# Uninformed Plating of Micro vias and Blind vias

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Jobs are becoming more difficult to complete to specifications as the complexity of parts increases. With electronic power components getting more advanced everyday reverse pulse technology is offering a great solution in today's PCB shops. From five years ago or even one year ago there have been many improvements in reverse pulse power supplies. We are seeing very high quality pulses with repeatability. Some manufacturers are integrating intelligent pulse optimization systems into their power supplies. All of these functions increase the reverse pulse process from 30% to 40% better than before. Prices of these units becoming more affordable and make reverse pulse an even more attractive option to complete those hard to do jobs. With the latest developments in user interface and IPOS in reverse pulse power supplies this integration into your facilities makes an easy transition from your old system to a new system. With today's reverse pulse power supply technology and our global economy could reverse pulse be one of the solutions for your shop?

The constant improvement of electronic components has resulted in many advantages for pulse and pulse reverse power supplies. Some advantages include output currents getting higher to meet the larger scale production facilities needs. The integration of intelligent pulse optimization systems imbedded into the core software. This enables us to see pulse shape monitoring to achieve repeatability and self optimizing control loops to adapt to bath characteristics. All of these functions give a repeatable waveform and the ability to repeat the process and adjust for changing bath conditions. When working with a delta I 10000A with a slew rate of 100ųs or less, inductance must be addressed in order to maintain a repeatable pulse form. In order to understand the problem a little better inductance is defined as the following. "The property of a circuit or circuit element that opposes a change in current flow, thus causing current changes to lag behind voltage changes. It is measured in henrys." With this in mind there has to be consideration on how to compensate for this in the control of the power supply. IPOS and the latest designed power supplies are using separate voltage and current loops simultaneously this keeping the over and under shoot to a minimum. The next thing to be considered is the connection between the power supply and the plating cell. Depending on the current and the placement of the rectifier either coax cable or twisted pair should be considered. If the distance is not that significant twisted pair would be sufficient. If the distance is significant coax cable should be considered. Coax cable has a lower inductance compared too twisted pair. Most rectifier suppliers should have two types of cooling available when choosing reverse pulse. The first type is air cooled. The size of the rectifier will determine whether the unit will be convection or forced air cooled. The other option will be water cooled. Things to consider when choosing air cooling are the environment it will be placed in, ambient temperature, and cable length. If choosing water cooled, you are able to place the power supply right next to the plating cell to achieve lower inductance. However, water temperature and water quality needs to be considered.

With the development of a new reverse pulse rectifier there is a complete new approach to the industry. This approach combines the technical advantages of pulse plating with consultancy input prior to installation. It also provides a user tool which is based on the experience of experts in the field and the operator's need for easy handling. This system does more than just provide a database of a 1000 pulse patterns which might be applicable. With the new control software the new reverse pulse units offer there are many features that make this process easy to use and repeatable in a production environment. Thus one can achieve faster plating rates, less rework, and scrap. I have listed a few very important control features to have a successful reverse pulse facility.

- Current density calculator
- Batch programming stored in power supply
- Operator screen / Supervisor screen Password protection
- Data logging
- Ah counter

The **current density calculator** calculates the effective current of the waveform being used. For example, assume you would like to run a rack of boards at 20ASF with 15 square feet on the rack. Depending on your duty cycle, forward and reverse ratio, your forward and reverse currents will not equal 300 amperes. In order for the user not to have to calculate every load going into the plating, the user interface should have this function built in. Once the unit and process has been setup the operator simply inputs the total amount of area going into the plating cell and the interface does the rest. This function removes any burning or insufficient copper in the hole resulting giving a more consistent plating process.

