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PRECIOUS METALS ARE MEMS' BEST FRIEND, BUT THE TINY TRINKETS DON'T ALWAYS BEHAVE

By Rosemary Clandos

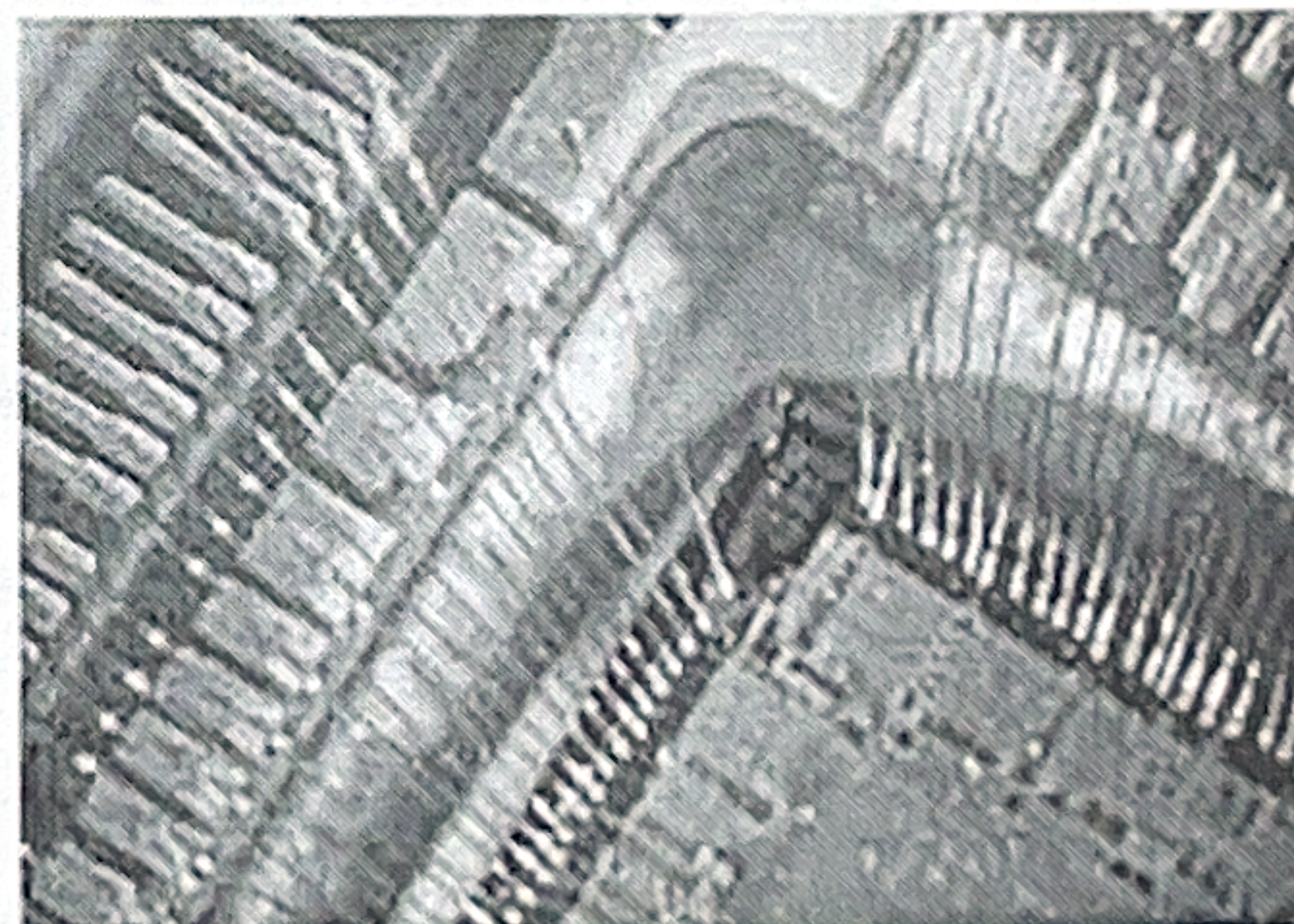
Small Times West Coast Correspondent

The days when precious metals were used strictly to make jewelry are long gone. Now, tiny amounts of the costly material are used in MEMS sensors for the aerospace industry and brain probes for patients with Parkinson's disease.

Gold, platinum, iridium, titanium, and palladium are used in fabricating and manufacturing MEMS, microsystems, and nanoscale devices because their noble qualities make them less corrosive and more durable. They don't tarnish or oxidize easily, and they are resistant to chemical attacks so they don't dissolve readily in strong biofluids or in simple bases, acids and solvents.

