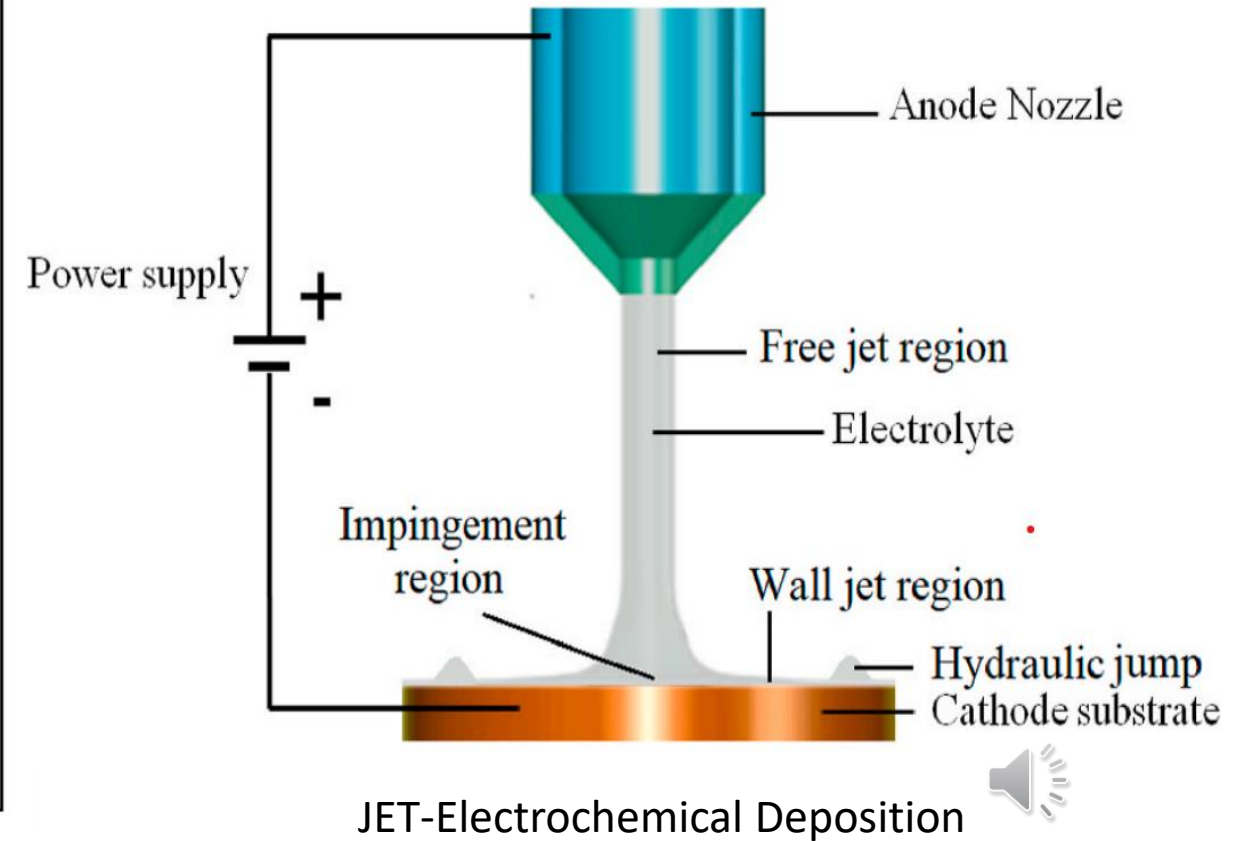


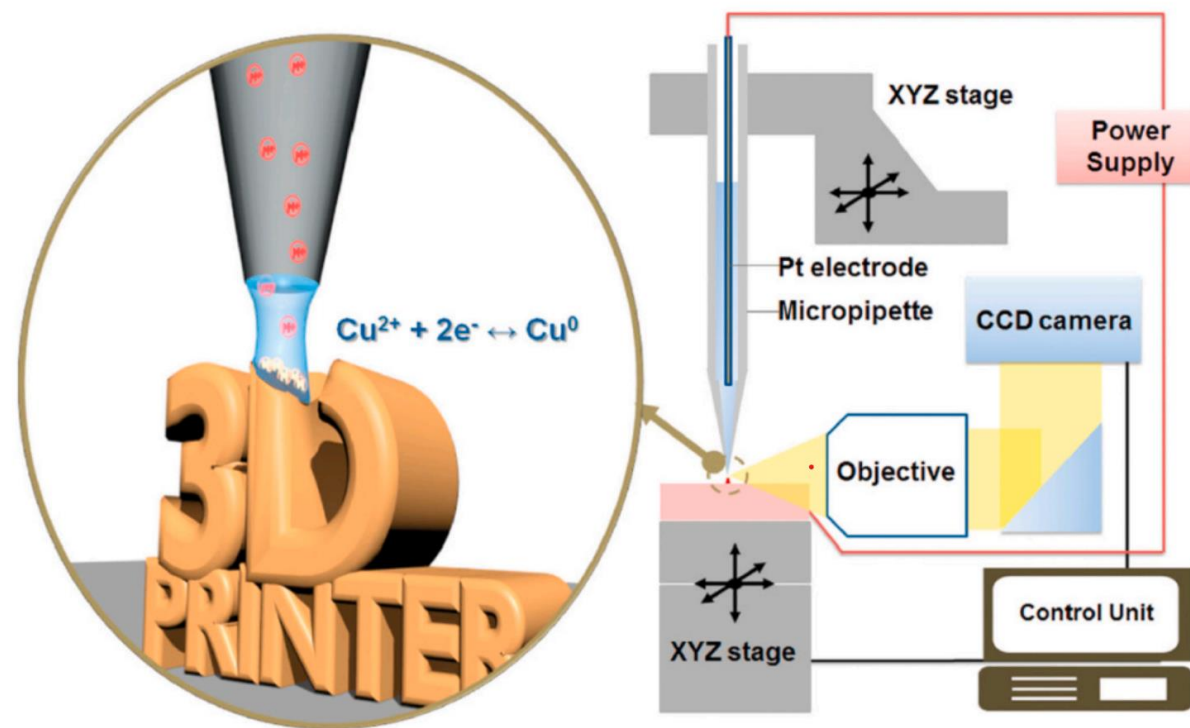
Generic Apparatus for microECM

Types of Electrochemical Micromanufacturing