**Batch programming** is used in many different applications. Batch programming allows you to use multiple waveforms during one process. Here are a few things to consider if batch programming is needed for your application. First you would need the current density calculator within the batch for every waveform so you can achieve that current density through the whole process. You should also consider that the batch is stored inside the power supply, not in a PC or PLC. If the power supply should lose communication or if the PC PLC should go down, your parts in the tank will not come out the proper way. If this data is stored inside the power supply your process will continue to run without any communication or external source

When placing a unit in production, some type of operator **screen** should be considered for a successful operation of a reverse pulse power supply. An operator screen is a good idea due to the many different parameters available in a reverse pulse rectifier and the effects of those parameters on a process. This screen should only have current density adjustments and file selection, and should not have access to manager functions within the supply. This will ensure that the correct waveform for your process is run every time. If the proper waveform and current density are not applied during the reverse pulse cycle this will reduce the over all production of your facility.

With all of these things in mind significant improvements have been made in the last couple of years. Based on this new approach of introducing a user screen and monitoring of the pulse shape of the output data has been collected on actual production lines. Below are some examples and results from this new process.

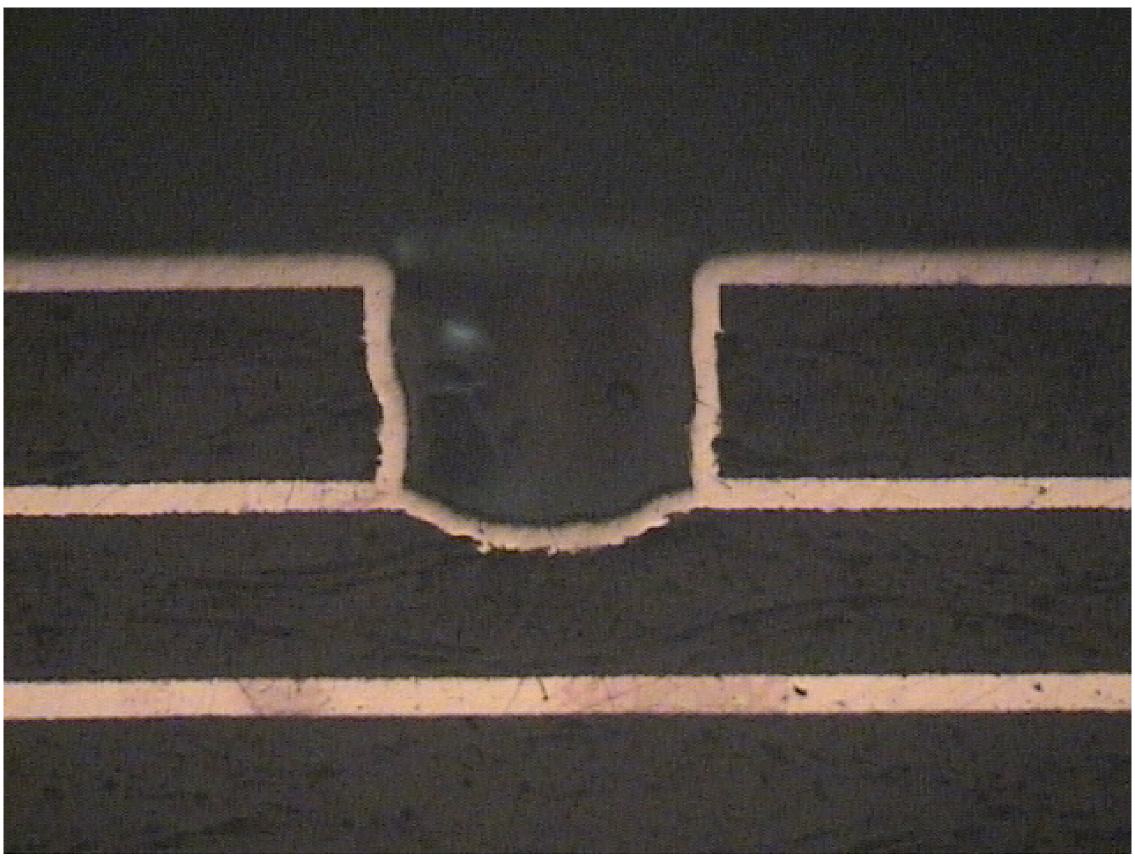
(Mr. Kevin Knapp Colonial Circuits)

