Reactive Ion Etching Vias in LaRC-SI Polyimide Films

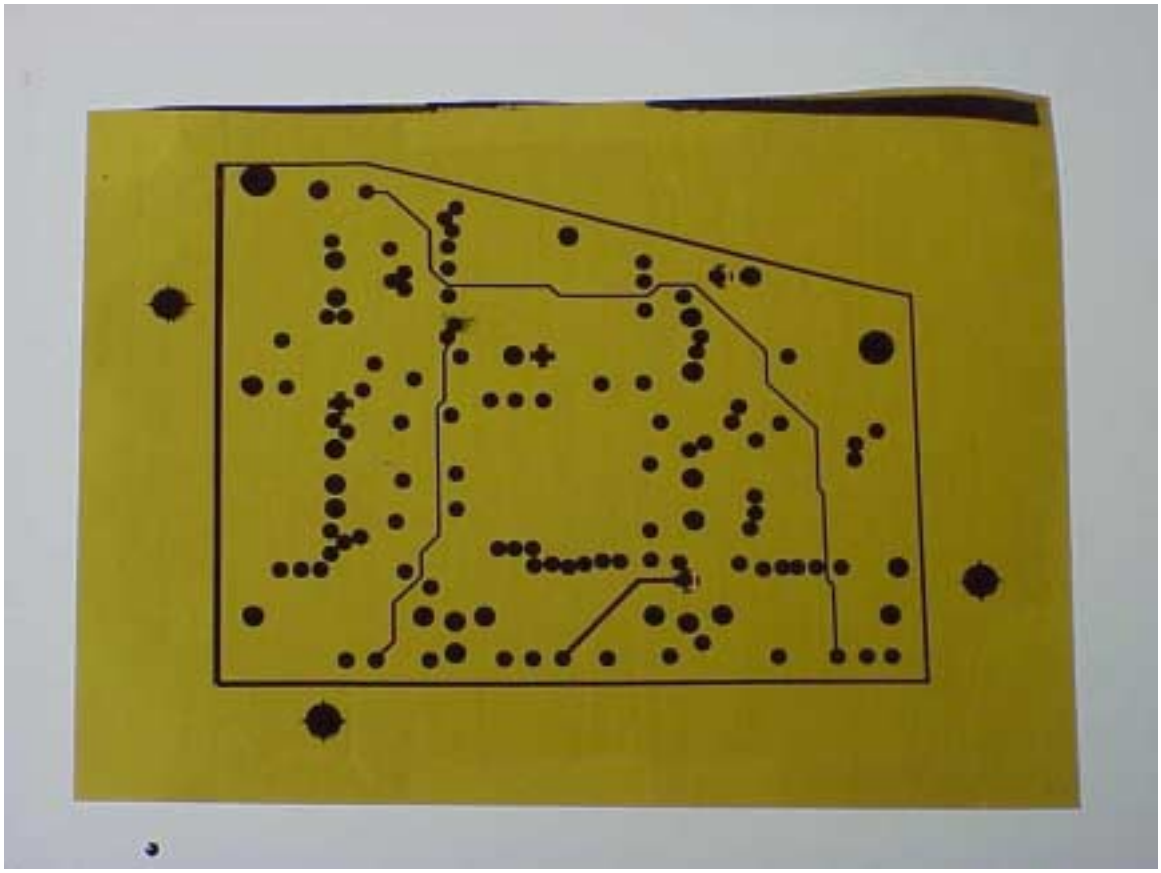
Introduction

This is a report of the efforts put forward to use reactive ion etching “RIE” to plasma etch via holes in LaRC-SI polyimide film in order to create feedthroughs for multilayer flex circuits. Three sheets of copper clad LaRC-SI polyimide films were circuit patterned. After patterning, the circuits were prepared for a plasma via mask. The plasma via mask consisted of aluminum foil, bonded to the circuit patterned films, with the via holes selectively etched through the aluminum mask leaving the LaRC-SI polyimide material exposed for a feedthroughs. The masked films were etched using an RIE plasma etcher. During the etching process, the exposed polyimide material was etched away yielding via holes in the films. The via holes were optically inspected with a Reichert microscope and photographed. The individual film layers were then consolidated together in an autoclave with heat and pressure to form a monolithic multilayer flex circuit. Lastly, the via holes were re-inspected after consolidation with a Reichert microscope and with a photographed with Polaroid micro-camera.