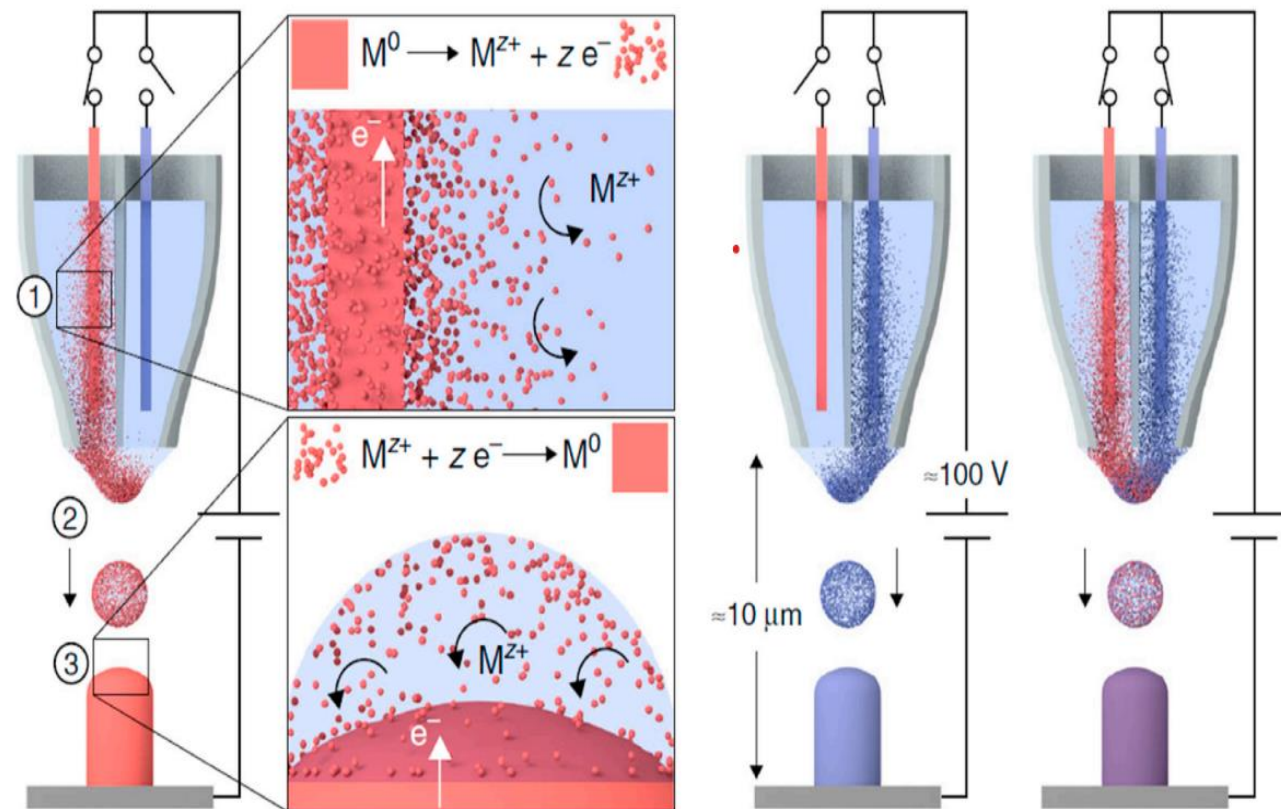


Localized Electrochemical Deposition Fabricating microstructure.





Meniscus-Guided 3D