However, precious metals aren't always a perfect fit in the world of technology, where an electrochemical charge can change their properties.

Jack Judy, an assistant professor of electrical engineering at the University of California, Los Angeles, is working on deep brain stimulators and other neural probes for patients who suffer from Parkinson's disease. In a commercialization project with Second Sight in Valencia, Calif., Judy has been using platinum probes to deliver electrical charges to the retina to stimulate visual perception in blind patients.



Gold wires, .001 inch in diameter, attach to this integrated circuit chip. Most of the wire is used for sensors. Courtesy California Fine Wire.

Typically, electrodes are made from platinum, which is inert and can last for a long time in the body. But when platinum electrodes are given an electrochemical charge they can corrode more easily.

And smaller electrodes -- the best choice for increasing visual resolution in patients -- have a greater propensity for corrosion when they receive an intense electrochemical charge.

Since larger electrodes have a lower resolution and don't solve the vision problem, Judy is working on ways to solve the puzzle with other metals that can withstand higher corrosion thresholds.

At the Jet Propulsion Laboratory (JPL) in Pasadena, Calif., the electronic beam lithography machine deposits gold strands that are 50 nanometers (1/20 of a micron, or 1/500,000 of an inch). Gold is deposited on a

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national labs have developed separate techniques to make diamond films that far outshine many materials used in MEMS and nanotechnologies.

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wafer and after a photo resistant chemical is applied and washed away, the gold remains -- deposited in the nano grooves.

However, at the nanoscale, there is surface migration of gold. It wants to clump together, said Paul Maker, manager of the electron beam lithography lab.

So scientists are working with a gold vanadium, an alloy that has a finer grain and lessens the severity of the problem, although it is more expensive to process.

Many researchers -- such as UCLA's Judy and James Lamb, JPL's manager of the microdevices lab -- said that costs for gold and platinum have been relatively consistent in the last few years and not overbearing.

But Chris Zorman interim director of the microfabrication laboratory at Case Western Reserve University in Cleveland, said the cost of a 3-inch-by-1/8-inch platinum target or deposition source used in sputtering is pricey at approximately \$5,000. At the university's thin film fab facility, layers of platinum and thin gold film are used in MEMS devices for sensors and biomed applications.

"Targets can be used repeatedly for numerous depositions. So the per-unit price is not a big deal," Zorman said. "But making many units over many runs can be significant."

At California Fine Wire, a company that supplies universities and other institutions around the world with minimicron wire made from precious metals, President Michael Greenelsh said that within the last year, the company has seen a 33 percent sales increase in silver, 65 percent sales increase in platinum, a 75 percent increase in platinum with 10 percent iridium.

The majority of the wire is used for sensors in the aerospace, aircraft, auto industries. It is also used for biomed devices such as cochlear implants -- devices that send a signal through the audio nerve to the brain to enable deaf people to hear well enough to talk on a telephone.

"People are using more metals now and they're doing specialty things with it; they might want different shaped metal or larger electrodes to carry more electrical current," Greenelsh said.

As of mid-May, his company has been paying about \$625 for an ounce for platinum, \$300 an ounce for gold and \$5 an ounce for silver.

Increased demand for another precious metal, palladium, has caused the price to skyrocket in the last 18 months. Dan Tracy, senior market analyst at SEMI, the semiconductor industry's trade association said that in the last five years the price has bolted from \$150 an ounce to \$1,000 an ounce and now it's hovering near \$850 an ounce.

That puts a dent in the semiconductor industry's plan to use palladium as a replacement for tin lead solders used in computer chips and circuit boards. It also has an impact on MEMS, where it is sometimes used in combination with platinum for devices to sense temperature and measure deflection or bending.

Bruce Koel, a professor in the department of material sciences and chair of chemistry at the University of Southern California at Los Angeles, said that not enough effort is going into metals research.

"A larger investment in R and D in this area would lead to new and better products,"

Koel said.

For example, at the nanoscale, very little is known about the mechanical properties of metal and what kind of deformations they can suffer, Koel said. Some of the mechanical and surface properties include thermal expansion, elastic response, chemical properties and temperature tolerance.

"People haven't really done some theoretical study to say what would be the best metals to use," Judy added. "There's a knowledge gap. We'd like to use more materials. But for most people, they take the attitude that it's good enough. They haven't been pushed."

Cover photo: A cross section of a OFHC copper wire that has been electroplated with a 40 micro-inch nickel strike on the copper surface and then a 50 micro-inch of gold plating over the nickel. The nickel strike acts as a barrier between the copper substrate and the gold plating; otherwise, the gold and copper would migrate together forming a gold copper alloy. The cross section is used to verify the quality of the electroplating. *Courtesy California Fine Wire.*

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