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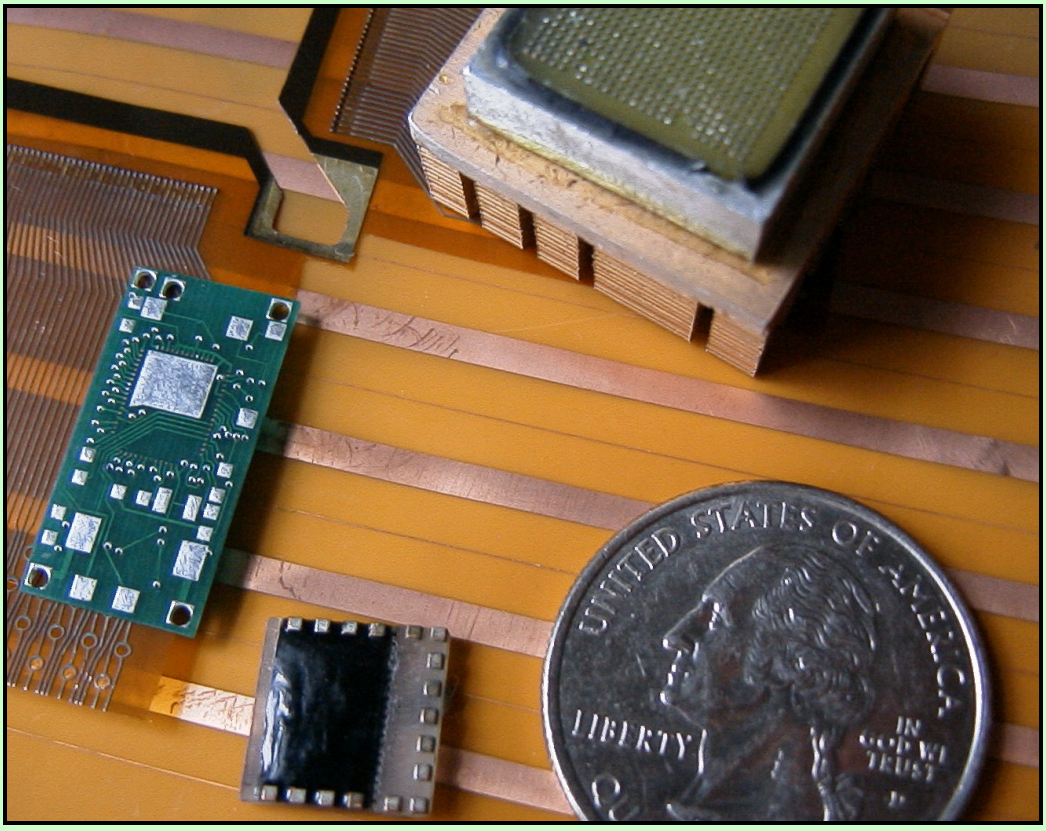
XTREME FINE LINE

PRINTED CIRCUIT MANUFACTURING



Written by

ROBERT TARZWELL

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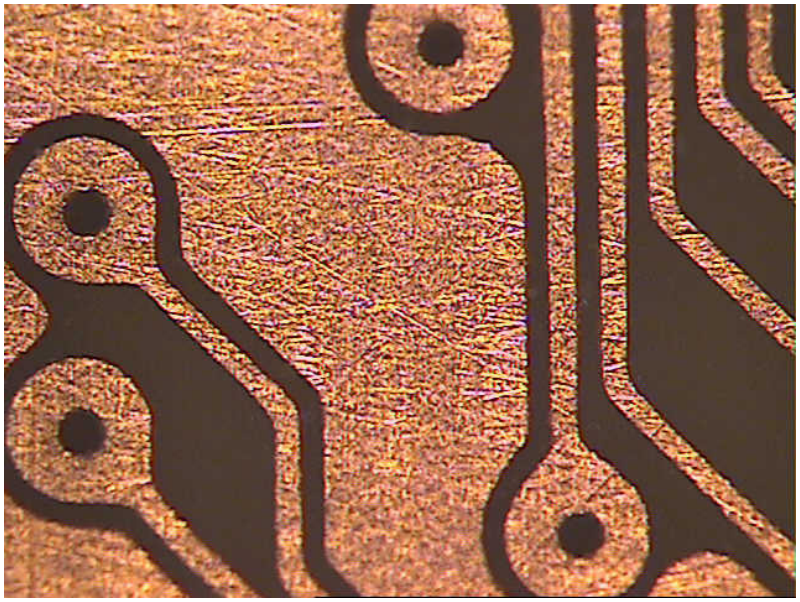
The information in this book is current to January 2009. As material specifications and manufacturing practices change and evolve, please ensure you are using up to date information.