Electrodeposition Technique



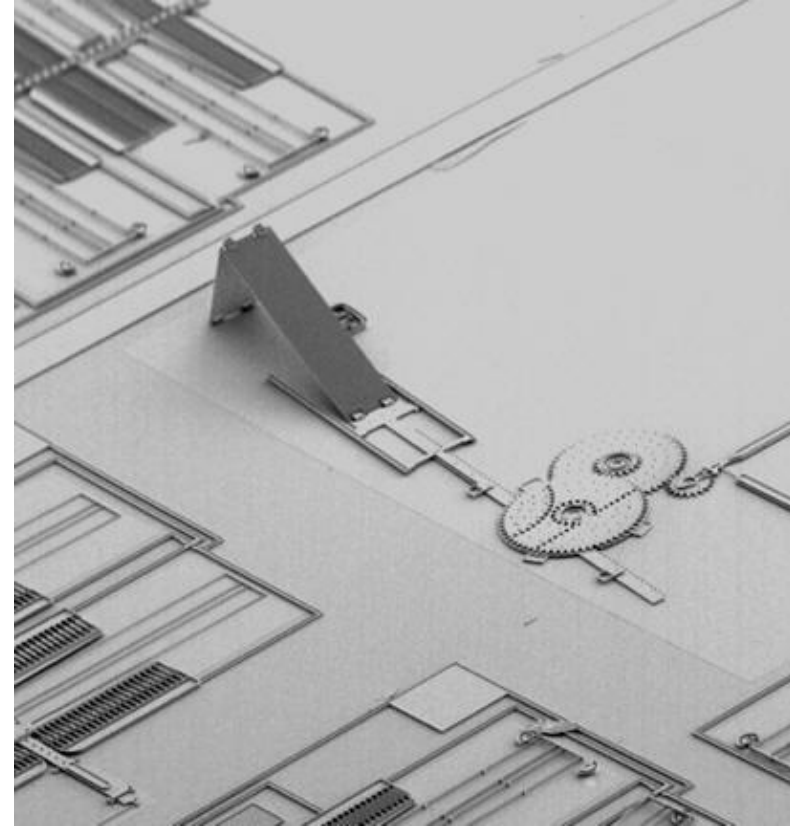
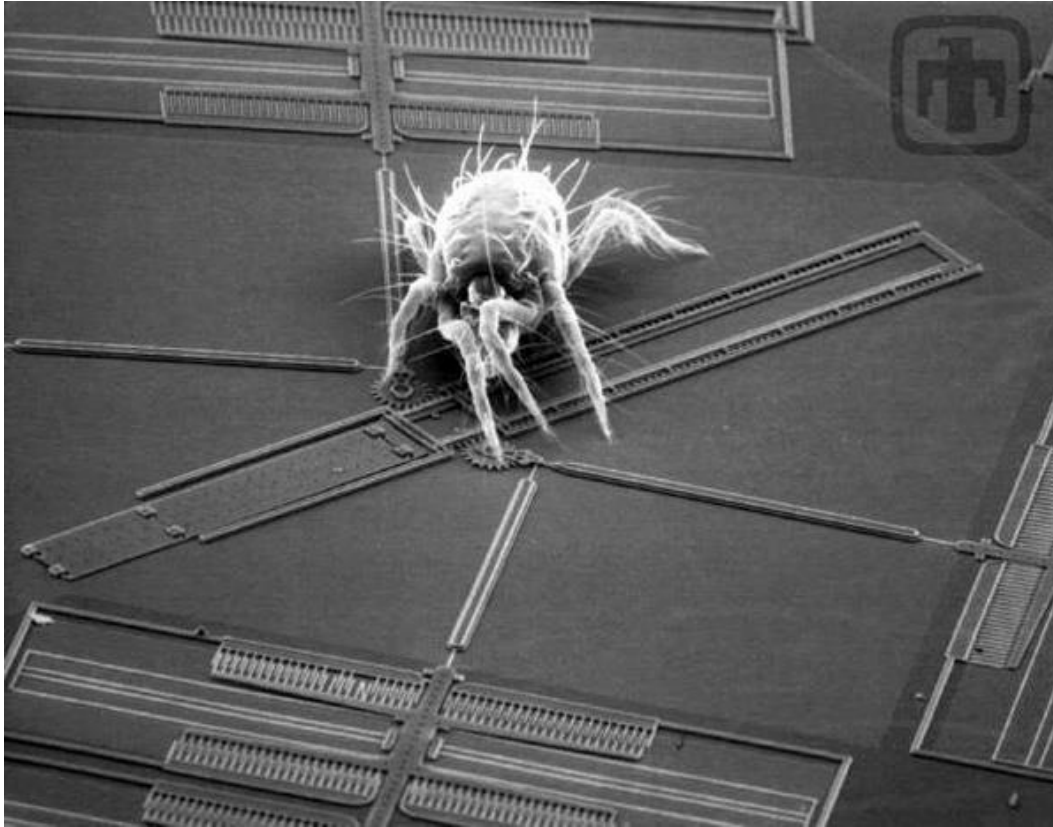
Electrohydrodynamic Redox Printing (EHD-EP)