Process

Patterning the LaRC-SI Film

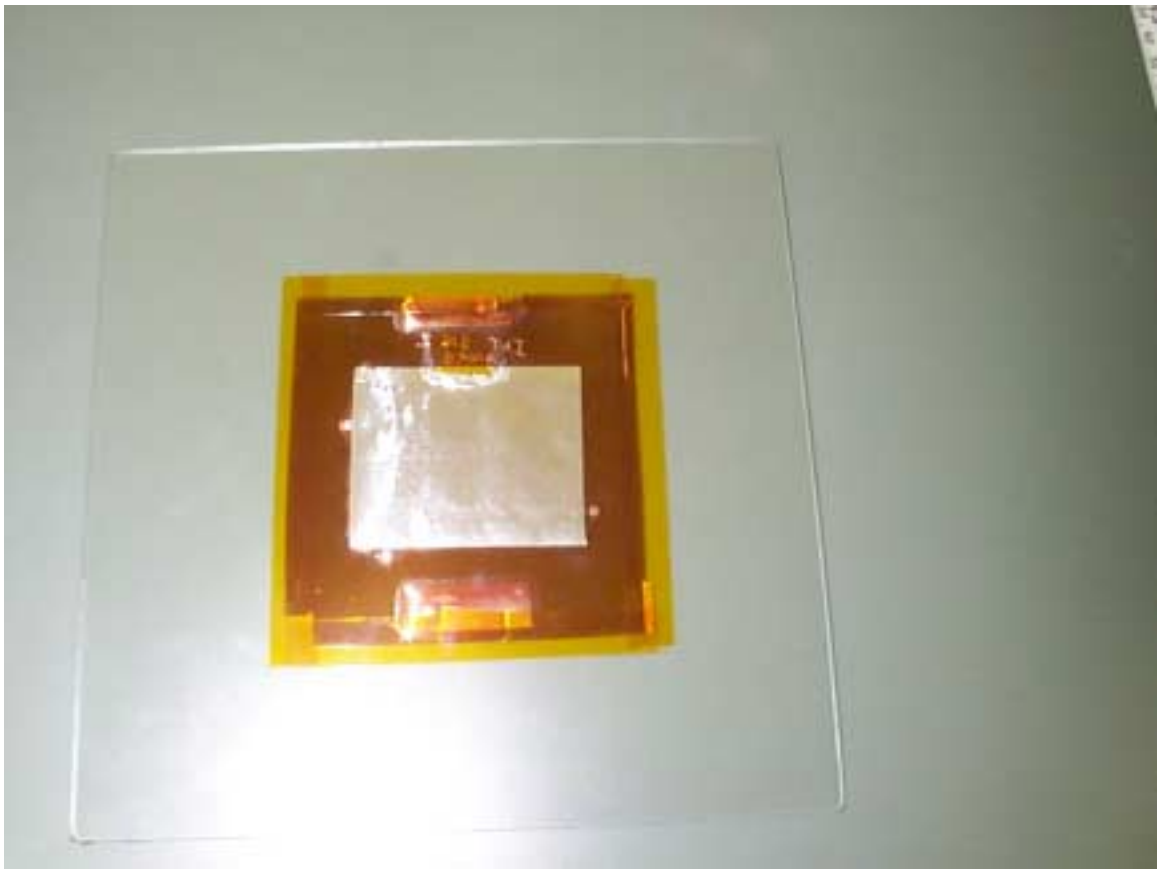
Several copper clad LaRC-SI polyimide films were patterned using existing artwork from a clock drive circuit. This artwork was chosen because the circuit pattern was a size that would fit into the 5” diameter chamber on the RIE plasma etcher. The artwork also contained a via mask pattern, essential for masking the circuit during the etching process. The via holes on the artwork pattern ranged in size from 0.020” to 0.065”. The LaRC-SI polyimide film was 2 mils thick and consolidated with 1 oz. (1.4 mils), rolled annealed copper foil for a total film thickness of approximately 3.4 mils.



