Periodic Pulse Reverse Opportunities In the General Metal Finishing Industry

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The success of pulse reverse (PR) electrodeposition in the PCB industry is generally acknowledged. The technique is now also diffusing into different fields of electrochemical application, such as electroplating, electroforming or electrochemical machining [the general metal finishing industry (GMF)]. This paper briefly describes the history of pulse and pulse reverse technology, focusing on the reasons for the eminent success of PR technology in the PCB industry. The challenges are discussed regarding the introduction of the technique in the extremely diversified GMF industry, particularly as related to equipment and processes. Successful implementation requires a thorough understanding of the application involved and the realization that PR processes are not simple plug-and-play DC replacements. This is illustrated by examples.

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Periodic Pulse Reverse (PPR) Electroplating

Periodic Pulse Reverse electroplating is the interruption and reversal of current in a bath, thus creating a periodic polarity change between the cathode and anode. This proceedure is used to influence the throwing power, distribution, roughness and other characteristics of the material during the plating process. This modified current is generally created by and delivered to the electroplating bath by the main power supply.

Successes within the PCB market

Periodic Pulse and Periodic Pulse Reverse electrochemical processes are not a new phenomena. These techniques have been in use for approximately 50 years. Pulse techniques were used in the mid 1980's, when gold prices were high and pulse deposition promised less material consumption. Later these promising technologies were revitalized in the early 90's, when an application that was never considered in the previous wave of enthusiasm was investigated. Copper deposition on high-end printed circuit boards (PCB's) was at the very limit of what DC processes could achieve, and it turned out PPR technology could go beyond that. All major process suppliers built business units around the PPR copper technology, thus shielding it from the rest of the electrochemical world and the General Metal Finishing marketplace.

Opportunities within the General Metal Finishing (GMF) market

Until around 2000, when the success of pulse reverse processes in the printed circuit board industry finally convinced many in research that electrochemistry as a whole could benefit from similar processing schemes. An understanding of the comparably diverse GMF marketplace was necessary. A direct technology transfer from the successes of PCB to GMF was extremely limited. This was mainly due to the various types of industries and applications that exist in the GMF industry. With this in mind, knowledge of the processes and various types of metal finishing applications (electroplating, electroforming, anodizing, electrochemical machining, & etc.) was required. The process, which includes chemistry, bath configuration and power, needed to be developed prior to implementation into the existing metal finishing marketplace. With this process understanding and development, metal finishers could realize the benefits of implementing PPR technology into their existing applications almost immediately.