Application examples



<https://youtu.be/12-IOyuPIZo>

Micro-Manufacturing Examples



A mite measuring 500 μ m long sits on a mirror array used for optical data switching. The mirror [flat in the left image, folded in the right] is positioned with a gear mechanism.



[Source: [Sandia National Laboratories/SUMMIT Technologies](https://www.sandia.gov/news/story/20130320_mite_on_mirror_array/)]

Micro-Manufacturing Examples

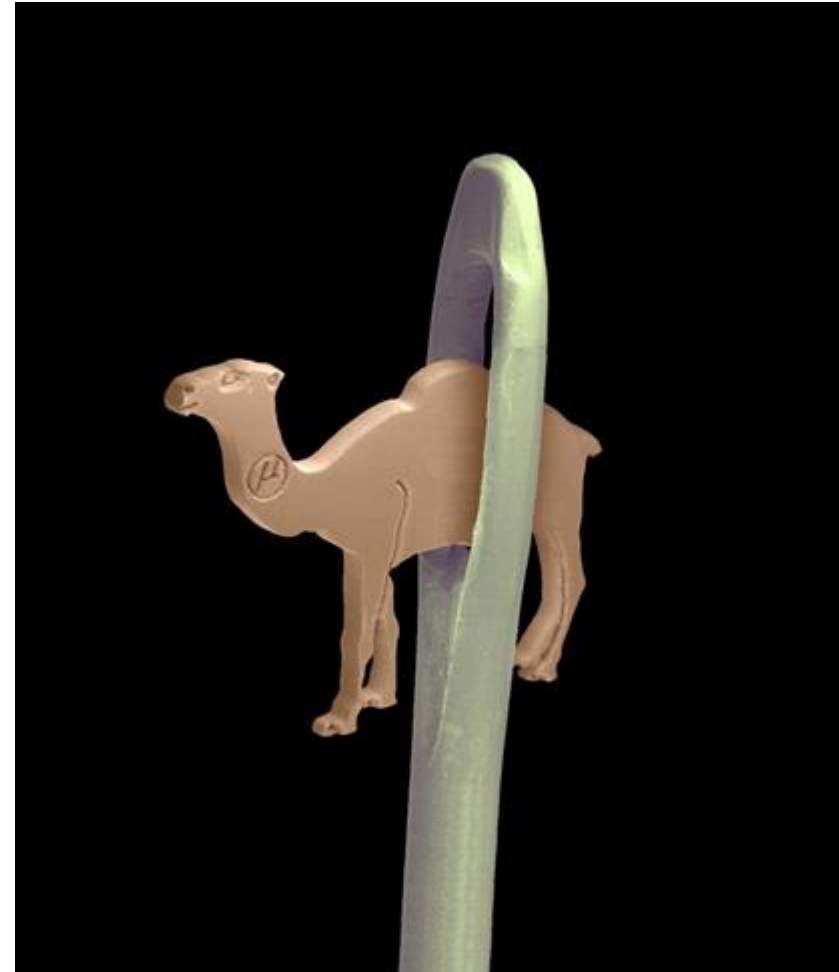


This preserved housefly is sporting a pair of two-millimeter-wide eyeglasses, engineered with ultra-precise fast-pulse laser technology.

