# Pulse Plating

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## Pulsing Off the Shelf

***Columnist's Note:*** *This introductory column is devoted to non-DC plating. It will endeavor to explain and explore fundamentals and advanced applications of this potentially powerful, yet often misunderstood, method of surface manipulation by non-steady-state currents. Questions and contributions are welcome.*

Why would anyone desire a "Pulse Plating" column? In my case, it was the only way out of writing the "Design Engineering" column. Besides, every other design engineering article had a little pulse plating information in it, and those columns got feedback.

The real reason I suggested this topic is malignment. Yes, your pulse rectifiers on the shelf are the skeletons in the closet. The science of pulsing is perhaps complete, but application of the technology and science is needed. Translating professorial papers into plater pamphlets requires the combined skills of jumping through different hoops while changing hats.

When I presented a paper on the influence of (the structures of) water on mass transfer (of ions diffusing a field-generated barrier) for pulse plating acid copper, I had to understand chapters from *Theory and Practice of Pulse Plating*.[1] Now, I had read and reread this book from time to time for the past 10 years. Correlating chemical structure to pulse theory required knowing terms and concepts, and required researching all my plating books and journals, the Internet, etc. I had only eight weeks to prepare the talk, and it had to be consistent with theoretical reality—whatever that means. Combining pulse and plating theories gelled understanding electroplating. Although I had thought I was "current," now I *am* current. (A reporter once asked Salvador Dali, the "melting clock" painter, if he took drugs. Dali replied, "I *am* drugs!")

After my enlightenment, pulsing boiled down to several parameters. These are used to correlate plating variables, such as bath composition, electrode conditions, etc. My point is that pulse plating isn't that complex if you really understand electroplating. Most platers have a good grasp of plating from experience, but they have a difficult time making the leap to pulse plating. It's not intuitive. After boiling it down, however, it is really quite simple. Take a little hydrodynamics, solution chemistry, electrochemistry, surface physics and coordination chemistry, then add some iontophoresis and *voila*! Indeed, it can be contrived as hideously complex. But it's just like driving a car—you can read all the books you want, but you'll never be able to drive without a car, a key, some gas and good brakes to practice in an empty parking lot. You don't need to know the complex engine workings, and it won't help knowing complete automobile functioning.

It was interesting re-reading a 1979 Australian review of pulse plating.[2] The authors likewise affirm three independently variable pulse plating parameters: Current density ON; time ON; and the OFF period. Interestingly, they pointed out that pulse plating is a special case of pulse reverse, in that cathodic pulses are interrupted by zero current pulses instead of anodic ones. You can call current fluctuating from one value to another whatever you want, but it remains that current variation is done to effect some sort of change at the work surface. This is why we like pulse plating, right? You can control grain size, alloy composition, hardness, crystal orientation, smoothness, catalytic characteristics, electroforming without internal stress or treeing, microelectroform, electropolish, electrochemically machine (EDM), making faster semiconductors (for G3s), smaller printed circuit boards, soft magnetic thin-film heads, superconductors (YBCO), metallic glass, eliminate hydrogen generation, hard anodize at room temperature, etc.—all by pulse plating.

What can be added to the 20-year-old report comes from rectifier improvements in rise and fall times, frequency ranging, maximum output control, programmability, etc. Rectification is key to research, as well as the production line. It can shorten initial surface barrier charging times, change or keep a steady state "on" current or voltage, ramp pulses up and/or down, forward and/or reverse ... and on and on. The following pulse current (or voltage) conditions therefore become important:

1. Control of current rise rate and magnitude.
2. Length of time on.
3. Rate of current change to zero or non-zero value.
4. Length of time at zero or non-zero value.

Next month: The barrier barrier. P&SF

### About the Columnist

*After Steve Koelzer mastered chemistry at Cal Poly while teaching university chemistry and machine shop 19 years ago, he began a plating career in reel-to-reel connectors, microwave tube components, physical and chemical bath analysis, supervising shops, chrome sales, hazardous waste treatment and regulations, semiconductor copper pulsing R&D. He is now a consultant and serves on various AESF boards and committees. He is chairman of the Society's Pulse Electrodeposition Processes Committee and a member of the Santa Clara Valley Branch.*

### References

1. J. Cl. Puippe & F. Leaman, eds., *Theory and Practice of Pulse Plating* AESF (out of print), 1986.
2. G. Perger & P. Robinson, *Metal Finishing*, December 1979.