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Control: Modulated Current + Electrolyte Additives

Chemists design electrolytes. Electrical engineers design power supplies. A battery of designers is needed to create functional finishes. The surface design engineer must wear many hats.

In order to design a surface finish, one must have seen different finishes in action (empirical) or understand the materials science of surfaces, as well as electrochemical equations describing plating mechanisms (theoretical). In order to execute such finishes, empirical and theoretical, additional knowledge of power supply capabilities (theory and practice) must be gleaned. Don't forget to throw in the salesman's hat, because someone must buy it and someone must sell it. After theory and practice and buying and selling, the design of the surface must be executed: Someone must manage the lab to do the experiments and, afterward, test to prove the concept. This may sound far off, but we're closer than we think.

Theories are built step-by-step and advancements require most of the above steps. You crank out some electrochemical theory and make the power supply to test it, then refine the hypothesis and create more theory, and so on. Using non-interrupted (DC) current, many advancements occurred with electrolyte and additive compositions.

Because pulse plating is special to the electrical side, as opposed to the chemicals side, the development of electrolyte additives for pulse plating has a relatively short history. More important (and relevant) is recent research on the mechanism of action of additives at metallic surfaces. The recent investigations on the influence of chloride on copper, or sulfate on silver or even water on nickel, for example, affect specific crystal planes and terrace edges. Pulsing has had to either examine basic, non-additive systems (more theoretical) or compromise and use additives developed for DC. The quest for specific additives comes from two branches: (1) the theory of recent advancements of additives on specific atomic planes; and (2) reconstitution or modification of the DC-type additives developed. The three classes of power supply interactions with electrolytes are:

1. Pulse With No Additives

This work has gone on since the 1970s with many citations, but few correlations with crystal orientation. Much theory of pulsing has resulted. There is room for advancing diversified waveforms to take advantage of surface macro- and micro-morphologies. Surface qualities such as heat and electrical conduction may be impeded, but those like catalytic and quantum effects may be refined.

2. Pulse With Specific Additives

This is the arena where a little research would yield huge rewards (and formulations). Refined reagents might be more quickly integrated with diversified waveforms. The result: a shorter path to defined objectives and more room for exploration of surface phenomena and quality.

3. Pulse With General Additives

Here is the economic state of the art. Advancements are small because commercialization is involved. Diversified waveforms have little hope because of the overall control by additive packages. Gains from exploiting diversified waveforms would be a great expense because of the time involved.

Remember KISS? No, not the rock group, but Keep It Simple, Stupid! Advancements in pulse plating are diversified. There is no collective body of information readily available. Pieces of data are all over the place, except for the 1986 book, *Theory and Practice of Pulse Plating*. The field of theory and application is immense and this book is the only coherent collection of information. The AESF's International Pulse Electrodeposition Processes Committee has endeavored to update and extend this book. Because it had been difficult to update, and because the book really fell out from the 1985 Third International Pulse Plating Symposium, the Fifth International Pulse Plating Symposium was developed with this in mind. The symposium (June 29 & 30) has been organized in conjunction with this month's SUR/FIN® conference. Anyone interested in the subject should make it a point to attend.

Also, the number of publications since the book was published (some 500-600) deserves separate document inclusion, perhaps on CD. It is estimated that there are about 2,000 citations in pulse plating that will be assembled in the effort to update this subject.

The diversity and amount of information available on pulse plating demonstarte the potential and interest in this powerful tool. P&SF