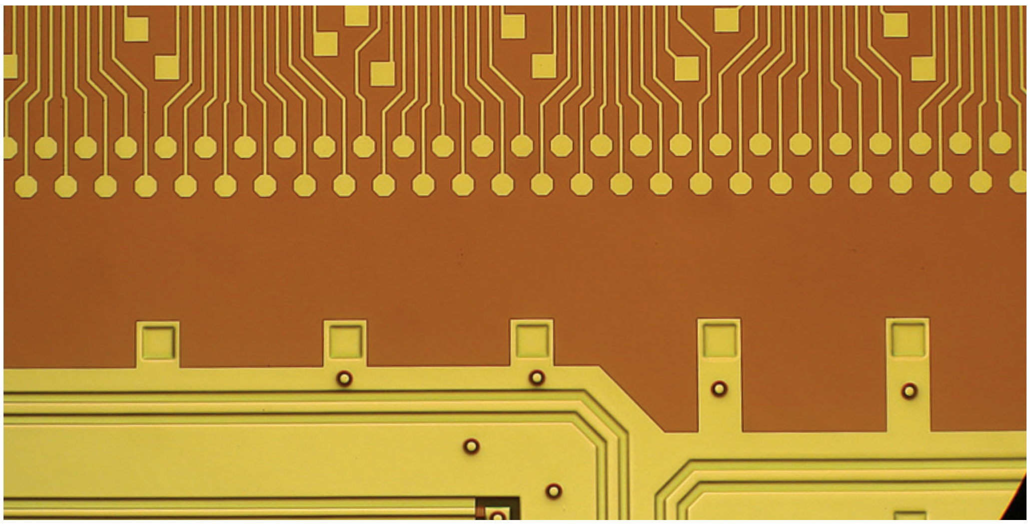
A Foundation in Thin Film Circuit Manufacturing



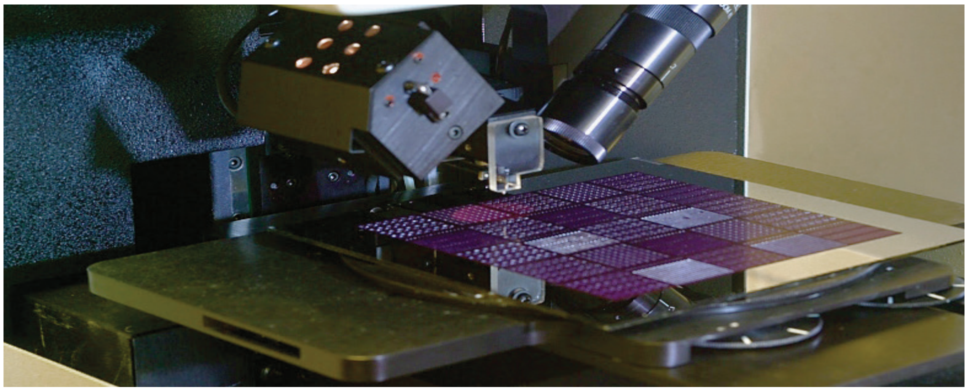
Introduction

Our thin film process is a fundamental technology uniquely suited to the task of making miniature circuits with extremely small and uniform features that have extremely consistent electrical performance throughout.

The process also tends to be much faster and less wasteful than subtractive manufacturing methods like chemical etching. That's because only the conductive material needed to define the circuit geometry is being deposited, which results in in a manufacturing process that is more efficient and less wasteful.

A Better Process Yields Better Circuits.

Our thin film circuits are produced by an additive process that results in extremely small and uniformly shaped features with extremely consistent electrical properties. The process also tends to be faster than alternative manufacturing methods.



How is a Thin Film Circuit Made?
As the name implies, our thin film circuits consist of one or more thin metal layers, each of which is sputtered on either a base substrate (if this is the base of the circuit) or on a polyimide layer (if this is a higher layer in a multilayer circuit).

Available rigid substrates include:
- Quartz/fused silica
- Aluminum nitride
- Alumina
- Ferrite/garnet
- Titanates
- Glass
- Sapphire
- Silicon

Available conductive materials include:
- Nickel cobalt
- Nickel
- Copper
- Pure gold
- Hard gold
- Palladium
- Platinum
- Rhodium

Once the sputtered layer is applied, more metal must be added to create the circuit lines. That's done using photolithography, where light shining through a mask creates a stencil of exposed metal lines separated by areas of nonconductive photoresist (where the surface was not exposed to light through the mask). Additional metal is then electroplated onto these exposed metal lines until circuit traces of precise height and width are obtained.