[Source: [Micreon GmbH](#)]



Micro-Manufacturing Examples

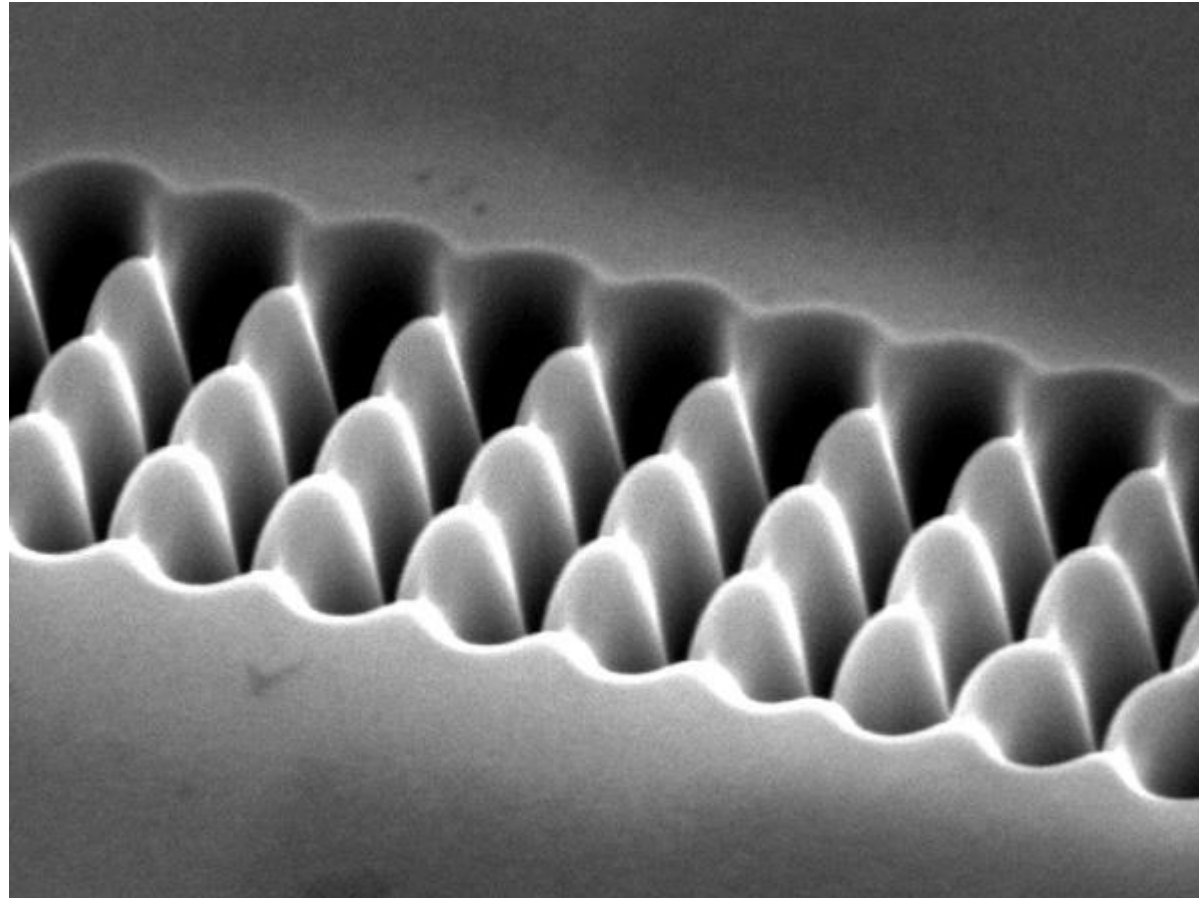


This two-millimeter-tall camel was made of gold foil.
Posed here passing through the eye of a needle 300 microns wide.



[Source: [Micreon GmbH](#)]

