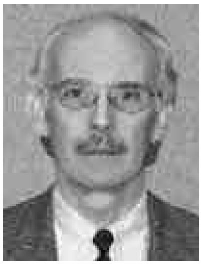


Eric W. Brooman, Ph.D.
Consultant
Materials & Processes Professional Services (M&PPS)
E-mail: eric.brooman@wpafb.af.mil

Emerging Surface Finishing Technologies and Synergy

Many of you may be asking "Why the need for another column?" The reasons are many, and I hope this somewhat regular column will provide an answer to this question, whether you are interested in (a) R&D for its own sake, or (b) process improvements, better product quality, greater productivity or (c) bigger profit margins, opportunities to diversify and perhaps grow your business. The simple answer, however, is that surface finishing technology is an important part of most fabrication and manufacturing operations, and developments in materials, equipment and processes are continuously being reported worldwide. It is becoming more and more difficult to keep track of such developments, let alone to look for synergy with existing technologies. In this regard, and to help provide some direction for the AESF Research Board for funding worthwhile projects, about five years ago the AESF Board of Directors approved the establishment of a new "Emerging Technologies Committee" (ETC). Its mandate is to (a) provide a forum for all those interested in identifying and promoting new and emerging technologies in surface finishing and related operations and (b) disseminate this and related knowledge about research, development and technology implementation. As a result, the Mission Statement reads "new markets and business opportunities may be identified and technology insertion facilitated and expedited."

In 2002 the ETC committee established a "Nanomaterials Subcommittee" to promote the study and development of nanostructured and nanocomposite materials and coatings. This subcommittee was so active and successful in meeting its Mission Statement that in 2004 it was made a stand-alone committee, now under the guidance of its Chairperson, Dr. Melissa Klingenberg.

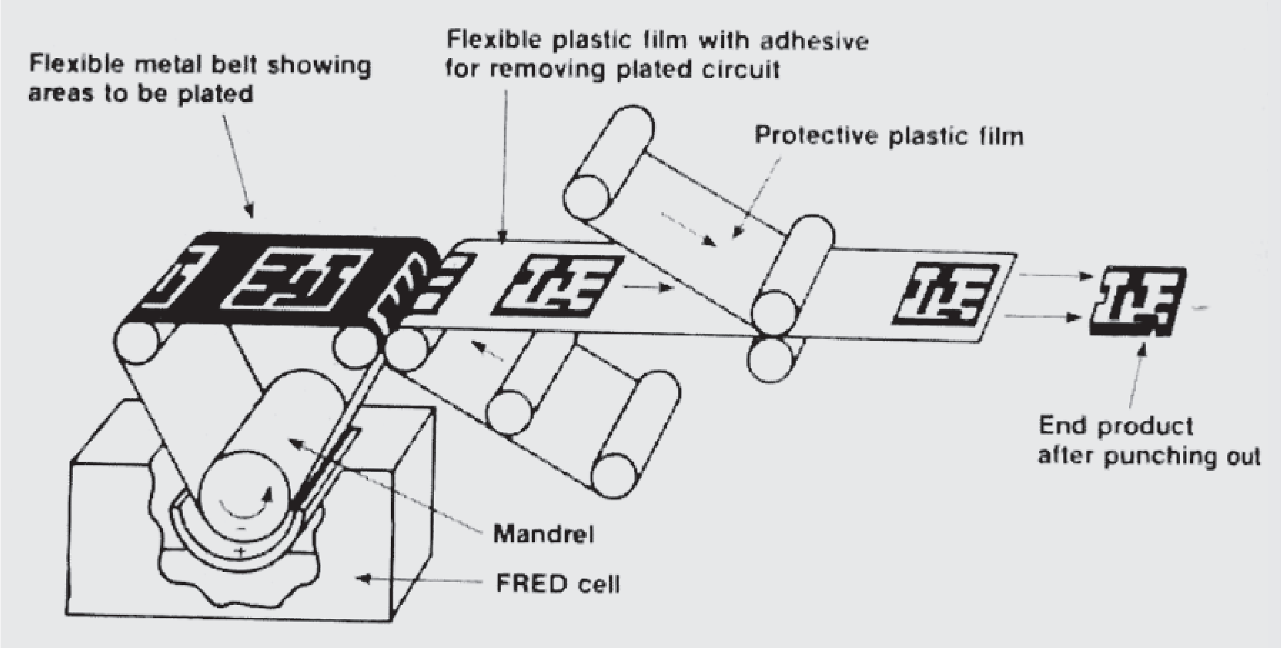
In 2003 a second subcommittee focused on "Electrochemical Metal Removal" was established to promote new technologies and applications associated with electrochemical machining, electropolishing, etching and deburring. This subcommittee held its first symposium in 2004, and more are planned.

Finally, in 2004 a third subcommittee was established by the ETC. Called the "Micro-Electro-Mechanical Systems Subcommittee", or "MEMS," it provides a focus on precision electroforming, finishing and coatings on a micro- (or even nano-) scale. Industries beginning to use these processes include those fabricating medical, electronic, semiconductor and electro-optic devices, precision instruments and audiovisual components.