Sample of LaRC-SI Patterned Film

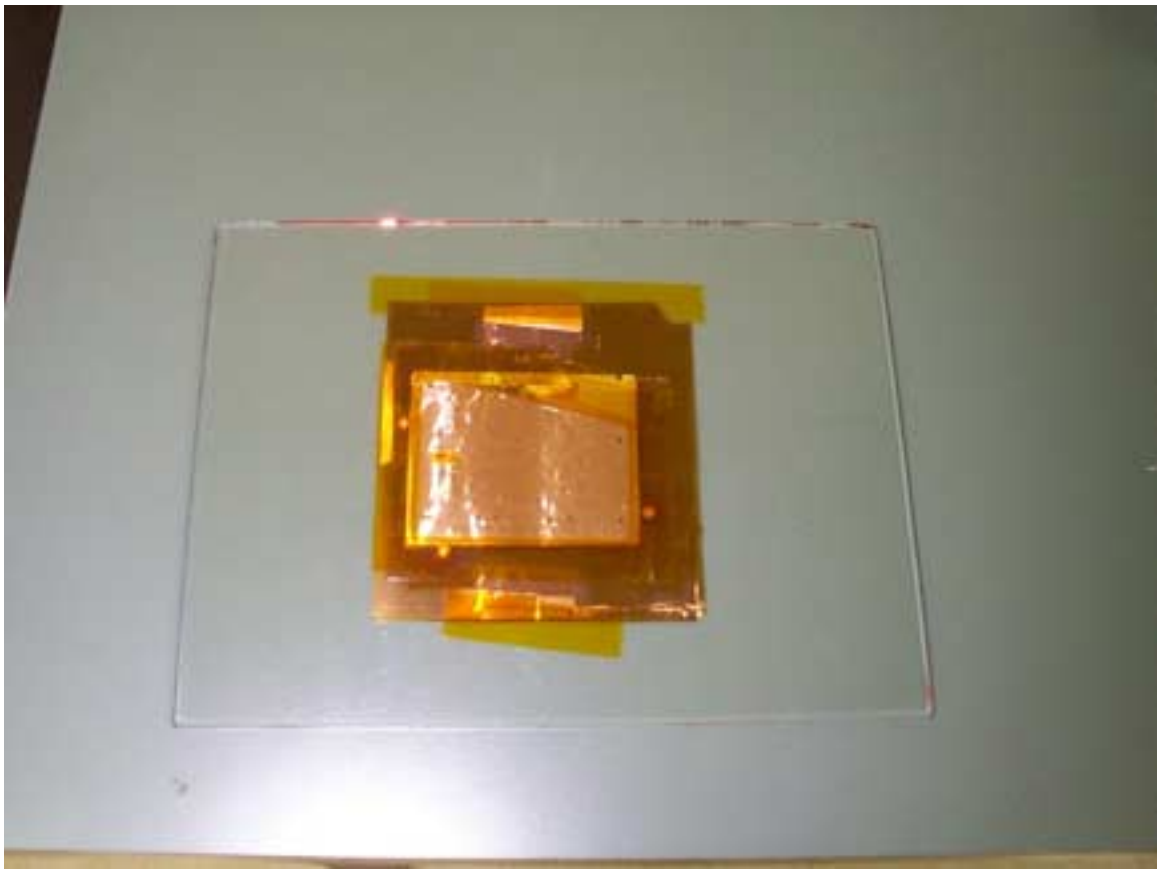
Aluminum Mask for Via Etch

After circuit patterning, the films were then prepared with a via mask. Blanks of aluminum foil were cut to size so as to cover the circuit pattern on the film. The aluminum foil was hot pressed to the patterned films using an autoclave.