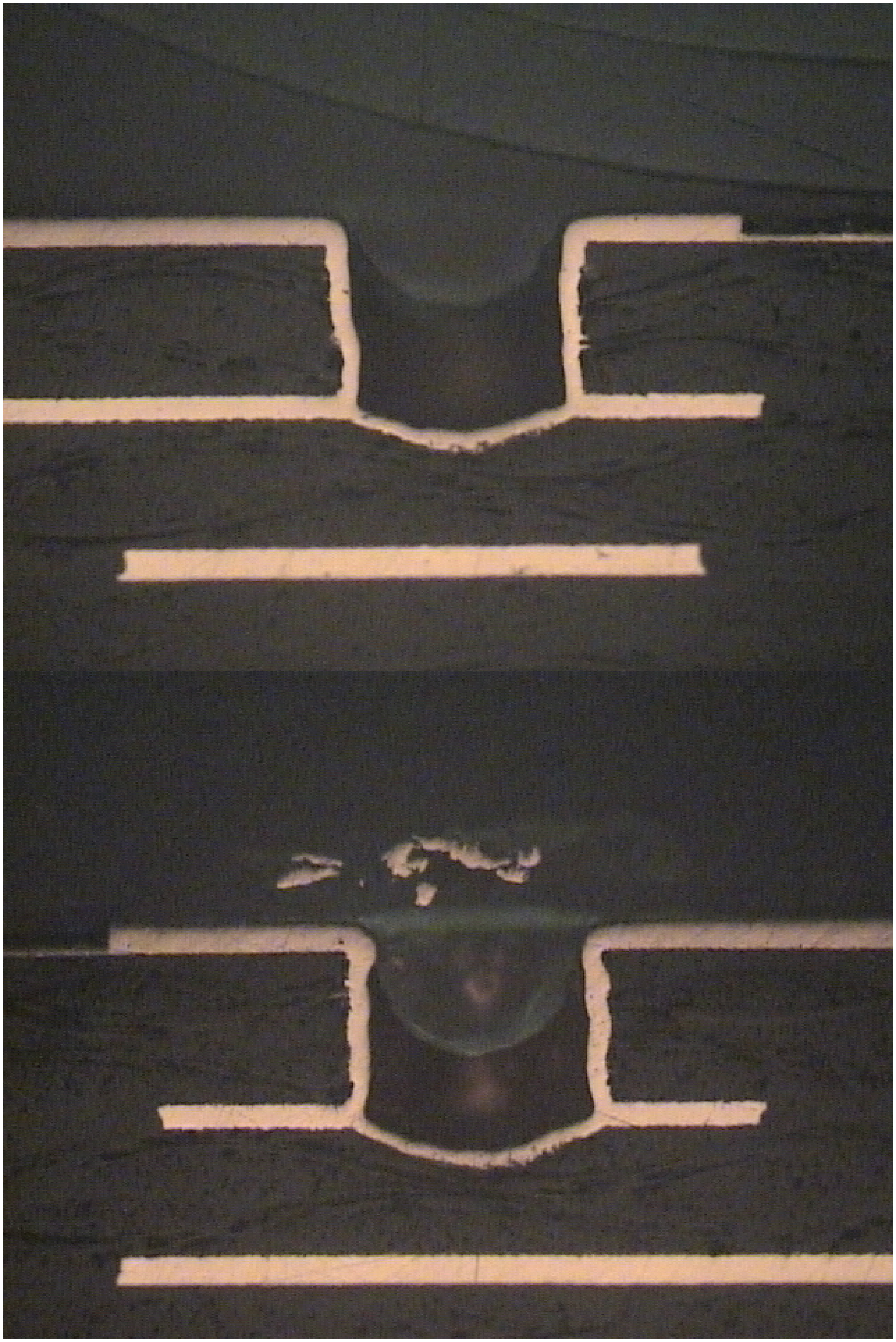
"Pulse plating is not a new concept in the printed circuit board business. It is, however, fairly late to catch on and have an impact. For many years we have been content to plate with DC rectification and be content with the results. As an old school plater I learned to plate with DC rectification it became ingrained in me that there was nothing to be gained beyond that level of technology. As we have progressed from the basic single and double-sided boards with 50 mil lines and spaces and about 1 to 1 hole aspect ratios our plating techniques, particularly copper plating, became more sophisticated. We ultimately lowered our current densities and extended our processing times to accommodate the more difficult plating requirements. In my early days in this business we used to plate in the 30 ASF range for about 45 minutes. 20 years later we were plating in the 10 ASF range for 2 hours or more to achieve a reliable and uniform deposit in the holes. Pulse plating, although known for many years, is still a leap forward for many of us today. The cost of a quality pulse rectifier is not cheap and in fact is somewhere around 5 to 6 times that of a conventional DC rectifier. The big challenge there is how to justify that cost and ask how much of a return on investment we can reasonably hope to see.