Because of the important discussions and deliberations about the reorganization of the AESF, the Metal Finishing Suppliers Association and the National Association of Metal Finishers, and the need to decide on the new Meetings schedule, as well as the Board and Committee structure for the combined organizations, the Emerging Technologies Committee has been relatively inactive for the last year. As decisions are made, and details become finalized, the members look forward to increasing committee activities and identifying new developments in surface finishing technology that may be of interest. At the same time, this column will be used to communicate with you - the reader - what the ETC is doing, solicit new topics for evaluation, and share some thoughts on recent developments, along with some personal observations.

Of course, as a disclaimer, I must point out that we do not have the ability to cover everything that might be of interest, nor can we predict the probability that the emerging technologies discussed will be used and become "the next big thing!" A survey of current journals worldwide will show the breadth of developments being made in surface preparation and finishing, including organic coatings, inorganic and hybrid coatings, surface modification, post-treatments and the other processes that are used to provide aesthetic and other properties to meet in-service requirements, customer and consumer expectations. For example, new developments in pollution prevention and waste treatment also may be subjects discussed in this column because of the industry-wide shift to "lean and green" manufacturing, and the ever-increasing number of environmental, health and safety regulations that must be complied with. Other topics may be covered by invited contributors who are experts in a particular field, or have been successful in implementing an emerging technology in interesting ways.

Earlier, I mentioned synergy and how it could be used for diversification and new business opportunities. A couple of examples - some old, one relatively new - may be in order to help explain what I mean. About 30 years ago, the technology of high-speed or fast-rate plating and electroforming was being developed by several organizations, universities and companies. Using high-speed deposition techniques it was possible to deposit metals and alloys from about 1.0 mil/min (*e.g.*, chromium and some of its alloys) up to about 10 mil/min (*e.g.*, copper and its alloys). Now, the throwing power of a chromium plating bath is not very good, so it proved to be possible to stack many piston rings on a mandrel and deposit the required thickness of hard chromium for wear resistance in a very short time without fusing the rings together. This process was implemented by at least one supplier to the automotive industry. With respect to copper, it was found possible to electroform simple electrical circuits on a rotating mandrel (with permanent or reusable masks) partially immersed in the high-speed plating bath in seconds to very close tolerances. This led to the development of a new process for making flexible printed circuits for automotive lighting



fixtures, mobile telephones, cameras and other applications. Compared to the old process of electroforming copper foil, stamping out the circuit traces and laminating them between plastic films, the new process was much more efficient in the use of materials and energy. On a continuous basis, the mandrel was rotated through the bath to form the circuit, rinsed, air dried, then pulled from the mandrel with a semi-cured adhesive on a plastic film. The latter was then passed through heated nip rolls with a covering plastic film, and finally the flexible printed circuit was die-cut from the laminated sheet as a finished product. The synergy between the new high-speed electroforming process and developments in plastic films and adhesives made this process possible. The merging of these technologies and the design of the continuous production line and equipment was where the human creativity was critical in making the process a commercial success.

Later this technology was further developed to directly deposit copper circuit traces in an injection mold, followed by injection molding the required polymeric material to make a finished product, such as a small lighting fixture, mobile telephone housing or switch. Of course, the circuit was now embedded in, and flush with, the surface of the part. Because adhesion of the copper with the polymer no longer was a problem, a wide range of materials could be injection molded - even poly(tetrafluor oethylene)! Both of these new processes had a common hurdle to overcome at the time. Those skilled in electroplating had no experience with plastics or injection molding, and the converse was true. However, because of the simplicity of the processes and the relatively low investment required in additional capital equipment, several companies found it advantageous to use the technologies.

More recently, we have seen some synergy developing in the semiconductor industry. Not so long ago, this industry sector generally looked aghast at wet processes and focused its attention on dry, vacuum-based technologies to make the wafers and integrated circuits, believing that these processes were cleaner and easier to control at an micro- and atomic level. Now, with decreasing sizes of chip elements and the need for improved metallic interconnects between circuit layers, precision electrodeposition technology is being used to provide the required performance. The need for process control to ensure product quality and reduce reject rate is a very high priority, and involves bath composition control and maintenance. New bath analytical techniques are being developed to meet this need and provide results in real time, or at least very short times, for those bath components of interest, whether inorganic (*e.g.*, copper) or inorganic (*e.g.*, the numerous additives). For the relatively small bath volumes used (liters as opposed to tanks with dimensions in meters) a small build-up in a contaminant, or small depletion of an additive, could have an adverse effect on deposit quality and properties. Along with the need for bath control, more emphasis is being placed on using modeling to predict current distribution, to design fixtures, establish voltage/current settings and generally optimize the plating process. The need for many diverse skills is obvious for component design, modeling, bath formulation and control, power supplies, analytical methods, fixturing, software and hardware development, and so on.

Next time, we will talk more about the modeling of electrochemical processes and how it may be used more widely to shorten process development and optimization cycles, increase efficiency, reduce rejects and rework, design fixturing and reduce resource (labor, chemicals and other materials) and utility requirements. Some examples will be provided. ***P&SF***

Answers to I.Q. Quiz #423

1. The basis metal itself.
2. The plating stops.
3. They become ions in the solution.
4. The build up of substrate metal reaches a point where the bath must be dumped and replaced regularly.
5. Coverage is uniform, independent of part geometry.