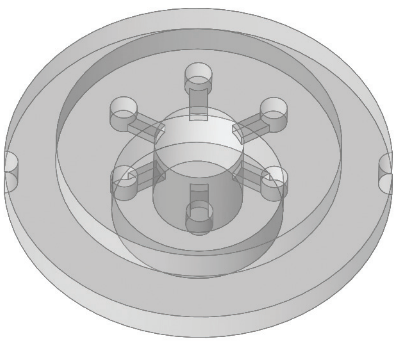
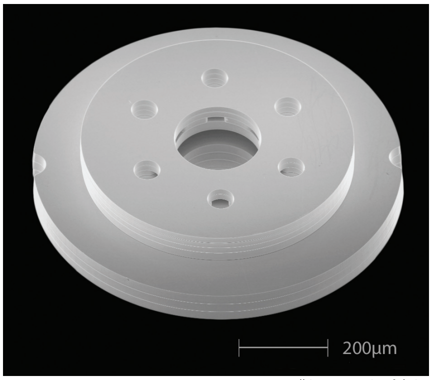
MICA Freeform combines fabbing techniques

MICA Freeform is a microscale fabrication process that bridges the gap between traditional micromachining processes, such as microEDM and laser machining, and newer methods, like LIGA—a process developed in Germany that combines lithography, electroplating and molding.

MICA Freeform, developed by Microfabrica Inc., Van Nuys, Calif., produces parts and devices by forming and stacking thin metal layers. A hybrid technique, it combines the batch-processing advantages of semiconductor chip production, the additive-layer principles of rapid prototyping and the metal-deposition capabilities of electroplating.





All images: Microfabrica

Internal channels, created via MICA Freeform, would make this 850µm-dia. washer impossible to manufacture with traditional micromanufacturing techniques. The internal channels can be seen in the CAD model (top) but not in the finished product (bottom).

MICA Freeform can produce 3-D components and devices with features as small as 20µm and tolerances of ±2µm. It can also produce multipart micromachines with independently moving parts that require no assembly. Typical applications include components used in semiconductor testing and in the aerospace, defense and medical device markets.

The process begins with a 3-D CAD model of the part or device. This model is exported into an STL file (a format developed for stereolithography applications) that is read by a proprietary Microfabrica software program that divides it into 2-D cross sections. The cross sections are the basis for a set of photomasks, essentially quartz plates with submicron-resolution chrome patterns. The photomasks are used to define the areas on a ceramic wafer where metal is electrodeposited layer upon layer until the original CAD model is reproduced in solid form.

Layer thickness can range from 5µm to 25µm, with a thickness tolerance of ±2µm. The maximum number of layers in a part is 50, producing a maximum part thickness of about 1.25mm. Part lengths and widths can be in the submillimeter range, with X and Y tolerances of ±1µm to 2µm.

According to Richard Chen, Microfabrica's vice president of design engineering, most parts and devices currently produced via MICA Freeform have thicknesses of less than 0.5mm.

Each layer contains sacrificial material (copper) and structural material. If the end product is to be detached from the substrate, the first layer deposited is made entirely of sacrificial material.

For each succeeding layer, one material—either sacrificial or structural—is patterned using photolithography, and the other is deposited in blanket form. Every layer is planarized to ensure precise layer thickness, flatness and surface finish. When layering is complete, the sacrificial material is removed via etching. This frees individual parts so they can move, and releases the part or mechanism from the wafer.

Either production or prototype manufacturing is possible via alterations of the photomask details. In production, hundreds, or even thousands, of examples of one device are replicated across the entire wafer; in a prototyping job, up to 10 or more different devices can be fabricated on one wafer.

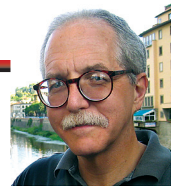
In addition to enabling the manufacture of multipart micromachines, the layering process also allows parts to be made with internal channels, embedded features and complex geometries that could not be created with traditional micromanufacturing techniques.

Although the layering process resembles rapid-prototyping techniques, MICA Freeform differs in that it produces functional devices, requires tooling and is a high-volume production process.

Chen said, "In order to meet high-volume manufacturing requirements, we borrowed batch-fabrication concepts from the semiconductor industry."

Development began in about 1999, and in 2005 a patent application was filed for the process then known as EFAB. Commercial fabrication began in about 2008, and high-volume manufacturing commenced in 2009.

By Bill Kennedy,
Contributing Editor



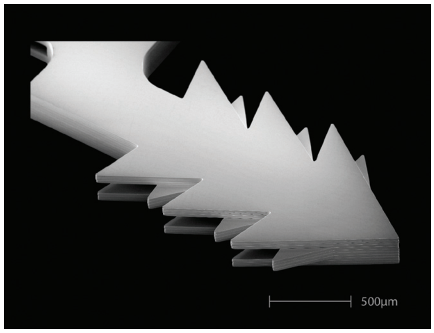
Gen 2

Last year, Microfabrica introduced MICA Freeform, the second-generation evolution of EFAB. MICA Freeform adds new materials and new design rules that enable fabrication of finer features. For example, the minimum gap or clearance around a hinge or between gears with EFAB design rules was 30µm. With MICA Freeform, that gap can be 10µm.