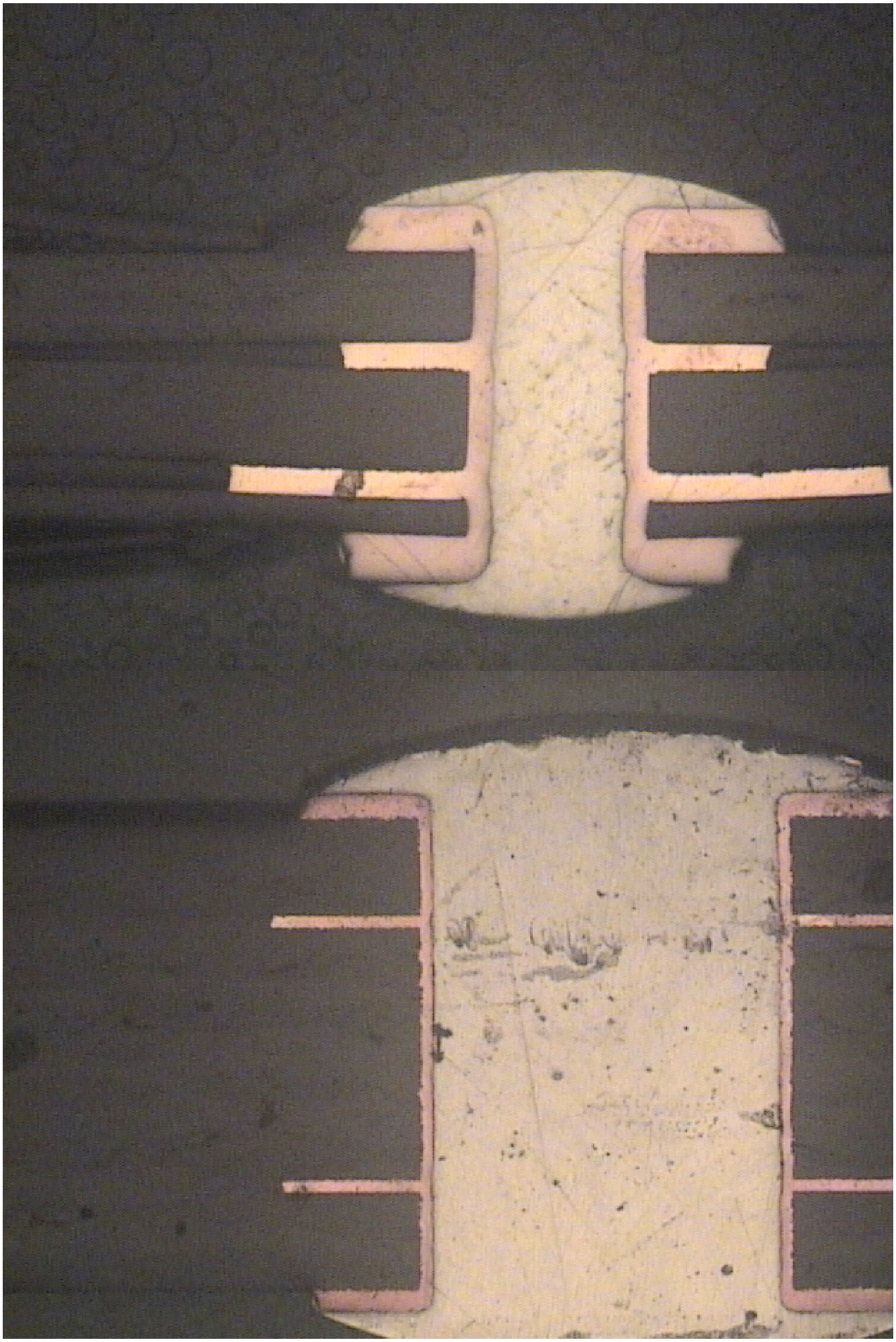
"Much of what we see today in our industry involves typically 5:1 hole aspect ratios or roughly thereabouts. However, up to 12:1 hole aspect ratios are becoming less and less unusual. The ability to lower current densities to achieve uniform plating in a high aspect ratio hole can only go so far. Much beyond an 8:1 ratio hole is extremely difficult to plate without dog boning, plating such a low current density that much of the leveling property of the brightener package is lost and incurring unreasonably long plating times. The 4th picture below shows an 8:1 hole. Note the degree of uniformity in the hole and the surface to hole ratio. This was achieved using a 65-minute plating cycle. Conventional DC plating would likely have taken at least 2 hours to achieve this degree of uniformity in the holes. With holes becoming smaller and denser on the boards, lines and spaces have followed suit. We must realize that not only is the plated hole impacted during copper plating but so is the subsequent etching process. The goal these days is uniformity across the panel and a 1:1 or less surface to hole ratio. The combination of small holes and fine surface features is the worst of all worlds and typically leads to surface over plating on the outside areas of the panel as illustrated in the first picture in the series below. Note that the plating in the hole is tapered and the plating on one side is considerably higher than the other. This comes from a design which is not unusual these days which has ground plane on one side and isolated circuitry on the other. This was plated with conventional DC plating and would normally be considered quite acceptable given the degree of difficulty involved. Not exactly the same board but one of very similar outerlayer design is shown in 2nd picture in the series below. Note the much greater degree of uniformity in the hole and the surface to hole plating ratio. They are both superior. With 2, 3, and 4 mil lines and spaces becoming more frequent it is easy to see why keeping the surface copper to a minimum is critical to facilitate stripping and etching.