If the circuit is to be multilayer then a new polyimide layer is applied on top of the first layer's circuit elements to support a new metallization layer. Metal is then sputtered (and/or plated) on top of this new polyimide — and this cycle continues until all circuit layers are added. The polyimide layers separating the circuit layers range in thickness from 10 microns up to 100 microns and possibly more. The tradeoff is that thinner polyimide offers less electrical impedance, so there is a greater likelihood of crosstalk between layers.

Typically, openings need to be created in the polyimide layers to allow for electrical connections (plated vias) between layers or for contact pads. These openings are imaged using photolithography or, alternatively, are drilled with a laser if the holes are too small to be imaged.

Advantages of Additive Process

Thin film's additive process offers multiple advantages over subtractive processes like chemical etching — in both performance of the actual component and in the component's manufacture. These advantages are particularly relevant when it comes to miniature components.

As just discussed, the additive process uses electroplating to layer more metal on top of the thin metal lines left exposed in the photo mask. With chemical etching, photolithography is also used to create a pattern of photoresist spaces. The difference is that in the subtractive process much more metal is sputtered onto the substrate than is required by the finished device. Circuit lines are then defined by etching away all metal left exposed by the photoresist. These spaces act as insulators separating the remaining metal, i.e., the circuit traces.

In other words, thin film's additive process builds circuit lines between spaces, while the subtractive process etches insulating spaces from between circuit lines.

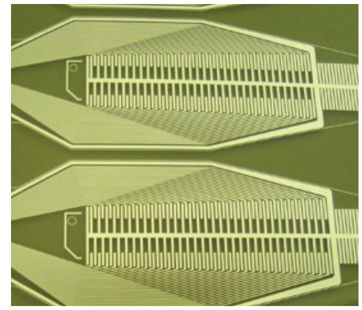
Circuit Performance Advantages

Regarding circuit performance, the key advantage is that the additive process builds up circuit traces that are the same width at the top as at the bottom. Chemical etching, on the other hand, produces metal traces that are wider at the bottom than at the top due to the fact that the metal at the top is exposed longer to the etching agent. This variation in width leads, in turn, to variation in circuit conductivity and therefore to less reliable operation of the component.

This difference is particularly relevant in miniature components where circuit widths can be as small 10 microns. At this scale, even a variation of only a few microns is much greater on a percentage basis than if the circuit traces were wider to begin with.

Manufacturing Advantages

The advantage in manufacturing demonstrates the difference between electroplating and sputtering. In electroplating, virtually all the plating metal electrically bonds to the conductive thin layer, with none of it left behind to either be thrown away as waste or reclaimed. Sputtering, on the other hand, does leave metal behind to be thrown away or reclaimed. It's a process where material is ejected (sputtered) from a metal target (typically gold or copper) onto a substrate; however, not all the metal is deposited on the substrate and some of it is instead deposited on the walls of the reaction chamber and must be removed. Furthermore, since sputtering is less efficient at adding metal to metal than it is at electroplating, it also takes more time — thereby lengthening the manufacturing process.



Thin Film Circuits at a Glance

Using an additive fabrication process we define circuit lines by electroplating or sputtering metal traces onto either a rigid substrate in a single layer device or onto a polyimide layer in a multilayer device.

The technique achieves extreme uniformity in trade geometries as well as the ability to deposit exactly the desired amount of metal in exactly the desired location.

Other Success Factors

A number of other factors are involved in making sure your thin film circuit will perform as designed and can be manufactured at high yield, including:

Circuit Design
These factors include line (or trace) density, line width and height, number of layers, and the number and proximity of various features, such as coils and vias. Where features are located on the board may strongly impact performance factors such as a circuit's electrical impedance, and whether features can be fabricated as part of the photo imaging process or must be cut out with a laser as a separate step — which increases manufacturing cost, complexity and, potentially, risk.

Mechanical and Environmental Challenges
How much heat will the circuit dissipate? How much shock and vibration must it withstand? What about acceleration loads? Is it subject to high humidity? Liquid emersion?

Quality of Manufacturing Facilities
Whether your circuit can meet design requirements, mechanical challenges, and environmental hazards has a lot to do with the capabilities of the manufacturing equipment and processes involved in making the circuit. Those capabilities include state-of-the-art systems for computer-aided design, photolithography masking and imaging, the layering of metals at an almost atomic level, advanced laser cutting, and ultra-pure manufacturing equipment and clean rooms. Even a 2-micron-size piece of lint can do serious damage to a circuit with features in the 5-micron range.

Thin Film Circuit Manufacturing Experience
Advanced skills are required throughout the thin film circuit prototyping and production cycle. Product and process engineers must know what will work and what won't so as to meet the application's design, mechanical, environmental, and cost criteria in high volumes at high yield — and within tight market windows.

Got a Significant Micro Circuit Market Opportunity?

Talk to us. We will be happy to assist you in coming up with a manufacturing solution that meets all your criteria for success!

[Visit our website for assistance with design guidelines.]

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