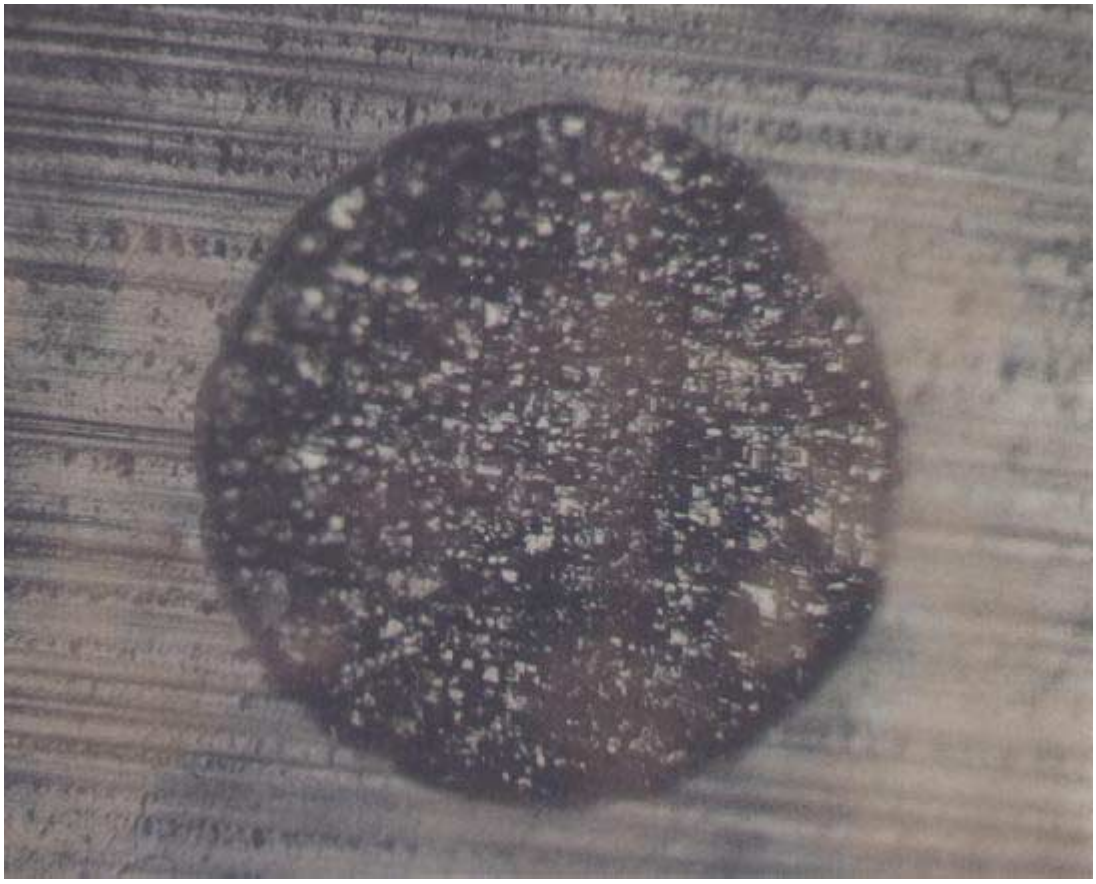


Aluminum Masked Film

The aluminum masked film was then selectively via etched.



Aluminum Masked Film with Via Pattern (Note: the vias have not been etched through the LaRC-SI polyimide film)



Close up of via hole after chemically etching the aluminum mask . The circle is the exposed LaRC-SI polyimide film before plasma etching has occurred.

After the via pattern was formed on the aluminum masked film, the film was RIE plasma etched.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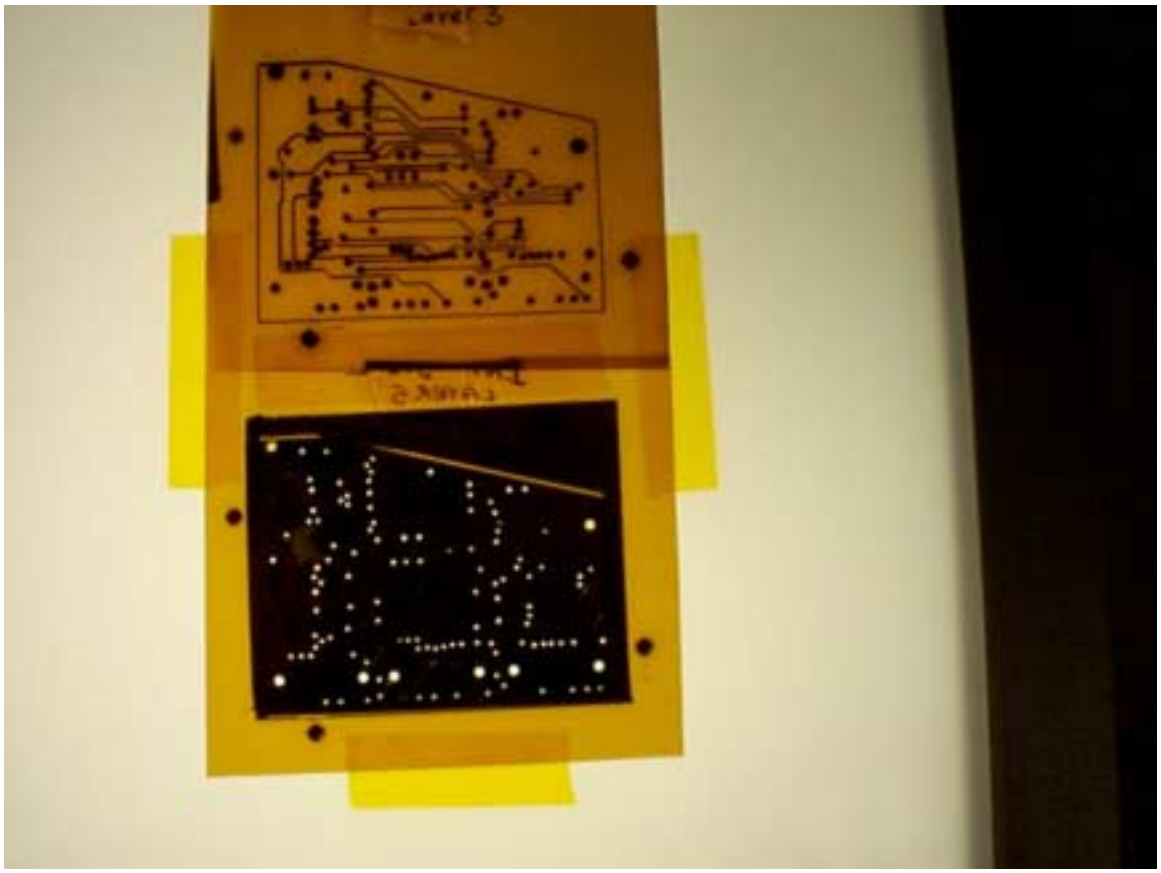
Aluminum masked film, selectively patterned for via etching in an RIE plasma chamber