Foreword

The first printed circuit board that I made was a single sided, simple board with bare copper traces, which was state of the art in 1964. Through high school and college, I always seemed to work at a printed circuit facility. Even during my years at CBC in Ottawa in the engineering lab, I was the one making the proto boards in very crude facilities. In 1979, I started Megadawn Printed Circuits Inc. a proto and fast turn facility. It grew and prospered. In 1990, I sold the shop to the employees and was retained as a consultant. The shop continued to grow. In 1995, I purchased the shop back with the express idea to design and sell high technology electronics. The Canadian government offers a very lucrative research and development incentive program, of which I took full advantage. Over the next 5 years, I developed many new and innovative printed circuit technologies. Many were sold to other printed circuit businesses.

The most successful, by far, was the heavy copper technology; companies with the clout of Ford, Boeing, Echostar, Rockwell, IBM, Delphi and many others integrating this new invention into their products. There was a surprising offshoot of the heavy copper technology; the ability to image and define very small lines and spaces. My shop was sold in 1999. I then worked as VP technology at the flex shop, StrataFlex in Toronto and developed and transferred new fine line and heavy copper technology. I purchased a beach property in the Bahamas and built a 12 unit executive resort for my imminent retirement. From 2004 to 2009, I worked at Sierra Proto Express as Director of Technology, transferring my advanced fine line HDI and micro electronics technologies.



1.5 mil lines, 3 mil hole

Introduction for Robert Tarzwell

One of the most amazing things that I have seen Robert Tarzwell do, and there are many, is the day he told the owner of a $20 million board shop that he could take a walk through his shop and come up with savings of at least half a million dollars. The owner took him up on his challenge. Bob walked through the shop and came up with a list of things the owner could do to save money; all in about an hour time frame. A few months later when I was again talking to that owner, I asked him if he had ever followed any Bob's suggestions from the walk that day. *"Oh yes!"* he answered with enthusiasm, *"We took all of them and the only thing he was wrong about was that we actually are realizing savings larger than he predicted."*

Bob Tarzwell is truly one of the Printed Circuit Board industry's technology gurus. With his grasp of today's technology and his insight into the technologies of tomorrow, he is the real "go-to" person for anyone who is looking for the right direction to take their company. Bob has that unique ability to take very complicated problems and come up with elegant and seemingly simple solutions. Whether you are talking about learning how to produce the absolutely best four layer board, in the most cost efficient way possible, or talking about fabricating a circuit board with one mil lines and spacing, Bob is literally the only person in the industry that I know of who can get it done.

Not being technical myself, Bob is the person I go to when I am working with a client who has a new technology and I need it explained to me. Bob will talk to the client for me and then come back and explain the technology in a way that makes it so clear to me that I not only understand it but then can proceed to do my job of helping the client sell it. There are not many people who can do that. As A Wang once said *The true sign of a genius is someone who can take something very complicated and make it simple enough for everyone to understand.* And this surely applies to Bob Tarzwell.

Dan Beaulieu

President
D.B.Management Group L.L.C.

Chapter 1

Overview of Fine Line Printed Circuit Design

Very few printed circuit shops can manufacture a 3 mil line circuit board. Yet, customers are designing and looking for manufacturers that can resolve lines and spaces as small as .0004 inches (10 microns). Well, news flash! The 10 micron circuit is not only possible but is presently being sold by a few shops. The proper manufacturing of fine lines is an entire package, which covers thinner laminates, small vias, smaller features with shorter interconnecting paths and special laminates to carry the traces and support the chips.

