METALWORKING IN THE 21ST CENTURY

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Metalworking is perhaps the oldest, one of the richest, and most intriguing fields of essential technology. Historical periods were often designated by the dominant materials capability of that period; e.g.; Stone-, Bronze- and Iron Ages. As we moved into the metal ages, everything from art and currency, to implements of war, was dictated by the metallurgy and metalworking skills of the era. Metal processes, including intricate casting, have been known for thousands of years. We may have learned how to solder while casting works of art over 5,000 years ago. So with a learning curve longer than recorded history, can anything be new in the metal working field?

What if you could create designs on a computer and then directly fabricate dense components using light and matter? Enter Optomec, a company in Albuquerque, NM with roots to Sandia National Laboratory. This company claims to have perfected laser processes that can fabricate all kinds of parts with selectable material properties using CAD software, lasers, and atomized powders. Their *Flow Guidance*, or Laser Direct Material Deposition process, appears to be new and unusual. Lasers have been used for many years to create plastic structures, including build-up type from photoreactive polymers. And lasers continue to find ample applications in material shaping but as removal methods. We drill and cut metal under the general heading of laser machining, but just about all of the metalworking processes are subtractive. This one is additive and that is the important difference. Let’s look at the process mechanisms.

One deposition method uses a stream of gas and atomized materials. A liquefied material source is aerosolized and entrained in a gas stream. The source materials can be metals, precursors, ceramic particles, or a combination. The gas-entrained material is directed into a deposition head and the gas and solid dispersion is compressed into a thin stream only .001” in diameter. Over 1-million particles/second can be deposited as 2- or 3-dimensional patterns. A laser anneals the deposit if required.

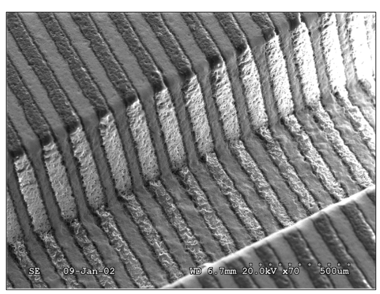

Figure 1 - Silver metal deposited over a step; 50-micron lines on 100-micron pitch

There could be endless applications in electronics and other fields. High-density interconnects (HDI) and circuits can be directly written onto 3-dimsional substrates as shown in Figure 1. Since different materials can be deposited, this method has considerable versatility. The capability to draw traces in 3D might also open up possibilities in packaging, especially for stacked chip arrays. The conductors could be formed along the sides of a die stack, for example. Redistribution circuitry can also be applied to chips with bumps formed during the process as shown in Figure 2. Bumps can be made of several different metals and it may be possible to form elongated column-like structures for higher standoff. But dielectric ceramics can also be applied by this method and that could make it possible to “print” embedded capacitors.

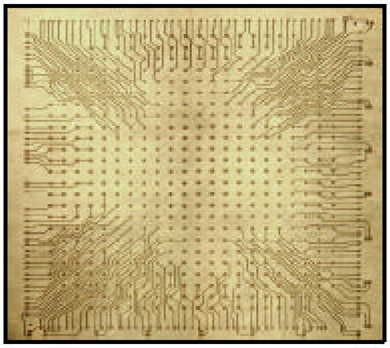

Figure 3 – On-Chip Redistribution;
35m lines with 75m bumps

Another possibility is antenna printing. A custom precision antenna could be applied to a PWB, a package, or even a chip. Figure 3 shows a tapered spiral antenna for GPS. The large selection of materials that can be deposited suggests that this method could address some of the wireless hardware and logistics problems as systems get smaller and frequencies move higher. It should be possible to print, tune, or even "set" an antenna to a specific frequency to meet a just-in-time order.

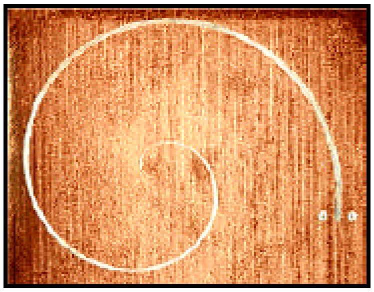

Figure 3 – GPS antenna

There are modifications of the powder dispense/laser fuse process. Laser Engineered Net Shaping (LENS) allows one to design a part using standard CAD software and build it directly from metal powder in a large format (12" x 12" is the present limit). This method uses a high-powered laser focused onto a substrate to create a molten pool. Metal powder is then injected into the melt pool to increase its volume. Scanning back and forth creates a layer of deposited material. New layers are built upon previous layers until the entire object in the three-dimensional CAD file is reproduced. The process provides shaped components with embedded structures and superior material properties. The additive nature of the process allows repairs and modifications to existing parts, including molds and other tooling. A pre-programmed library of standard shapes and simple user interface minimize operator training. A software plug-in for AutoCAD® is used to quickly create machine tool paths from CAD drawings making this an ***art-to-part system.***

So, no matter how long a field has been around, we should always expect new technology because imagination is boundless.