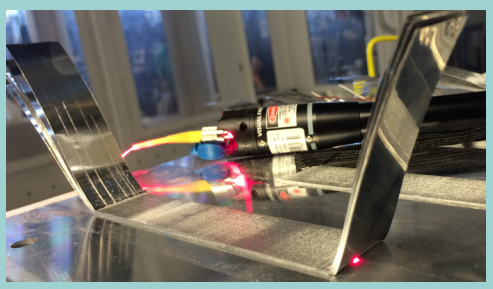
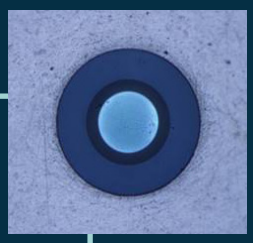
Embedding Sensors and Electronics

HOW IT WORKS: 3D PRINTING WITH SOUND

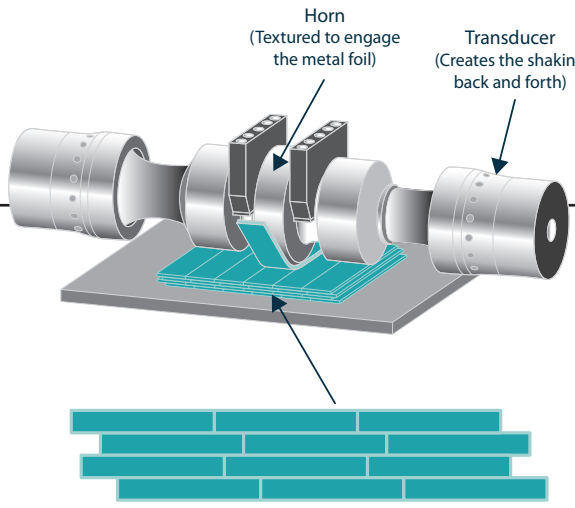
Ultrasonic Additive Manufacturing (UAM) is a 3D metal printing technology that lets you embed electronics and sensors into metal parts of any design. The process uses ultrasonic sound waves to merge layers of metal foil together in the solid-state; there is no melting of the metals. The process produces 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, complex chemical reaction chambers with embedded controls can be easily printed with UAM.



OVERVIEW TECHNOLOGY



Sensors are widely used throughout industry to detect and respond to external stimuli. Unfortunately, conventional manufacturing processes often dictate that the sensors be placed far away from the stimuli. Fabrisonic's new 3D printing process allows sensors to be embedded anywhere in a metal structure, which offers several benefits:

- *Higher protection* – A common problem with sensors operating in harsh environments is degradation from radiation exposure, corrosion, impact, wear, and so on. Ideally, it would be best to bury the sensors in a solid metal substrate for protection. However, this is often difficult using conventional manufacturing technologies due to complications in sealing and elevated processing temperatures.

- *Higher performance* – Most sensors in use today are attached to the periphery of equipment, limiting signal strength and response times. Manufacturing

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processes for metal such as casting, cutting, and welding are performed at a high temperature and thus forcing sensors to be an add-on item to the final structure. Embedding sensors in metal allows the sensors to be placed at the ideal location for measurement and control, leading to higher performing products.

- *Design freedom* – Metal 3D printing is changing the design paradigm of products from cell phones to jet engines. Low-temperature metal 3D printing enables electronics and requisite wiring to be placed anywhere in a structure. As the part is grown in the printer, wiring can be placed through circuitous routes throughout the center of a large structure. This gives designer freedom to locate structure, sensors, and wiring at the optimal location for function; not the optimal location for construction.

The combination of additive and subtractive stages in UAM allows components to be integrated into the part along the way. The difference with UAM, compared to other 3D metal printing technologies, is its low processing temperature. This is important when it comes to embedding sensors and electronics as these materials are easily damaged at elevated temperatures. UAM enables functional embedding of sensors, electrical circuits, smart materials, and other temperature sensitive components into fully dense metallic structures.

EMBEDDING ELECTRONICS WITH UAM

Thermocouples, pressure transducers, USB ports, plastic connectors, accelerometers, and strain sensors have been successfully integrated into metal components with UAM.

The most exciting research is Fiber Optic Bragg Gratings (FBG). The general strategy for embedding a sensor or electrical component begins by making a "pocket" or "crevice" in the structure through the CNC stage of the UAM machine. For smaller devices, this pocket may not be needed. Then, the device is placed into the pocket for encapsulation using the additive welding stage. For some applications, epoxy or another dielectric material may be used to "pot" the device to constrain, protect, provide structural support, and to insulate it from the neighboring metal material. The additive stage continues to build material to reach the required part size.

To read more about building sensors into metal, go to our website **www.fabrisonic.com** or visit **www.makepartsfast.com/how-to-embed-sensors-into-metal/**.