Pulse Plating

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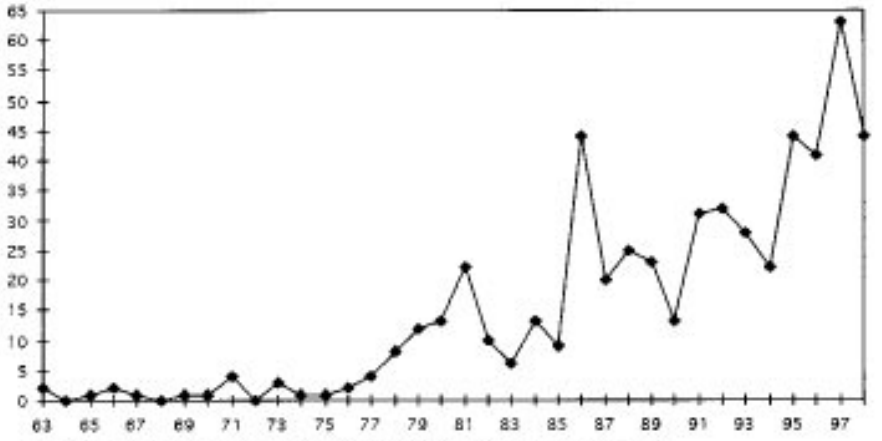
Pulse Plating Standards, or: The Barrier Barrier

The science of pulse plating evolves as more is discovered about how the surface electroplates, and vice versa. Amidst the flurry of publications of this multi-colored black art (see chart), the need arises for maturation, standardization or unification of terminology for understanding.

Buckminster Fuller stated that the flow of energy through a system tends to organize that system. Indeed, we are drowning in information but starved for knowledge. "For every thousand men hacking away at the branches of evil, only one is attacking the roots." Objectivity is seldom pure and the developing science is compromised by concensus divisions, outside criticisms and, of course, funding and other economic motivations.

Consider diversified terminology for "reverse," in which current changes to anodic conditions. The following are terms used in 11 percent of 558 "pulse" publications, in order of appearance, each [multiple] with years: (1893) pulsieren den Strom mit periodischer Stromumpolung (pulsating current with intermittent, or periodic, opposite pole current); ('49, 79, 86, 87, 88, 89, 91) Periodic Reverse Current; ('50, 63, 88, 91, 95) Periodic Reverse; ('86) Modulated-pulse Periodic-reverse Current; ('87, 93, 96, 97[5], 98) Reverse Pulse; ('88) Periodic Reverse Polarity; ('90, 91, 92, 93[2], 94, 96, 97[2], 98[4]) Pulse Reverse; ('90, 93) Pulsed Reverse Current; ('90[2]) Direct-Reverse Pulse Current; ('90, 93) Pulse Reverse Current; ('91) Current Reversal; ('92, 93, 94, 95) Pulse Reversal; ('92[2]); ('92) Periodic Current Reversal; ('93, 94) Pulse Reversed Current; ('95) Periodic Reverse Electrolysis; ('97[2]) Pulse with Reverse; ('97) Current Pulse with Reverse; ('97) Reverse Pulse Current; and ('97) Reversible Pulse.



Number of pulsed plating articles published annually (total = 546).

Some of the terminology is incorrect, while some reflects "coined" terms. If one were to unify the terminology to such an application, it could accommodate all non-DC plating: Pulse-on-pulse, duplex pulse, reverse pulse (anodize), etc. A standard format should include whether the system is voltage- or current-controlled; should indicate the degree to which the current or potential is reversing for the purpose of affecting the potential or current, respectively; and should include terms such as stepped, gradient, sine, etc. The format would follow programming templates used in current and/or voltage modulation of computerized rectifier outputs, taking advantage of and accommodating improved rise and fall rates and capacities of modern rectifiers. Once objective terminology standards are implemented, duplicative boondoggles will disappear.

An increased coalescing of disciplines will require another terminology unification. Each discipline contributing to the understanding of (pulsed) electrodeposition has its own evolution, as well as its own terminology. Unification would be likened to Eskimos trying to communicate with Egyptians.

Atomic force microscopy began 15 years ago, and I never thought it would *become* a form of pulse plating! Yet Kolb, *et al.*,* have used scanning tunneling microscopy for tip-induced pulse underpotential metal deposition of palladium nanoclusters onto Au(111). AFM also contributes to plating with depiction of surface ultrastructure just after (or during) pulse plating. This reciprocally benefits surface scientists and metallurgists who, as a result, contribute to understanding pulse plating.

Many other surface and super-

surface physical and chemical analytical spectroscopic methods are pieces of the surface condition puzzle and help the plating mosaic mechanism unravel. Electrochemical engineering contributes in its terminological way, advancing the great foundation built by von Grotthus, Faraday, Volta, Ampere, Helmholz and Stern. Electrical engineering also needs inclusion for rectifier advancements for contributing to understanding grain and amorphous electrical conduction (tunneling) effects.

The chemistries of ionic solvation and coordination and reaction kinetics hold the last key to help unlock the white box of the black art. Every necessary discipline is required and each must come to terms in, and of, understanding. The aforementioned example of authors from various disciplines using the diversified terminology for "reverse" exemplifies the need for a congress or another organization to standardize rectification.

The interface between surface and solution is not completely understood. Chemical and electrochemical phenomena are the same as those responsible for the "pulse of life." Perhaps understanding pulse plating requires knowing the most basic of life's forces. To paraphrase a college graffito: If it's solid, it's physics; if it's cleaned and solid, it's surface science; if it's cleaned and solid and it's plated, it's materials science!

Next month: How and when pulse works. P&SF

* *Engelmann, G. E., Ziegler, J. C., Kolb, D. M.;* J. Electrochem. Soc. *145 (3) letters, 98.03.02, 1998.*

Finishers' Think Tank

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barrel. Compare results. Many geographical locations are now experiencing winter chills—remember that quality rinsing decreases as the rinsewater gets colder. Trace bussing from saddles to rectifier, confirming actual hookup. With a tong tester, measure actual current to each rack. Skip the electrocleaner. Does the problem persist? Sure, it's fine to look, but it's better to see.

Our finishing journey has not successfully passed the soak cleaning and electrocleaning stages. The next stop will be: *Acid Dip—Active & Right*.

Finishing Trivia

- Soak, mechanical and ultrasonic cleaning are suitable replacements to solvent degreasing. Economic considerations and method of application serve as general guidelines for process selection.
- Alkaline copper plating systems offer these advantages: Non-cyanide; a dense, nonporous deposit; no carbonate buildup; simple process control.
- Benefits of mechanical plating include: No "dog bone" deposit buildup, does not fill threaded areas, provides highly corrosion resistant coatings and is cost-effective. P&SF