

## PulsePlating

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Listory of rectifiers or their advancement although it is a very interesting subject. Here, the fact remains that there has been a lot of advancement in producing virtually ripple-free current, programmability, including preset multiple-program sequences and spreadsheet-oriented capabilities of extremely fast transitions of potentials to drive currents. My favorite was integrated changes of pulse peaks forward vs. those in

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## Pulse Electronics

reverse. I believe that staged gradients are the now fad in PCB plating.

What good is all of this if the work surface does not respond? Why would it not respond, you ask? In fact, respond to what? Current travels at about 90 feet in a millisecond as it is used in ionizing the surface to prepare for electro-reduction of solvated cations. The work being done consists of overcoming surface adions and adatoms derived by aquation, sulfonation, clathration, chelation or simple sequestration, with the degree of energy required depending on how soft the acid (metal) is and the hardness of the base (anionic species). This also includes various surfactants with correlative properties, such as the derived polyethers.

So, the surface response to equivalent current depends on the pH and ionic milieu. Let's take a case where there is a lot of thiourea brightener in plating copper or nickel. The monodentate ligand, thiourea, is strongly attached to the metal ion. When the metal ion tries to reduce to metal at the surface, a high enough potential must exist to drive off the ligand to an undissociated state. This is similar to using hydronium ions (H<sup>+</sup>, protons, hydrogen ions) to dissociate EDTA from copper and allow reassociation selectively with iron (ferric ions) in alkaline waste precipitation. The ion potential must overcome the association potential (affinity) of the ligand. In this case more acid is used to drop the pH, and likewise, more current is used to "neutralize" the surface capacitance of the adsorptive state of derived surface metallic ions.

No metal has a purely metallic surface. Water is present, oxygen is present, etc. Every metal has an oxide

layer, be it sub-monolayer, monolayer or what-have-you. The difference between oxide, hydroxide and hydrate depends on the metal's primary ionization constant. You can have sulfide layers, hemioxide layers or oxide layers depending on conditions, but you always have the derived laver unless extreme conditions are used for some experimental purpose. One such purpose I recall from high school because it was so astounding, heard some 36 years ago. Evacuating all of the water out of a pressurized gas bottle by heating to 400 degrees or so (i.e., ridding all surface-bound water and replenishing with anhydrous gas) allows you to store both hydrogen and oxygen together under great pressure. One molecule of water floating about, however, will catalyze the recombination of the contained gases to explosively turn into water. Another such purpose is the heating of silver to >900 °C to drive off surface oxygen and achieve a pure metallic surface for brazing or whatever.

So, the rapid surface current is consumed in ionizing surface bound ligands, effectively representing the surface capacitance effect. The higher the current density, the faster you cut through. So the nice rectangular edged "square wave" is not really what you get when viewed on oscilloscope. Instead, you get a curving slope approaching the potential current peak. The degree of curvature from the vertical with time is inversely proportional to the current density applied. The only way to have your current mirror the potential "square wave" is by over-driving the potential such that when trying an overshoot, your potential is relaxed a

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