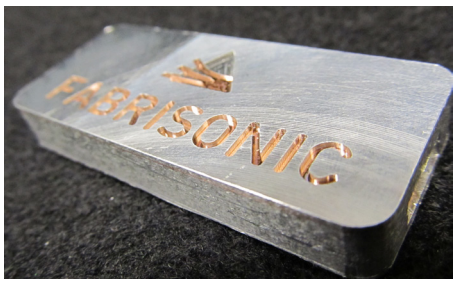
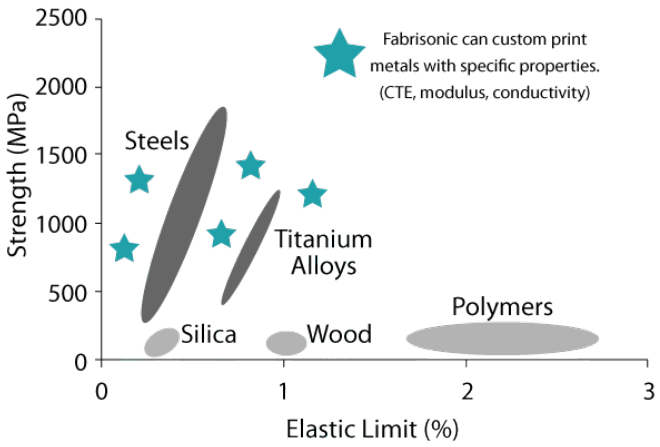
Printing Custom Materials

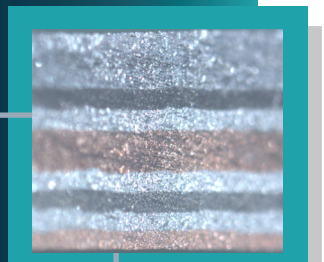
HOW IT WORKS: 3D PRINTING WITH SOUND



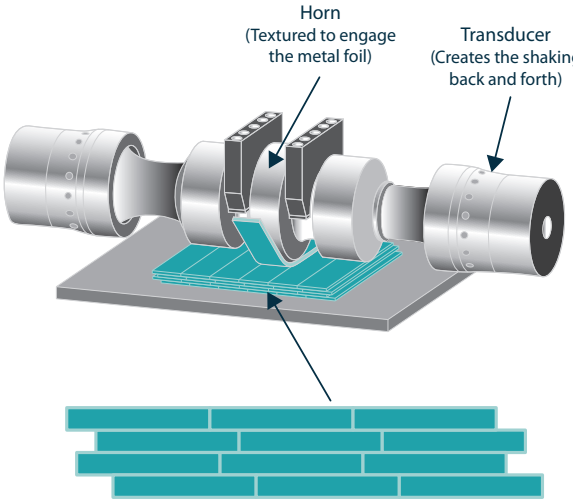
Conventional materials come with specific material properties. If the material property combination you need is not available, the overall design is developed by compromising one property over another. Over the years, alloys and composites have been engineered to attempt to span the gaps between monolithic materials, but gaps still exist.



What if you could combine two, three, or even five metals in a graded laminate? One could then engineer a composite metal that meets the engineering needs.



Ultrasonic Additive Manufacturing (UAM) is a 3D metal printing technology that lets you build with different metals while keeping their mechanical properties. The process uses ultrasonic sound waves to merge layers of metal foil together in the solid-state; there is no melting of the metals. The process produces true metallurgical bonds with full density and works with a variety of metals including aluminum, copper, stainless steel, titanium, and more. Dissimilar metals can be printed together due to the low temperature welding process.



Computer Numerical Control (CNC) machining is used interchangeably with foil layering to introduce internal features along the way and for part finishing. By combining a hybrid system, with both additive and subtractive processes, UAM can build complex internal geometries considered impossible to replicate with conventional manufacturing. For example, a metal heat exchanger can be made with aluminum and a layer of copper can be added to wick away heat.