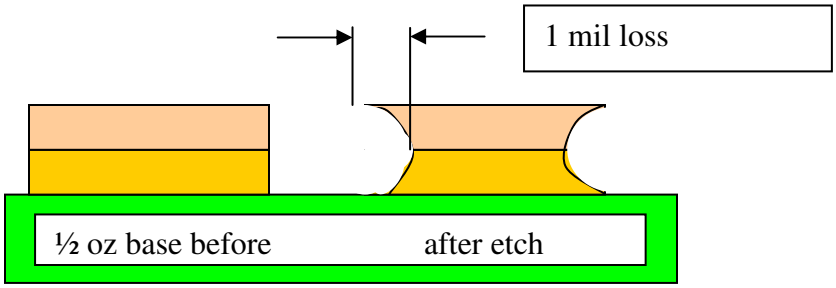
The evolution of fine line circuits has required the re-thinking of the whole printed circuit manufacturing concept. You cannot properly etch standard 1 oz or ½ oz copper to line widths less than 2 mils (50 microns) which therefore requires a new approach called differential metal plating. This is used in chip manufacturing to build up the fine traces without significant etching. In fact, I have had to borrow quite a few chip technologies to get the finer lines and vias. As the circuit gets smaller, it usually is required to be thinner. This means using new thinner laminates which need to retain the strength of the older, thicker laminates. New laminate needed to manufacture the fine line circuits had to be researched with a different mind set as to its required properties. To try and find such a new unique fine line laminate, a hunt of new possible substrates was initiated. Slowly, I found different ways to make fine line circuits, using new manufacturing methods to shrink the size of the packages. What this book will try to do is inform you, the designer, or the printed circuit manufacturing engineer, of various options available to you when you're thinking in the future today and designing your new fine line circuit. This book is a summary of over 2 million research and development dollars spent by various PCB shops on my effort to lower line widths,

We will look at all aspects of a fine line circuit, giving you as many variables and options as we can. I will explain in as much detail as possible, giving away all the secret technology that I know. As many of the circuit components that make up any one fine line circuit can and do interact with each other, some of the technologies are dependent on specific combinations.

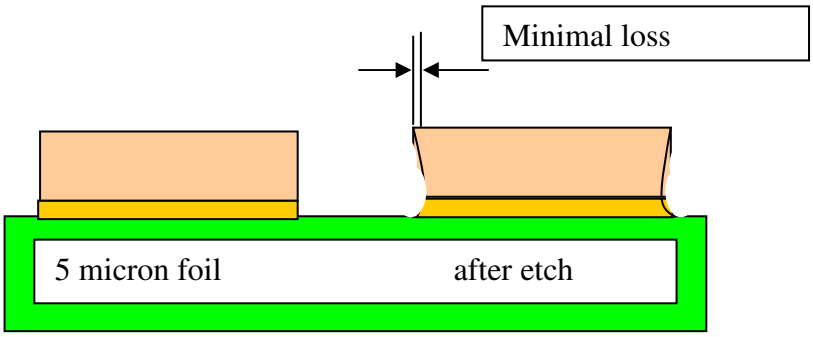
When a printed circuit manufacturer produces a board featuring 3/3 lines and spaces, they are not really producing 3/3. The undercut from etching distorts the shape of the track as much as 2 mils less cross sectional width.

The inventive fine line technology uses a new plating technique to create the fine lines instead of destructive etching. The finer the lines and more importantly, the narrower the spaces, the more important the plating accuracy needs to be. The act of etching the copper produces a large undercut of the base metal and the plated on copper which reduces the line width and creates a fragile overhang which can sliver off causing shorts.

The overhang sliver also reduces the cross sectional thickness of the line width. Fine lines can only be plated, as the normal ½ oz etching process is too destructive and too variable. However, plating of 2 mil lines is very difficult due to resolution problems of normal dry film at that feature size.



