The 35th William Blum Lecture
Presented at the 81st AESF Annual Convention (SUR-FIN 1994)
in Indianapolis, Indiana
June 20, 1992

Electrodeposition of Alloys

by
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Recipient of the 1993 William Blum
AESF Scientific Achievement Award

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Editor's Note: Originally published as *Plating and Surface Finishing,* 80 (9), 12 (1993) and 81 (5), 28 (1994), this article is a summary of the 35th William Blum Lecture, presented at the 81st AESF Annual Convention (SUR/FIN 1994) in Indianapolis, Indiana on June 20, 1994. A full paper was not made available, but material for the summary to follow was provided prior to the conference.

SUMMARY

Dr. David Lashmore is Electrodeposition Group Leader at the Institute for Materials Science and Engineering, National Institute of Standards and Technology (NIST), in Gaithersburg, Maryland.

"I have viewed and strived to apply electrodeposition as a valuable technology for the synthesis of new materials," said Lashmore. "In our group, we have found that electrodeposition can often accomplish what dry processing used to do, only faster, cleaner and under better control."

The lecture covered a summary of Dr. Lashmore's work on magnetoresistance of thin-layered structures, with emphasis on applications of electrochemically produced materials for magnetic read heads, and for other sensors.

Thin layered alloys research

Lashmore and others (M.P. Dariel, C.E. Beauchamp and C.E. Soltani) had an active program on the electrochemical deposition of very thin layered structures. The material has properties that deviate substantially from the average bulk properties of related materials and are difficult to produce on a large scale by alternative processing techniques.

The group took advantage of the low temperature of the plating process to produce materials that exhibit a higher degree of perfection (on the basis of x-ray diffraction and magnetic properties) than materials produced by MBE or sputtering. On the practical side, the multi-layered material is well suited for large scale commercial application, and the group is promoting commercial development through a cooperative research and development partner.

Continuous fiber composites

Another project at NIST took advantage of the capability of electroplated alloys to completely embed a continuous fiber so that when the fibers are bundled and pressed into a shape, each fiber is separated by the coating. This project succeeded in electrochemically producing various manganese, titanium and nickel aluminide intermetallics. In addition, the carbide forming capability of tungsten has been used to produce cobalt-tungsten alloys on graphite to provide effective diffusion barriers. The process can produce low resistivity (1 ohm/ foot) and high-strength gold-coated fibers for the superconducting super-collider grid. It can also be used to make copper-tungsten wire reinforced composites. Others involved in this research were G.R. Stafford, T. Moffat, N. Wheeler, C.E. Johnson, D.R. Kelley, and J.L. Mullen.

Trivalent chromium research

Lashmore and others (C.E. Johnson and E.C. Soltani) developed a new process to electroplate a functional "trivalent" chromium alloy (carbon, oxygen and hydrogen) with thickness exceeding 660 pm, and with both dry-sliding and lubricated-wear behavior equal or superior to hexavalent chromium. The research was a part of the Sandia waste minimization program sponsored by Dr. R. Stoltz. NIST then worked with another private company to commercialize the invention.

Dental materials research

In an unusual application of electrodeposition and electrochemistry to powder metallurgy, Lashmore and others (MP. Dariel, M. Ratzker, E. Escalante, J. Tesk, D.R. Kelley and C.E. Johnson) developed and patented a number of different technologies that include powder coating steps.

The coated powders consolidate to transform into a metallic composite at body temperature with a high volume fraction of intermetallic compound. The results are based on the fast diffusion properties of some metallic systems. As an example, if their size is small enough, tin particles immersion-coated with silver will transform completely into a mixture of Ag_4Sn and Ag_3Sn intermetallic compounds at body temperature, Lashmore noted. "We have also developed processes to consolidate, or cold weld these powders *in situ* inside the dental cavity to allow this type of intermetallic to be used instead of the normal amalgams. This process eliminates the presence of mercury in the dental material." The technology, developed in cooperation with the American Dental Association and the National Institute for Dental Research, is being commercialized through a private company.

Standard reference materials

Lashmore has also been involved in the continuous function to produce the NIST certified Standard Reference Materials (SRMs) for coating thickness, microhardness, dye penetrate crack standards, corrosion step test, lead-tin standards and a stage micrometer for the calibration of scanning electron microscope magnification. This program was initiated by W. Blum, A. Brenner and F. Ogburn and later was directed by E.C. Soltani who developed new SRMs for electrogalvanizing.

Times have changed

Although traditional research is continuing at NIST, funding shortages have limited the start of new research projects in recent years. Lashmore said some of the research, such as the AESF-sponsored programs on properties of copper and nickel, or on coating standards, have been valuable to the industry. But, funds to carry out such programs today are limited.

"Our function has changed in the sense that we have now to identify a problem, search out an appropriate funding source, and carry out a relatively short-term (six months to two years) research program to solve it."

In these applications, the importance of understanding how the electrochemical parameters influence the microstructures and, in turn, how the microstructures affect mechanical properties, were emphasized. In summary:

1. Electrodeposition can produce very high quality materials as thin as three monolayers and that these exhibit spin valve behavior;
2. The quality of these materials is comparable to, or better than, sputtered materials; and
3. That electrolytically coated powders may open a new role for electrodeposition in powder metallurgy, facilitating not only dental materials, but also a new route to synthesis of intermetallics.

About the author:

This material was written at the time Dr. Lashmore was announced as the recipient of the 1993 Scientific Achievement Award and in the promotional material for SUR/FIN 1994.

Dr. David Lashmore has been selected as the 1993 recipient of AESF Scientific Achievement Award. The announcement was made during SUR/FIN 1993 in Indianapolis in June. The Scientific Achievement Award is the Society's most prestigious honor.

Lashmore is the Electrodeposition Group Leader of the Institute for Materials Science and Engineering at the National Institute of Standards and Technology (NIST), Gaithersburg, MD. He holds the same position as two previous winners of the award, Dr. Fielding Ogburn and Dr. William Blum. Both are considered "greats" in the plating and surface finishing field. Lashmore holds the same position at NIST that was held by the late Dr. William Blum, the distinguished scientist for whom the lecture is named.

Lashmore started his career at NIST in 1977 as a research associate for the Aluminum Association. He moved to the Electrodeposition Group as leader in 1979 and continues to serve there. His accomplishments in materials science have been numerous since the Electrodeposition Group was reestablished at NIST under his direction.

A member of the Baltimore-Washington Branch, Lashmore has served on the AESF Research Board for a number of years. He has also been very active in the Electrochemical Society and served as president of the Electrodeposition Division in 1987-89.

Born in Hempstead, NY, Lashmore completed undergraduate work at the University of Florida. He received an M.S. in physics from Michigan Technological University and earned a Ph.D. in materials science from the University of Virginia.

Lashmore has received many honors during his career. Some of them are: The Electrochemical Society Blum Award in 1992; the Electrodeposition National Research Award from that organization in 1989; and the Bronze Medal from the Department of Commerce in 1986. He is also listed in *American Men and Women of Science* and *Who's Who in Technology Today*. Lashmore is the author of 52 archival publications and holds 16 patents.