**The 33rd William Blum Lecture**
**Presented at the 79th AESF Annual Convention (SUR/FIN 1992)**
**in Toronto, Ontario, Canada**
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# Electrochemical Technology in Electronics: Past Accomplishments and Future Challenges

**by**
**Dr. Lubomyr Romankiw**
**Recipient of the 1991 William Blum**
**AESF Scientific Achievement Award**

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Editor's Note: Originally published as *Plating and Surface Finishing,* 79 (5), 12 (1992), this article is re-publication of a summary of the 33rd William Blum Lecture, presented at the 79th AESF Annual Convention (SUR/FIN 1992) in Atlanta, Georgia on June 22, 1992. A full paper was not made available, but the summary to follow was provided prior to the conference.

## SUMMARY

Dr. Lubomyr Romankiw, AESF's 1991 Scientific Achievement Award Recipient, is manager of the Electrochemical Technology Department, Manufacturing Research, at IBM Corporation's T.J. Watson Research Center, Yorktown Heights, NY. The following is the extended abstract for his address:

Electrochemical technology has had a strong impact on development of the electronic industry. Were it not for electrochemical technology, components such as multi-layer PC boards, with recessed vias and through-holes, or contacts and connectors with curved surfaces, could not have been manufactured in the forms we know today.

The ability to selectively plate metal films through polymer masks made possible fabrication of thin-film heads; these permitted much higher disk and tape storage densities than originally anticipated. Disk aerial densities of 200 mb/in$^2$ are becoming commercial, while laboratory experiments with thin-film heads and thin-film disks have demonstrated that 1 and 2 Giga-bits per in$^2$ are possible.

Selective through-mask plating processes, developed for thin-film heads are now finding application in chip carriers, interconnect technology and on-chip, multilayer metallization. Metal deposited in the polymeric mold can replicate features down to nanometer dimensions with large height-to-width aspect ratios.
As device integration increases and individual components continue to get smaller, conductors must support progressively larger current densities. Electromigration, electrical, magnetic and mechanical properties strongly depend on grain size and deposit structure, which, in turn, depend on deposition conditions, and levels of impurities and/or alloying elements. Electronic applications require thorough understanding of the relationships between solution chemistry, process parameters, and the deposit's composition and structure.

The empirical approaches used in the past are no longer adequate; they must be replaced by techniques based on science and sound engineering practice.

To meet future six-sigma requirements for defect levels, uniformity of thickness and composition, and control of deposit structure, it is becoming essential to improve plating solution formulations, to increase understanding of processes, and to introduce specialized tools.

In this William Blum Memorial Lecture, a review of some of electrochemical technology's past accomplishments were covered, then the focus was placed on key challenges facing the industry to enable manufacturing of the highly integrated components anticipated for the year 2000.

About the author:

*This piece was written at the time Dr. Romankiw was announced as the recipient of the 1991 Scientific Achievement Award.*

Dr. Lubomyr Romankiw has been selected as the recipient of the Scientific Achievement Award for 1991. This award, AESF's highest honor, is given annually to recognize an individual who has made outstanding contributions that have raised the theory and practice of electroplating and the allied sciences, raised the quality of products or processes, and enhanced the dignity of the profession.

Dr. Romankiw is currently the manager of the Electrochemical Technology Department, Manufacturing Research, at IBM's T.J. Watson Research Center in Yorktown Heights, NY. He has been affiliated with the Center since 1962. Dr. Romankiw received his B.Sc. in chemical engineering from the University of Alberta in Edmonton, Alberta, Canada, and his M.Sc. and Ph.D. degrees in metallurgy from the Massachusetts Institute of Technology in Cambridge, MA.

Dr. Romankiw holds 37 patents and 108 published inventions. He has published more than 100 scientific papers and reports, as well as three book chapters. In addition, he has served as the lead editor for three major symposium proceedings volumes, published by the Electrochemical Society: *Electrodeposition Technology Theory and Practice* (ECS PV 18-17); *Electrochemical Technology in Electronics* (ECS PV-88); and *Magnetic Materials, Processes and Devices* (ECS PV-90).

His research has dealt with almost all aspects of plating and etching technology. Throughout the years, he has presented many invited papers on his work in the U.S., Canada, Japan, Switzerland, Germany, Italy, Korea, the USSR, Poland and the Ukraine. His lectures at universities in the U.S. and abroad, particularly on the subjects of electrochemistry and electrochemical technology in the electronics and electrochemical fabrication of thin-film heads for high-performance magnetic storage had a very strong influence in the industry.

Dr. Romankiw not only played a major role in developing processes, techniques, tools and demonstrated applications of electrochemical technology in the electronic industry, but has also heavily influenced the directions for electrochemical research in industry and academia. He has encouraged graduate students to pursue doctoral theses on the application of electrochemistry and electrochemical engineering as applied to the electronic industry. At the same time, he has urged faculty to place more emphasis on theory and modeling, to transform electrochemical technology from empiricism and art to a predictable science.

For several years now, Dr. Romankiw has conducted very successful summer and cooperative student programs, as well as a visiting faculty program in his department at IBM. He sponsored an IBM-university doctoral program in which the theses were performed at the T.J. Watson Research Center under joint IBM-university faculty supervision, and provided graduate student fellowships, IBM grants and post-doctoral fellowships to help sponsor research in electrochemistry as applied to electronics.

Dr. Romankiw's biggest concern in research has always been to find and give a scientifically sound explanation to observed phenomena and to relate plating, solution chemistry, electrode kinetics and processing parameters to structure and properties of the deposits. Through this perspective, he has made a substantial contribution in making plating technology a science. Over a period of nearly 28 years of research at the Watson Center, he has focused on a wide range of topics:

- Applications of electro- and electroless plating, chemical and electrochemical etching, and electrochemical engineering practices to process development, process control and equipment design for electronic device fabrication.
- He pioneered the application of high resolution through-mask pattern plating technology for the fabrication of thin-film recording heads, x-ray lithography masks, bubble memory devices, and thin-film multi-chip carriers.
- Permalloy and other magnetic alloy plating systems capable of producing films of extremely precise composition, structure and magnetic properties.
- A very precise and reliable method for measurement of pH on the surface of electrodes during electrolysis.
- Development of a paddle plating cell, which became the leading high-precision tool for magnetic head manufacturing.
- High-speed, laser-enhanced selective plating/etching and laser jet and jet plating and etching.
- Current distribution and modeling for through-hole plating on multilayer PC boards.
- Through-mask pattern plating of ultra-narrow conductors on Si chips.

Currently, Dr. Romankiw, along with his co-workers is pioneering the use of high-speed electrochemical micromachining of minute electronic components.

In addition to being a member of the AESF (Mid-Hudson Branch), Dr. Romankiw is a member of the Electrochemical Society (ECS), the International Society of Electrochemistry (ISE), the IEEE, the Shevchenko Scientific Society, the Ukrainian Engineers Society, Sigma Xi and Phi Lambda Upsilon. For several years, he held various positions on the Electrodeposition Division Executive Committee, including that of Division Chairman. He was also a member of the Board of Directors of the ECS.

Dr. Romankiw's work on the development of a thin film recording head process and other aspects of application of electrochemical technology in electronic device fabrication has earned him six IBM outstanding invention and outstanding contribution awards, and 21 IBM Invention Achievement Awards. In 1984, together with R.J. Von Gutfeld, Dr. Romankiw received the research award from ECS's Electrochemical Division. He was named an IBM Fellow in 1986, and an ECS Fellow in 1990.