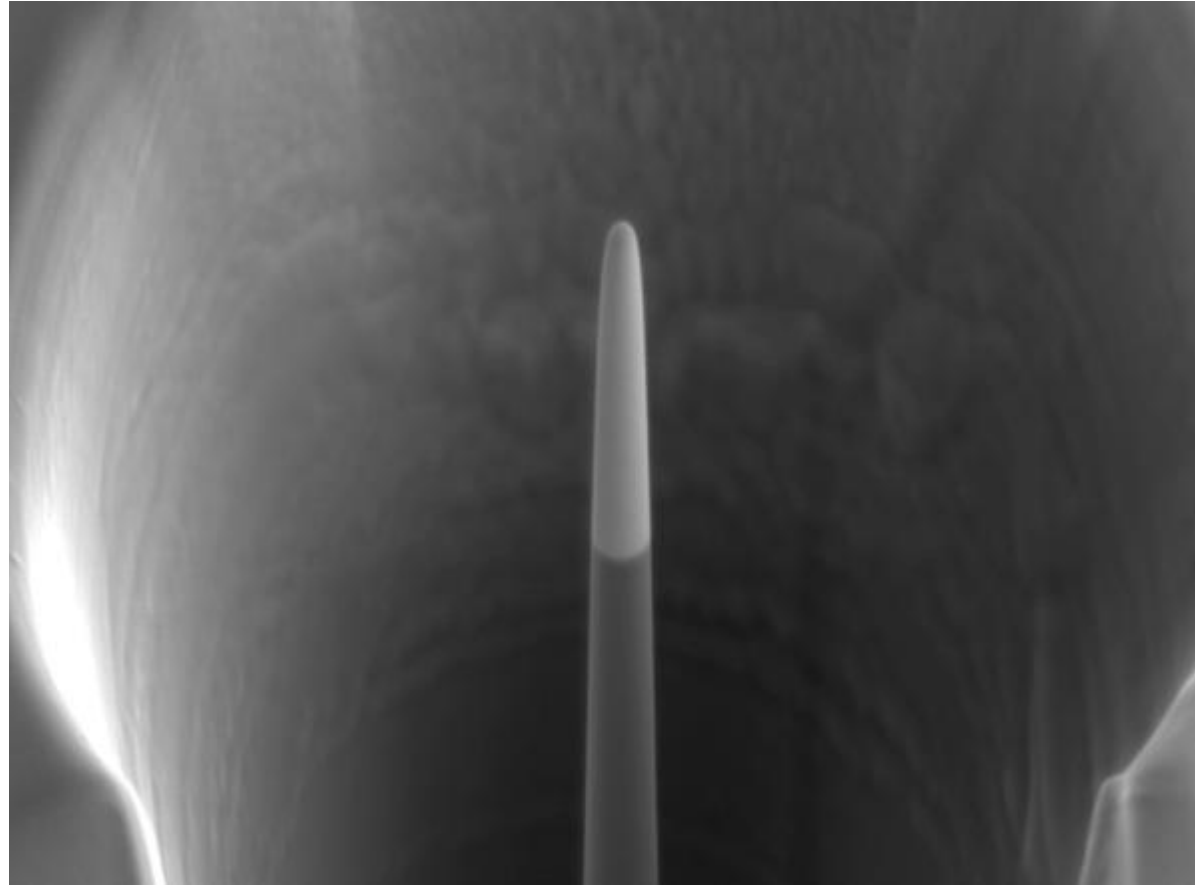
Micro-Manufacturing Examples



An array of holes, each measuring approximately 125 nanometers in length, was precision-drilled with a computer-controlled focused ion beam.