The films were etched under the following conditions:

CF4 – Mass Flow Controller = 50, Gas Flow SCCM 24%
Oxygen – Mass Flow Controller = 25, Gas Flow SCCM 80%
Power – 250 Watts
Time – 1 Hour

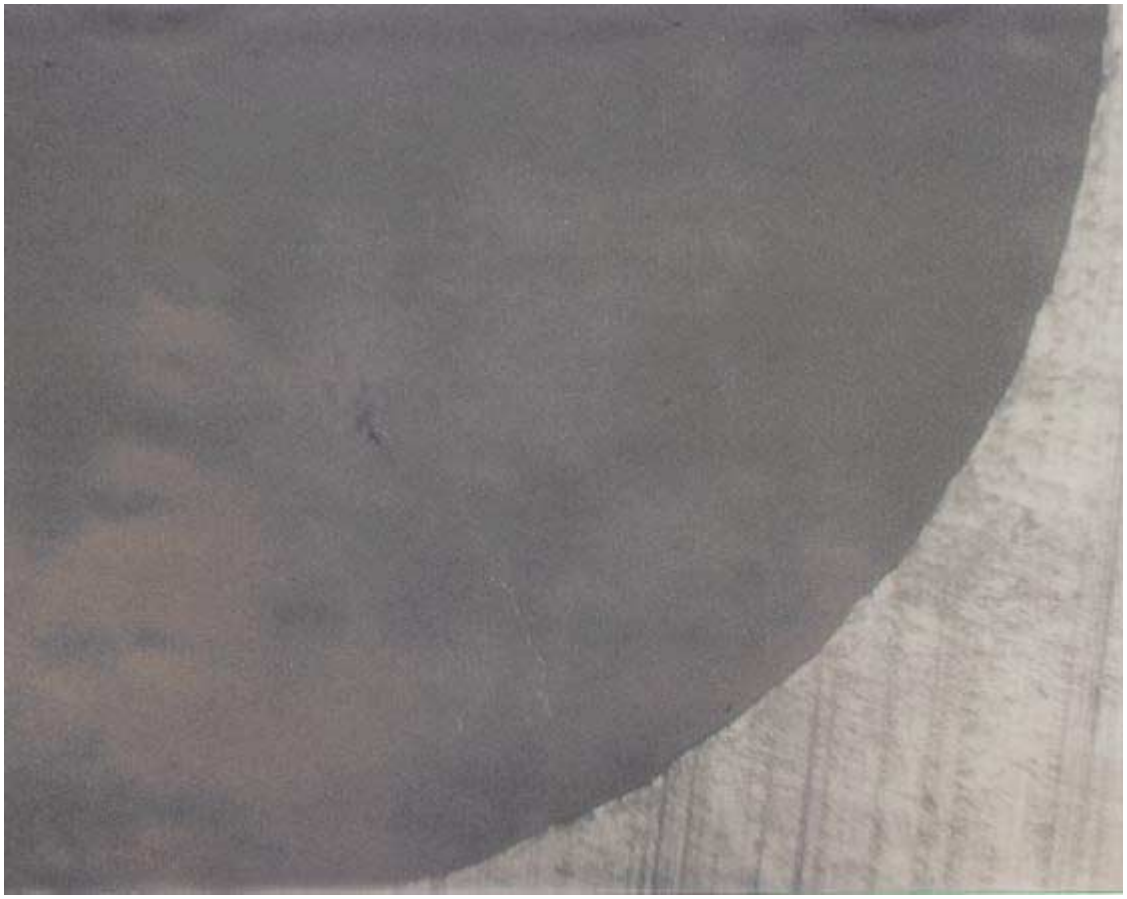
REI Plasma Etcher



Top: Circuit Patterned Film
Bottom: Aluminum Masked Film with RIE Plasma Formed Via Holes

After the via holes were plasma etched in the LaRC-SI film, the aluminum mask was chemically etched yielding a patterned circuit with via holes.