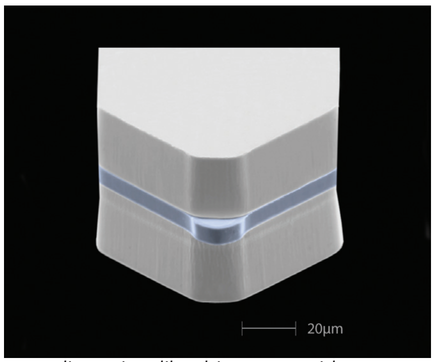
The EFAB process accommodated two materials: Valloy-120, a proprietary nickel-cobalt alloy similar to stainless steel, and Edura-180, a proprietary rhodium formulation for areas where increased wear resistance is required. MICA Freeform adds the noble metal palladium, which is inert and offers bio- and MRI-compatibility as well as radiopacity (the relative inability of electromagnetic radiation to pass through a particular material), making it an ideal material for implantation and medical device applications.

"The sweet spot includes designs that require a high degree of precision at the millimeter-to-micron scale," said Eric Miller, Microfabrica's president and CEO. "That being said, the MICA Freeform process itself is very flexible. We can fabricate a continuum of designs, ranging from very simple 2-D extrusions to complex 3-D micromechanical devices."

Miller said Microfabrica roughly categorizes its ultrahigh-precision fabrication into three areas: micromachines, subassemblies and ultrahigh-precision parts. "On one end of the spectrum, we can design and fabricate complex 3-D micromachines in quantities of 500 to 1,000 on a wafer, with literally no assembly. This can enable the development of entirely new categories of products or solutions. In the medical device space, MICA Freeform may enable the evolution from minimally invasive surgery to micro-invasive therapies, potentially benefiting both patients and providers."



The opposing barbs on this 2.4mm-long medical staple tip, created by MICA Freeform, cannot be made by other manufacturing methods because there is insufficient room between the barbs to permit EDMing or laser machining.



Compliant pins, like this 75µm-wide contact probe for integrated circuit wafer testing, are made from multiple materials and are manufactured in high volume through the MICA Freeform process.

On the other end of the spectrum—the ultrahigh-precision parts business—"MICA Freeform simply may be a better way to manufacture microparts that require a high degree of precision, with or without complex geometries," Miller said.

Compliant pins (very small electrical contacts used to test semiconductors) are an interesting application of Microfabrica's technology. The pins are surprisingly challenging to produce because they must be excellent springs, great electrical conductors and high-reliability contacts. No single material has all three properties, so Microfabrica fabricates a composite structure from three different metals, placing each alloy in the optimal location. The reliability demands are strict, requiring over a million cycles, and the pins are quite small—typically 50µm to 100µm in width. This combination of small size, tough technical requirements and high precision makes compliant pins an ideal application for MICA Freeform.

Precision at high volumes

Miller said MICA Freeform is not necessarily a replacement for traditional micromanufacturing methods. "We offer precision at a very specific scale, about a millimeter and below," he said. MICA Freeform produces parts with finer features and better tolerances than microEDMing or Swiss-style machining, but the parts are also much more robust than a typical MEMS part, according to Miller. "We like to think of MICA Freeform as an extension of traditional micromachining technologies, particularly as the need grows for scale reduction without sacrificing precision. Certainly there is a bit of overlap for parts 2mm and above. When traditional technologies start to drop off with regard to precision, that's where we pick up."

Added Chen, "The structures can be simple, but, in some cases, making extremely small features with a traditional technology could almost be impossible, or really expensive and difficult. For example, microEDMing can be used to make small features and claims high precision, but when it gets to volume manufacturing, it is pretty difficult to get uniformity and really sharp, precise inside corners, which are things that come naturally through our process."

The volume-production aspects of MICA Freeform set it apart, according to Chen. "If you have an EDM, you can make a handful of parts really quickly. But we are not a quick-turn machine shop. When you want volume manufacturing, when you need to make hundreds and thousands of identical components, we can be very competitive on price."

Compared to traditional microfabrication techniques, MICA Freeform can be considered a disruptive technology, Miller said. Acceptance of the technology will require component designers to become familiar with the process and its capabilities and limitations.

To overcome resistance to disruptive technologies, advocates for those technologies must "establish a beachhead," said Miller, referring to the concept laid out by Geoffrey A. Moore in his marketing text, "Crossing the Chasm."

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A beachhead, Miller explained, "is simply a target application that clearly defines your value proposition. By having this singular focus, you exercise your process with commercial intent, enabling you to develop a closer relationship with customers in that market. This translates into improved quality and reliability, and lower costs."

For its ultrahigh-precision parts business, Microfabrica chose compliant pins (micro-contacts) as its beachhead. "Through this focus, we have been able to ramp up revenues, expand our capacity, expand our process and materials capabilities, and put the company on a solid, profitable foundation," said Miller. µ

For more information about MICA Freeform, contact Microfabrica at (818) 786-3322 or visit www.microfabrica.com.

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