Micro-Manufacturing Examples



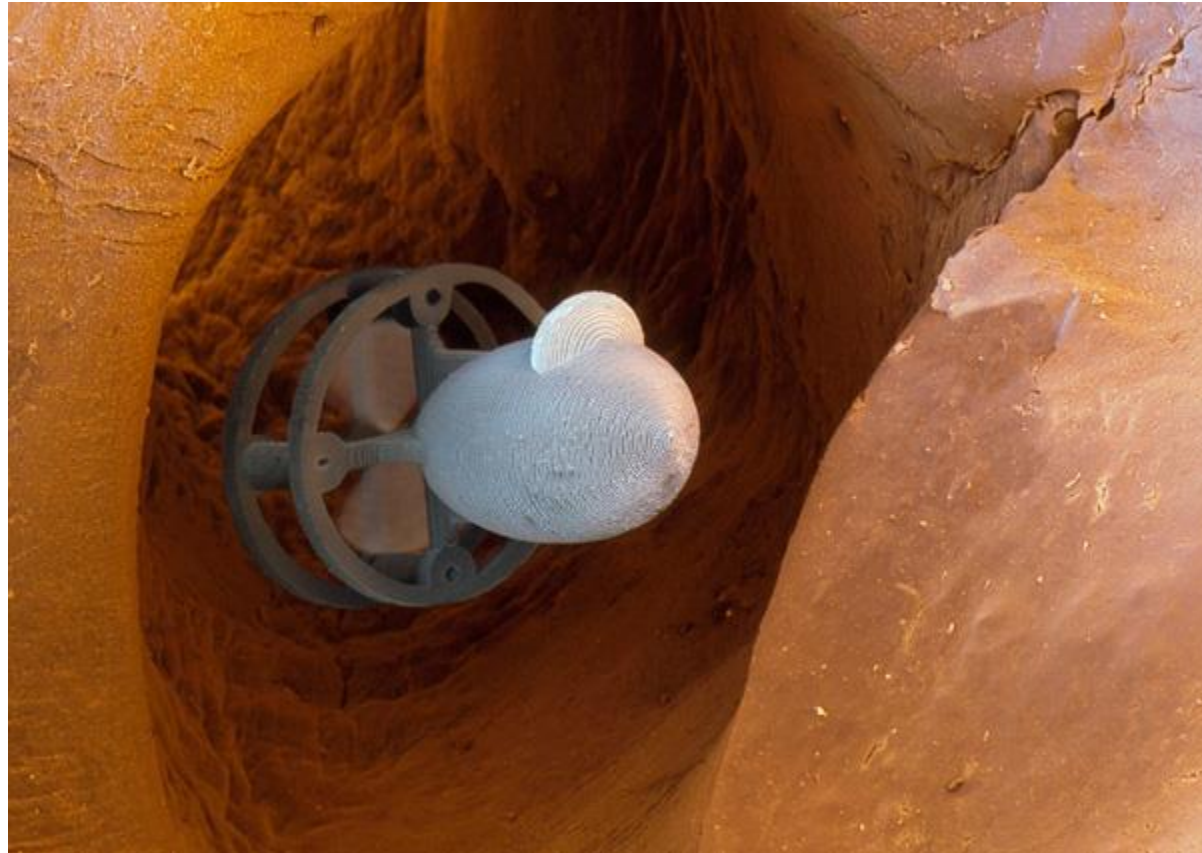
The platinum tip of a six-micron-long atom probe -- a device used to analyze the distribution of individual atoms in alloys and other substances is seen here at 25,000x magnification.

[Source: [FEI Company/Tools for Nanotech](#)]



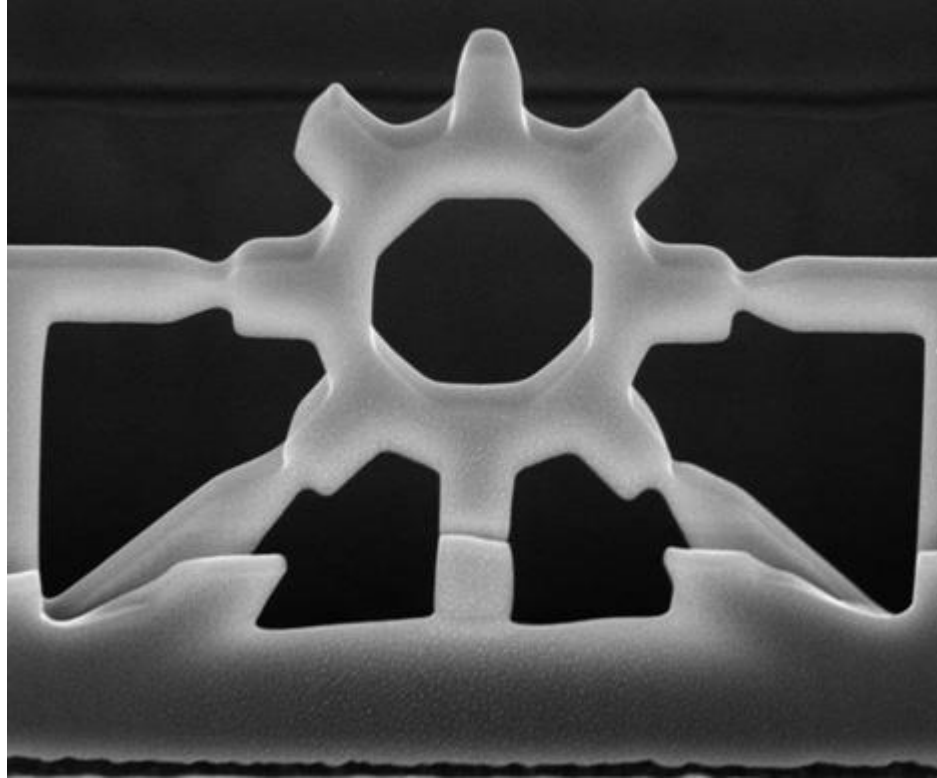
Micro-Manufacturing Examples

This 4mm long submarine is molded from an acrylic liquid that solidifies when it comes in contact with a computer-controlled laser beam. Its expected use is in future medical applications for treating the body on a microscopic level.