Normal ½ oz starting copper, 1 oz plating etch loss

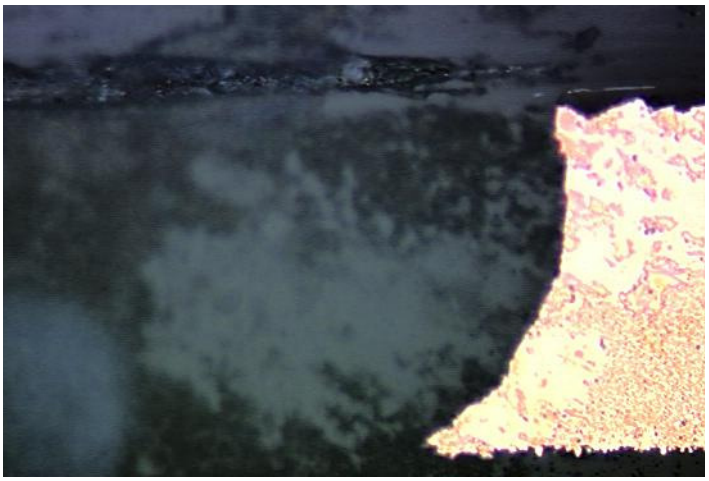


New additive fine line plating process

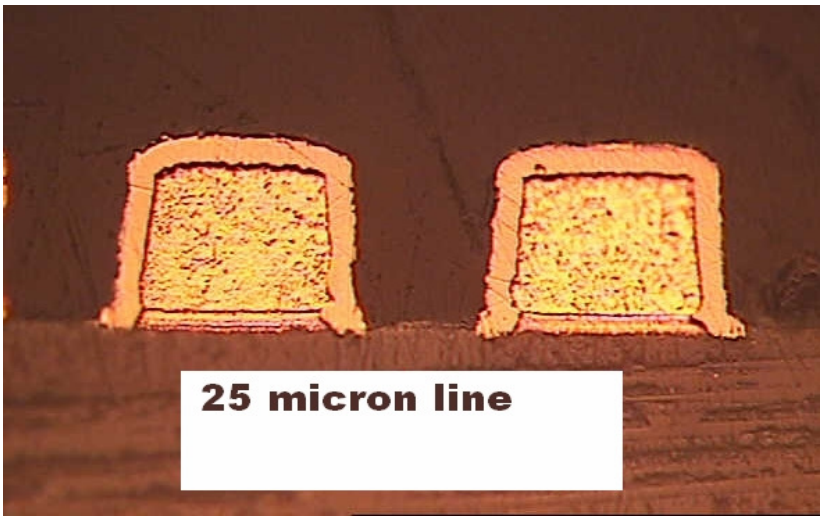
Line widths of 2 mil and below, need to utilize new optical imaging on special high resolution dry film and implement plating technique. Normal imaging with silver photo tools and normal printed circuit board dry film will not provide the proper resolution to obtain smooth edged, correct width lines and spaces. Therefore, we need to change direction and re-look at the entire process.

As I ventured into very fine lines and small holes, I realized that each reduction in line width is 10 times harder to manufacture. As the technology progressed from 4/4 to a proper 3/3, I found it 10 times harder. To venture down to a 2/2 line space, it is 100 times harder and, of course, to make real 1 mil lines and spaces is 1000 times harder.

The finer the lines, and more importantly, how narrower the spaces, affects how thin the starting copper needs to be. The act of etching the base copper produces an undercut of the base metal and the plated on copper reduces the line width, as well as tapering it. The etching creates a fragile overhang which can sliver off causing shorts while it further reduces the line width. Fine lines can only be plated up as the etching down process is too destructive and too variable. Yet, we all see various editorial engineers work the existing manufacturing to death, going into minute details of etching and over stressing strategies to shave a few tenths off existing line widths. I find this a waste of time, when all that is needed is to change directions. Look for newer technologies and manufacture 1 mil lines with ease.



Huge Side Etching of Normal ½ oz Copper



½ oz thick 1 mil Line with Very Straight Line Edge and No Overhang.

Chapter 2

Manufacturing Fine Line Circuits

To properly understand fine lines, we need to realize where the industry has been, where we are now and what we can do in regards to new technologies and changes. Both the plant procedures and personnel training are essential to the proper manufacturing of fine lines below 3/3.

Most printed circuit companies today are sort of producing 3/3 with a few of the more advanced ones doing 2/2. When I speak of 3/3 for most shops I need to qualify that. Example: The line/space required is 3 mils by 3 mils. We add 1.5 mil for etch compensation which gives us a film line to space of 4.5 mil line and a 1.5 mil space. We print and etch ½ oz copper inners and we get 2 to 2.5 mil line and 3.5 to 4 mil space, so we proudly announce we do 3/3 when in fact, we do 2/4. Now this is not all that bad because everyone else is in the same boat. However, the technology is very limited to ½ oz inners and the plant repeatability is poor with nick downs and opens/shorts lowering yields. Also, most importantly, the technology is bottomed out and cannot go below 3/3.

Therefore, it is obvious that we need to change technology to proceed below 3/3.

The following problems require solutions in order to progress below 3/3.

Fr4 surface is too bumpy from glass weave print through to properly adhere and image dry film below 3/3. The ½ oz copper over etches producing varying line widths. The silver film and diazo process is limited to resolution; below 3/3 the lines become bumpy from the overlap of the dots the laser shoots. The 1.5 mil dry film and the silver film set up a Venetian blind effect below 2 mils because of the period of the 350 nanometer wave length used to expose the dry film causing wavy lines.

The Secrets and Answers to the Problems

Now before you read the secrets, realize it will look too easy. The big thing that I do is make the complicated look simple. It took many years and almost $1/2 million to develop this easy system. Do not dismiss how difficult it was to develop. You now have the advantage as it's all laid out and ready to implement.

Please buy the fine line book to learn the secrets to manufacturing very fine lines.