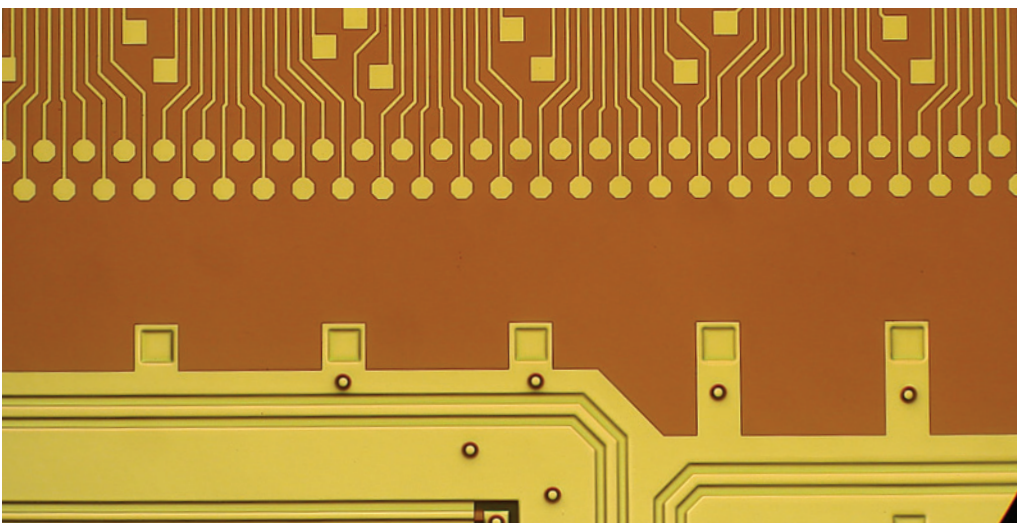


A Foundation in Additive Thin Film Circuit Manufacturing



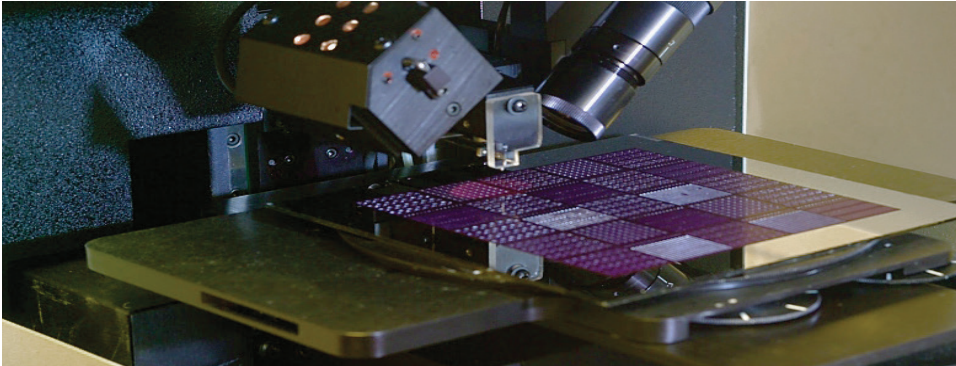
Introduction

Thin film process is an advanced additive technology uniquely suited to the task of making miniature circuits with extremely small and uniform features that deliver reliable and repeatable electrical performance from device to device.

The process also is much faster and less wasteful than subtractive manufacturing methods, like chemical etching, because only the conductive material needed to define the circuit geometry is being deposited. With insight in how thin film manufacturing works, designers can achieve the smallest circuits and work through design for manufacturability (DFM) challenges quickly.

A Better Process Yields Better Circuits.

[Thin film circuits](#) are produced by an additive process that results in extremely small and uniformly shaped features and consistent electrical properties. The process is also 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 is 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).

TECHNICAL BRIEF

A FOUNDATION IN ADDITIVE THIN FILM CIRCUIT MANUFACTURING

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 drilled with a laser if the holes are too small to be imaged.

Advantages of the 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

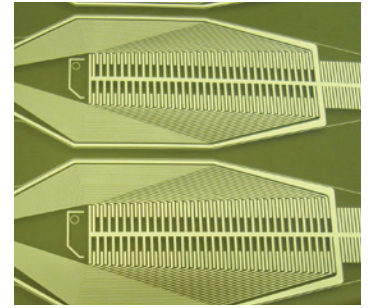
Regarding circuit performance, the key advantage is that the additive process builds up circuit traces that are the same width at the top as at the bottom. Chemical etching, on the other hand, produces metal traces that are wider at the bottom than at the top

due to the fact that the metal at the top is exposed longer to the etching agent. This variation in width leads to variation in circuit conductivity, and therefore to less reliable operation of components.

This difference is particularly relevant in miniature components where circuit widths can be as small as 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

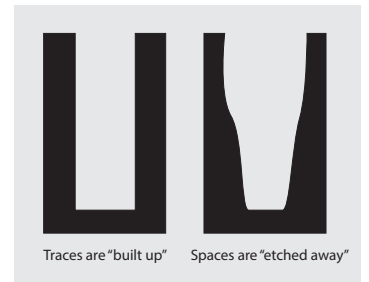
The advantage in manufacturing demonstrates the difference between electroplating and sputtering. In electroplating, virtually all the plating metal electrically bonds to the conductive thin layer, with none of it left behind to either be thrown away as waste or reclaimed. Sputtering, on the other hand, 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 ideal uniformity in geometries as well as the ability to deposit the exact amount of metal in exactly the right place.



Additive and Subtractive

Chemical etching, or subtractive technology, forms uneven traces and spaces leading to variable conductivity.

TECHNICAL BRIEF

A FOUNDATION IN ADDITIVE THIN FILM CIRCUIT MANUFACTURING

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 electrical, mechanical, environmental, and cost criteria in high volumes, and with high yield.

Have 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!

Next Steps

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