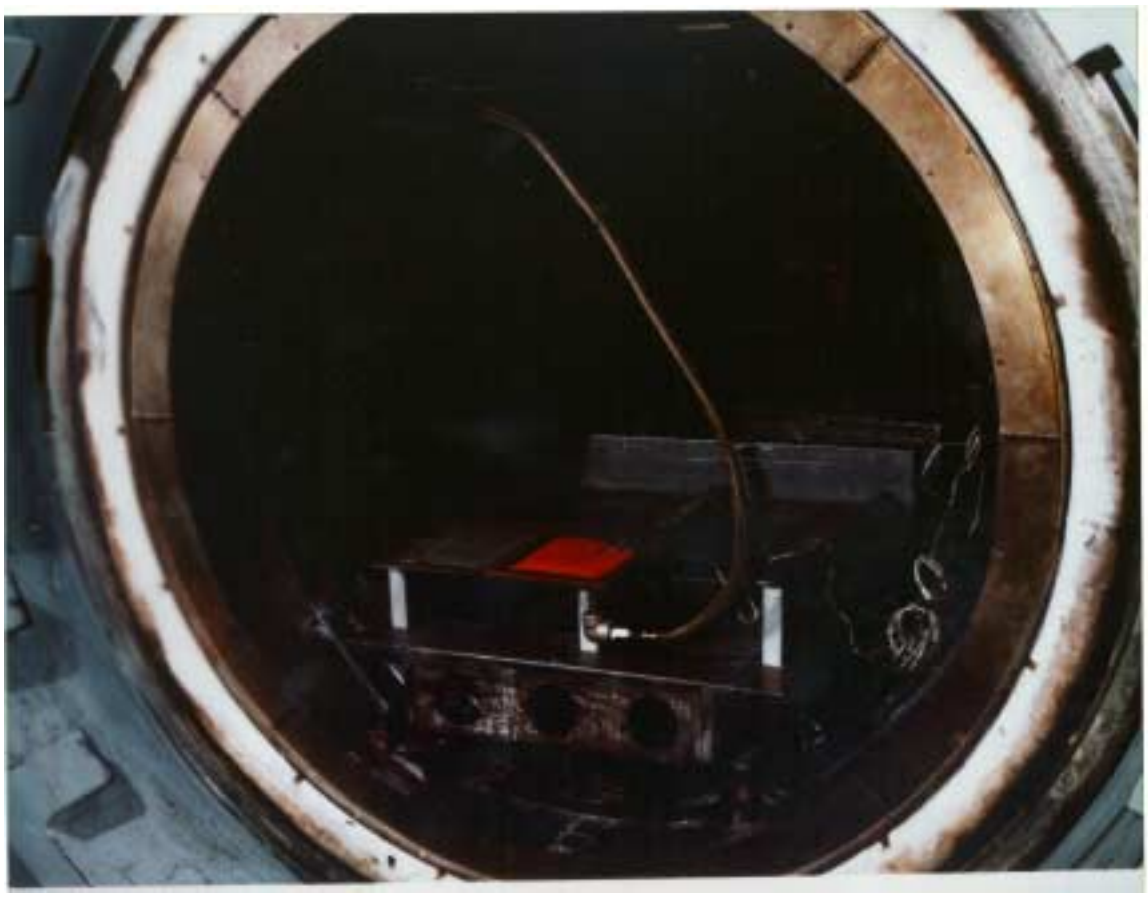
Close Up of an RIE Plasma Etched Via Hole – Small Via - 0.020”