[Source: Eye of Science/Photo Researchers, Inc]

Micro-Manufacturing Examples



A focused ion beam created this two-micron-wide gear, seen here at 50,000x magnification



[Source: [FEI Company/Tools for Nanotech](#)]

Micro-Manufacturing Examples

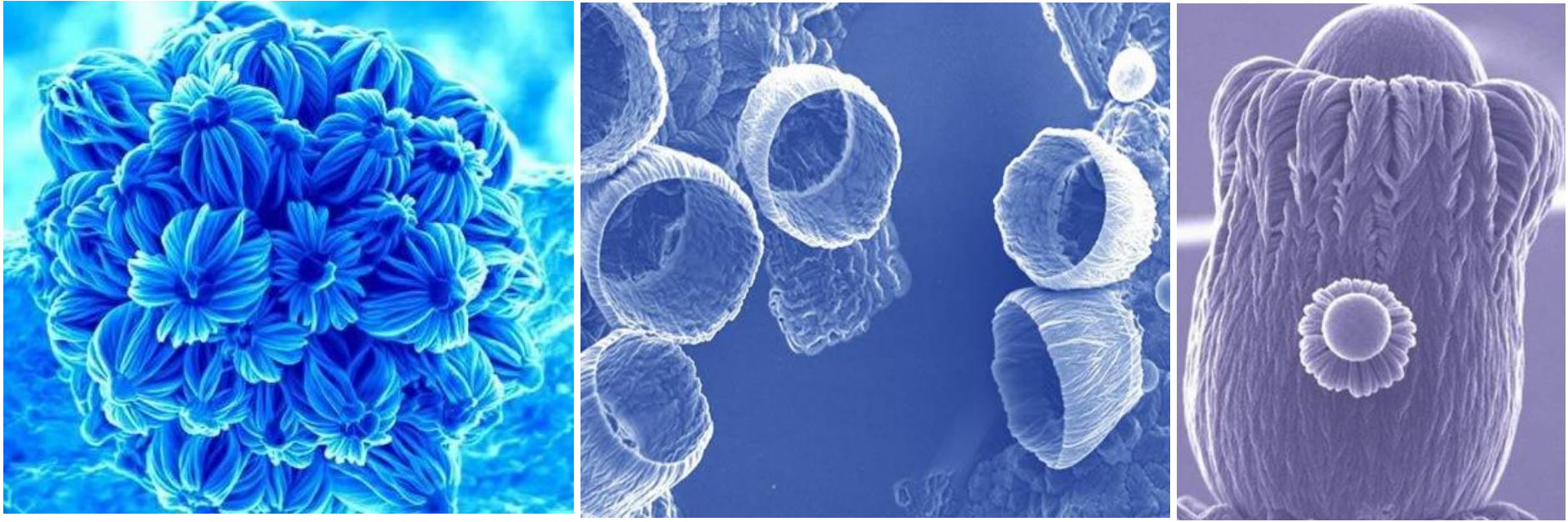


This chain of six microscopic gears can be used to drive micro-engines at speeds of up to 25,000 rpm. Longer chains can also be used in complex electronic locking mechanisms that are practically unpickable – each gear has to be precisely aligned in order to activate an electronic switch

[Source: [Sandia National Laboratories/SUMMIT Technologies](https://www.sandia.gov/summit-technologies/)]



Nano-technology: Silicon composite structures



Nano-technology is used to produce materials with feature sizes below 1μ , typically in the range 1-100nm. The fabricated objects may have many uses, including catalysts, coating for clothes, medicine, etc.



[Source: Univ of Cambridge Nanoscale science labs, Mark Welland & Ghim Wei Ho]

Conclusion

- Mask-based micro-AECM procedures often display greater surface quality and higher forming precision because the micro-sized geometries are created by electrochemically inverting the well-defined photoresist micro-molds.
- The micro-molds made via lithography are often quite exact in terms of their dimensions and geometrical shapes, with glossy, noticeably leveled surfaces. Furthermore, large-scale production of microfeatures and microcomponents is a strength of mask-based micro-AECM techniques. Hence, they have been created and employed more extensively in industry.
- The two industries that are most active here are the medical and electronic ones. The incentives are the same in both situations: producing smaller parts with greater functionality. A clear example is the cell phone. In a short period of time, it shrunk from being the size of a reasonably large handset to being smaller than a palm. The objective now is to pack these devices with more functions.
- In the medical field, the objectives are comparable. Units for various repair and pain-relieving devices must be modest since the human body has a finite capacity to take "additional" equipment. In order to reduce the risk of infection and promote quicker recovery, doctors also choose devices that are less invasive.



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