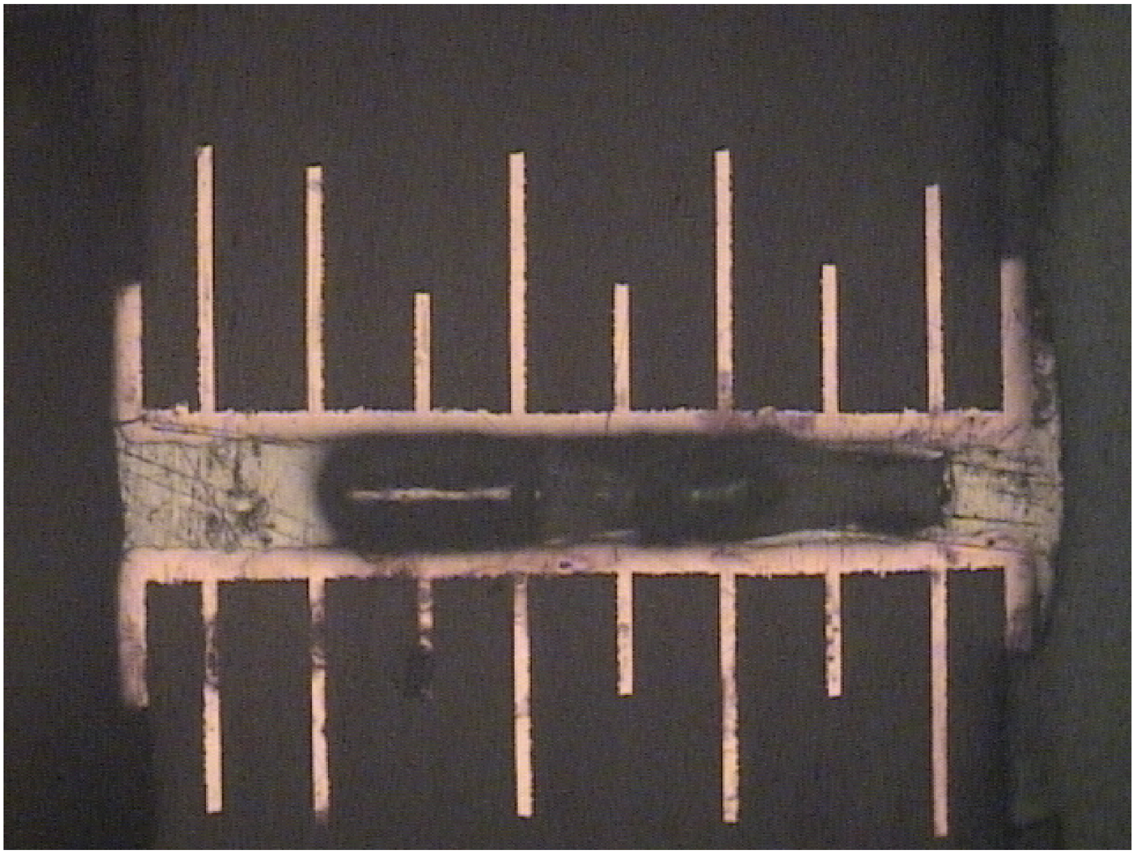
"Vias and microvias are becoming almost commonplace these days as they are incorporated in buried and blind via designs, via in pad technology and micro ball grid arrays. Controlled depth drilling of blind vias is almost a necessity in high layer count multilayers and designs with small and dense circuitry. I struggled mightily plating controlled depth vias with DC plating. I tried a variety of current densities with varying degrees of success but not a lot of consistency. I tried several different sparging methods in an attempt to more rapidly replenish the copper ions in the hole, again with limited success. With pulse plating these holes are no longer a source of difficulty. Pictures 1, 2 and 3 show typical controlled depth via holes with approximately a 1:1 hole aspect ratio which were plated using pulse at a current density of 25 ASF. Note the uniformity of the plating all the way to the connected layer. These results were unachievable using conventional DC plating. Picture 3 (below) shows a very typical 4:1 aspect ratio plated hole. This type of hole represents the majority of what most of us do every day. Again, the uniformity of copper deposit and surface to hole ratio are excellent.