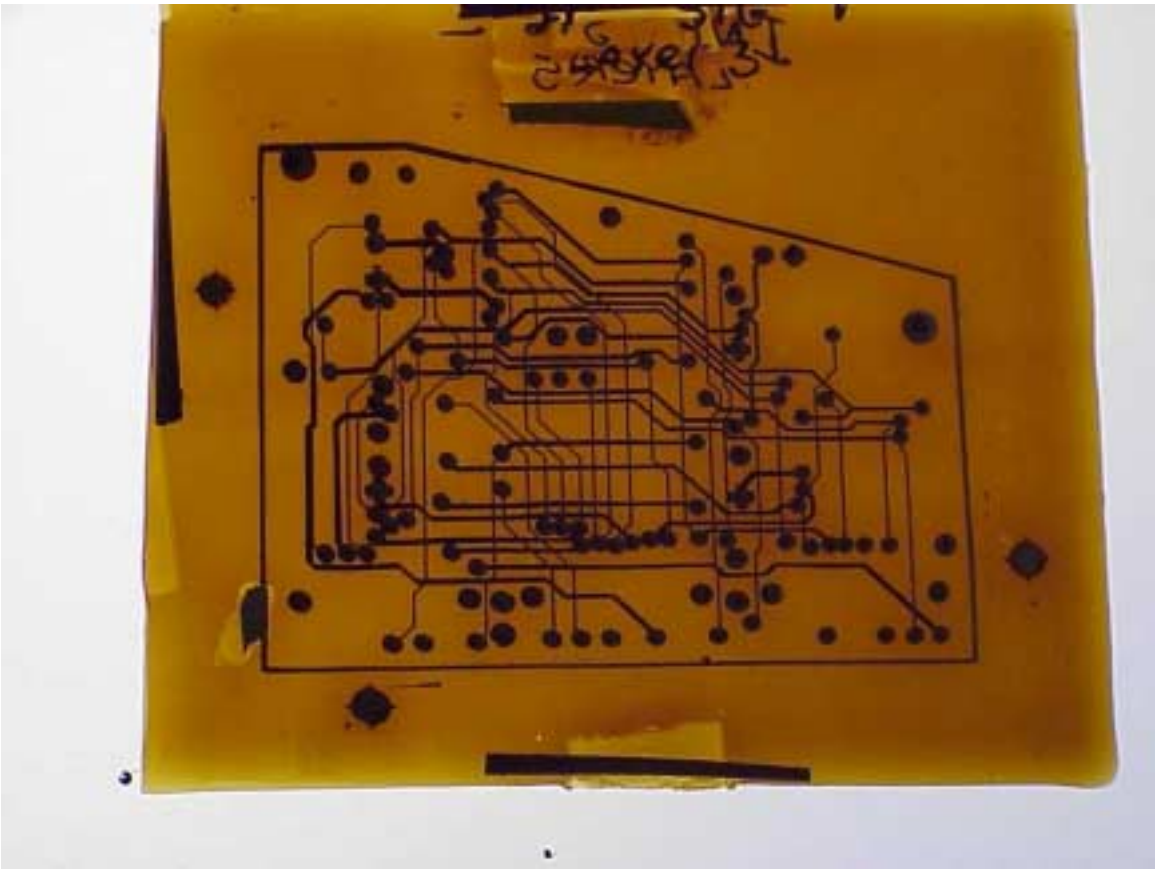
Close Up of an RIE Plasma Etched Via Hole – Large Via – 0.065”

Consolidation of Film Layers

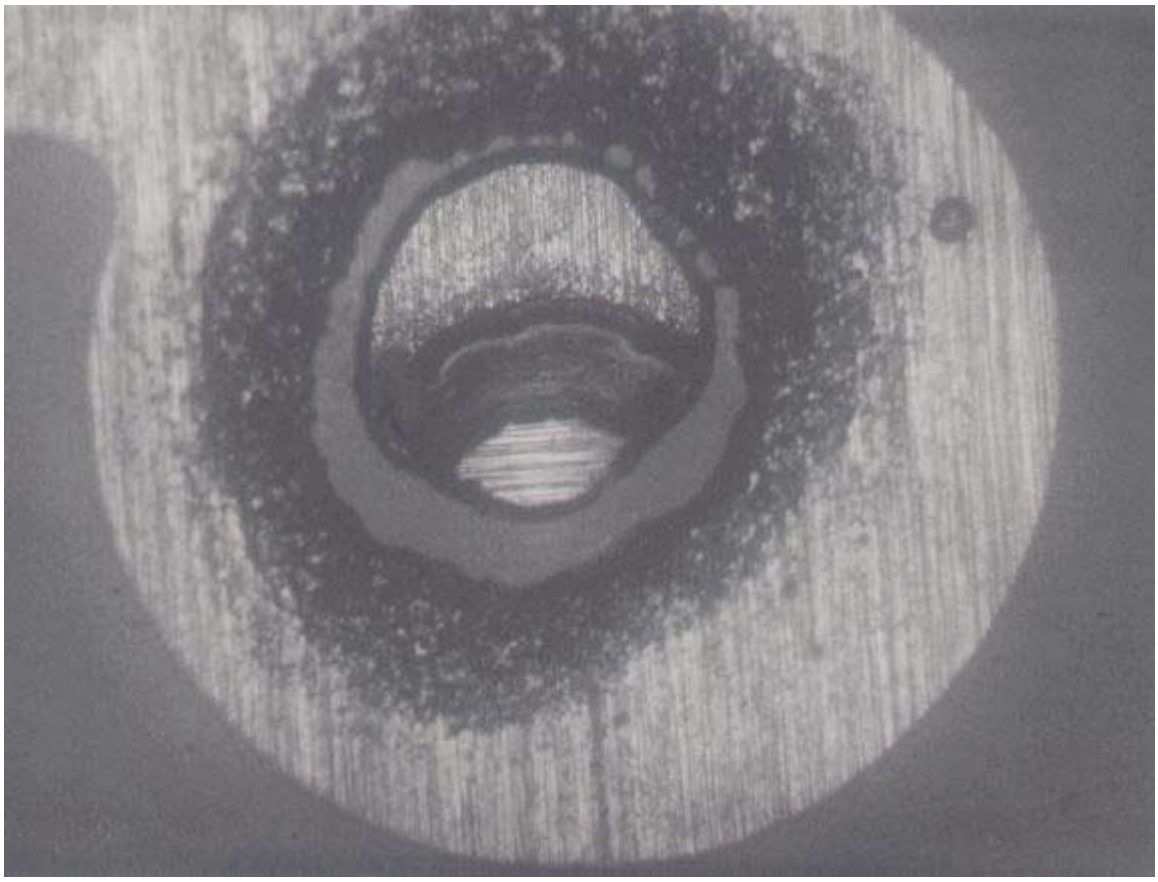
The individual film layers were consolidated with heat and pressure using an autoclave. The films were processed at 300 C, 100 PSI, for 1 Hour.