CREATION OF CUSTOM MATERIALS

The solid-state nature of the ultrasonic bonding process used in UAM permits joining of dissimilar metals without the formation of brittle intermetallics as seen in fusion processes. A wide range of material combinations have been successfully bonded

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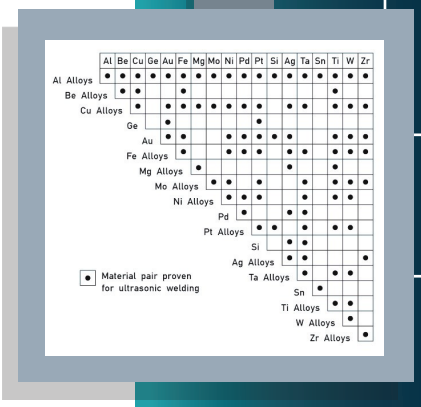
using ultrasonics. Al/Cu, Ni/Stainless, and Al/Ti are routinely joined. Fabrisonic has also worked with exotic combinations such as Ta/Fe, Ag/Au, Al/Mo, and Al/Invar. This capability allows for the creation of unique high performance multi-material parts for a wide array of engineering applications:

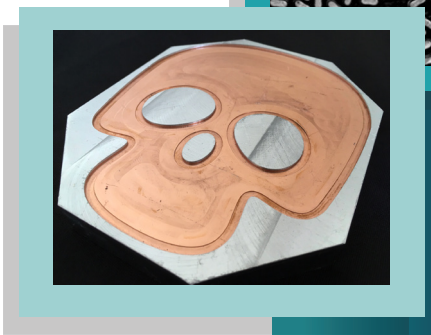
- *Cladding* – The layering of an expensive metal onto a bulk substrate of cheaper material. This can be helpful in a number of industries. For example, the oil and gas components are commonly clad for preventing corrosion.
- *Heat Transfer* – Using UAM, multi-materials can be selectively mixed to optimize thermal performance, copper and aluminum are often layered to optimize conductivity vs weight. This process is often combined within a heat exchanger to wick heat away from a flow path.
- *Strengthening Materials* – Fabrisonic has experience printing Metal Matrix Composites (MMCs) using continuous fibers. The continuous fibers can be embedded in solid metal using UAM and the metal will completely extrude around the fibers. This creates a high pull out strength allowing the fibers to carry significant load through a structure. Parts can be selectively printed with fibers at high-stress regions.
- *Light Weighting* – The ability to build parts with dissimilar metals to optimize strength vs weight. Monolithic titanium has been replaced as armor with laminates of Al and Ti. The laminate out performs monolithic titanium at a much better density.



SOLID-STATE AND DISSIMILAR METALS

The ultrasonic welding technology does not need a special atmosphere or any large pre-heating to fuse the metals together. For example, the peak temperatures are below 250 °F for aluminums. The chart to the upper right, shows metals that have been welded via ultrasonic welding (to see a larger version of the chart, go to **www.fabrisonic.com/materials/**. The solid-state nature is the key advantage of Fabrisonic's patented process as it:

- Protects material properties of the incoming feedstock. Since the materials are heated only slightly, the materials do not experience changes in grain size, precipitation reactions, nor phase changes. The properties of the incoming feedstock are the same as the properties of the final part without post processing (such as heat treat, HIP, etc).
- Bonds dissimilar metals without creating brittle intermetallics seen in fusion-based welding. This capability enables Fabrisonic to print custom materials to design a material with a given material property. For instance, layers of Aluminum and Titanium can be combined to produce an armor product that is lightweight but has sufficient ballistic performance.



- Embed electronics in solid metal parts. Many electronic components including microprocessors, sensors, and telemetry have been successfully embedded in a solid metal part using UAM. The low temperature bond allows delicate components to be embedded in solid metal without overheating.

To read more about dissimilar metals go to our website **www.fabrisonic.com** or visit **http://youtu.be/saSrmgEZJzM** to see our process in action.