"Here's the whole point to all of this. I consider myself a pretty fair plater. I have always contended, out of stubbornness as much as anything, that I can plate anything with conventional DC rectification that anybody else can plate with pulse. It is vital to understand that not all pulse is the same. I originally used a particular brand of pulse rectifier which was quite pricey not to mention all the money involved in wiring and cables. The results were perhaps marginally better but if anything my position was simply reinforced. As the rectifiers began to be maintenance burdens and parts became increasingly more difficult to get in a timely manner I replaced those rectifiers with other pulse rectifiers. This was NOT my idea but I don't sign the checks. At the point that I incorporated these rectifiers my mind was not only changed but I became a great proponent of pulse plating. The real world benefits are multifold. By being able to write batch files of recipes, the average plating operator is able to select this file and every load is uniformly processed. This eliminates a huge source of variation in manufacturing. Plating times are reduced by 30 to 35 percent consistently. This applies to any design, thickness, hole aspect ratio or material. Technology which required special attention such as that of a supervisor or engineer, specifically high hole aspect ratio or controlled depth plating is done as a matter or routine simply but turning the boards loose to the manufacturing floor. They are plated with no special attention paid and with confidence. Not only is the surface to hole plating ratio maintained but is maintained across the entire panel. This eliminates resist entrapment caused by mushrooming the surface. It makes the etcher very happy and when the etch operator is happy, everybody's happy. So to get back to the question raised earlier about how to justify the cost of pulse rectification….there is the obvious cycle time reduction which we've all heard about for years. It does indeed exist provided the proper pulse rectifier is selected. Moreover, the reality is that current and future designs are requiring the next step forward. To continue to be a player in this market and move forward, today's processes have to be capable of meeting today's design and technology needs."









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