Consolidation of Film Layers Using an Autoclave



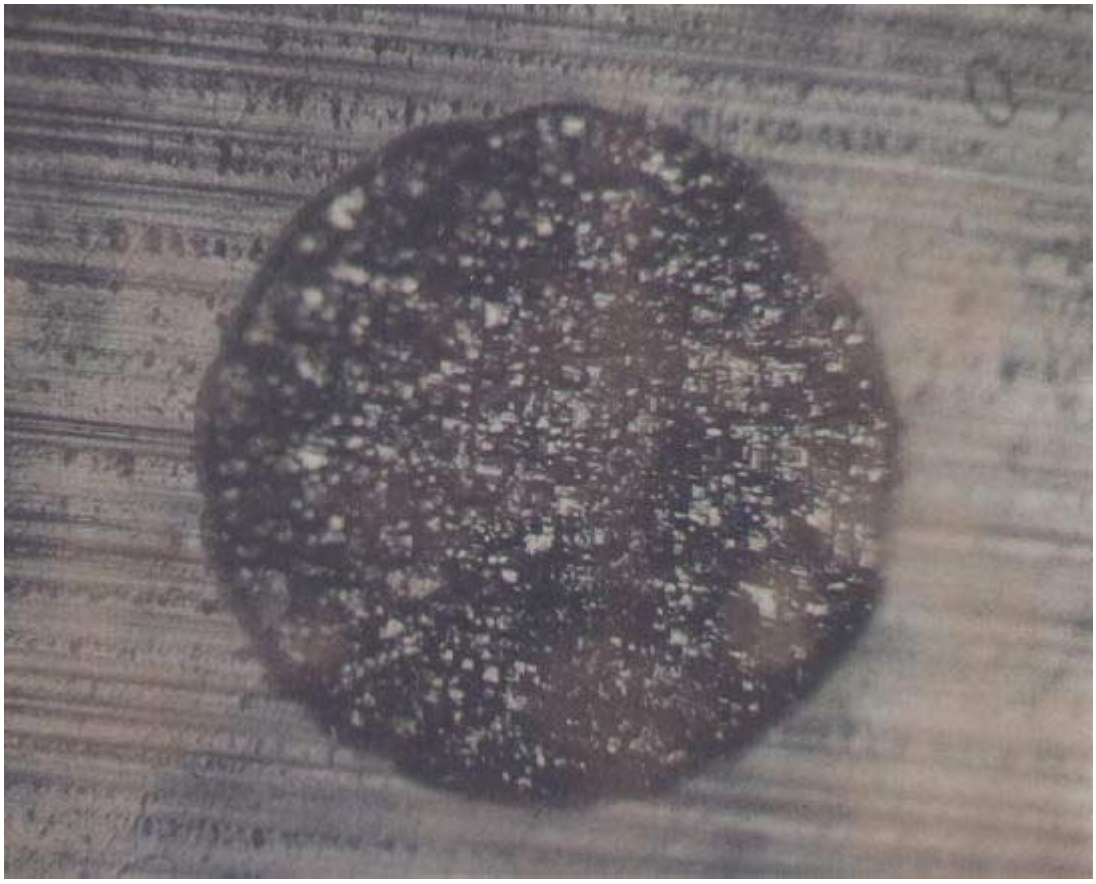
3 Layers of LaRC-SI Plasma Via Etched Film Consolidated into One Monolithic Film



Close Up of a Via Holes After Film Consolidation (Note: the LaRC-SI flowed into the via holes during consolidation)

Results

It was noted that the chemically etched via formed holes (see picture below) were not as well formed when etching through the rolled annealed copper foil, and hence the RIE plasma formed holes were also not well formed (see picture below).



Chemically Etched Via Formed Holes in Aluminum Mask

Plasma Formed Via Holes

After inspecting the via holes with a microscope, it was noted that the LaRC-SI flowed into the holes during the autoclave consolidation of the circuit layers.

Conclusion

The flowing of the LaRC-SI material into the via formed holes during consolidation will have to be further examined. The flowing could possibly be minimized by changing the processing conditions in the autoclave during consolidation of the layers (i.e. less pressure, lower temperature).