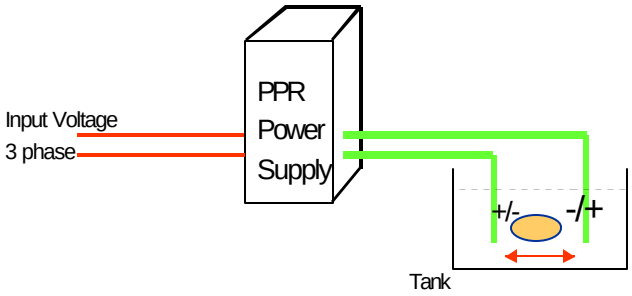

Fig1 average PPR current diagram

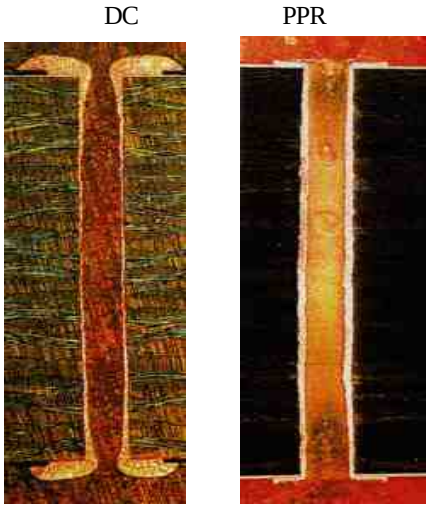

Fig2 comparison of DC to PPR with copper in a PCB application

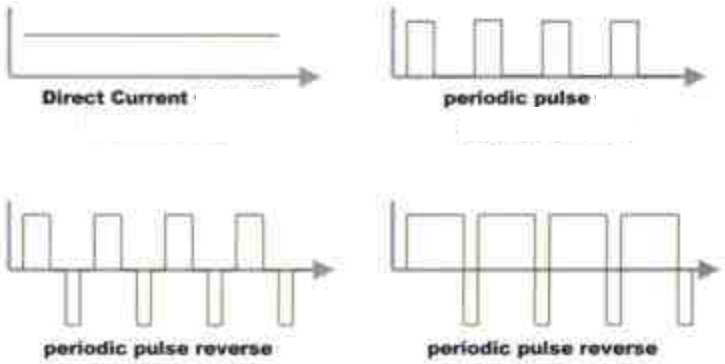

Fig3 types of waveforms compared

Successes within the GMF Market

As processes are developed, thus allowing for additional materials to become available with PPR, metal finishers can experience the benefits of a broad scope of opportunities. Today opportunities include applications with Copper, Nickel and Nickel electroforming, Silver, Gold, Zinc, etc.

Developing applications include micro electro mechanical systems, or MEMS for short. And not only electro deposition, but also electro chemical machining and anodizing processes are being developed.

Currently it is generally agreed upon that PPR technology is not just a component-wise plug-and-play replacement for DC technology. DC technology was developed during the better part of the last century. This process, over time has been improved and optimized to where it is today. PPR shouldn't be considered a competing technology to DC. It should be looked as an extension and a refinement to a process that is very strong and present in today's Metal Finishing industry.

Advantages of Periodic Pulse Reverse (PPR) Plating

-Improved throwing power

-Improved surface covering / deposit distribution

-Brightening

-Improved ductility / hardness

-Change of morphology, roughness (voids, porosity)

-Control over grain size

-Improved adherence to substrate

-Reduction of additives

PPR

DC

Figs4 comparison of PPR and DC in a nickel electroforming application

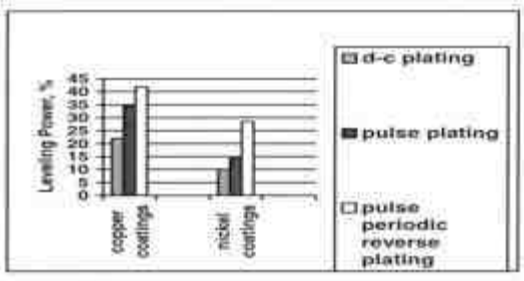

Figure 7 - The maximum values of leveling power of copper and nickel coatings obtained in three different plating regimes: d-c, pulse, and pulse periodic reverse plating

Fig5 PPR copper and nickel compared to DC

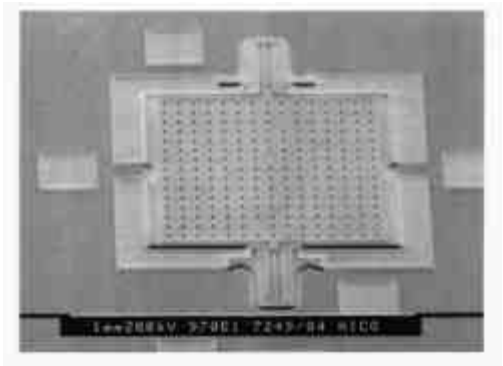

Fig6 MEMS nickel application example

Solutions to a successful PPR application include the optimization of the following:

- electrolyte composition
- additive package
- bath agitation
- cell (bath) design
- rectifier design
- pulse pattern

Pulse reverse plating leads to significantly improved surface distribution and throwing power

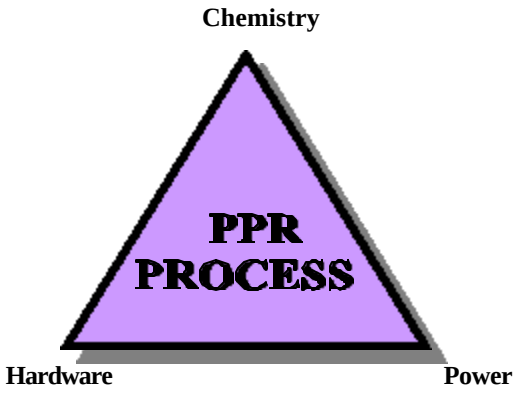

Fig7 essential elements of a complete PPR process