Electrochemical Processing Trends in Micro/Nano Electronics*

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Phenomenal miniaturization and increased performance in microelectronics are a result of continuous developments in electronic materials, processing technologies, and unique integration schemes. Along with lithography and vacuum technologies, electrochemical processing played a decisive role in micro- and nano-scale processing. Compared to competing vacuum processing, electrochemical processing has emerged as more environmentally friendly and cost effective micro/nano fabrication method.

Electrochemical processing includes both electrolytic and electroless methods of metal deposition and dissolution, and depending on the application, the processing may involve deposition/dissolution of blanket layers or it may involve localized through-mask fabrication of micro- or nano- structures. Since the development of through-mask plating for thin film heads in the1960s and 1970s (1, 2), an enormous amount of industrial and academic R&D effort has positioned electrochemical processing among the most sophisticated processing technologies employed in the microelectronics industry today (3-8). Electrochemical processing has thus become an integral part of advanced wafer processing fabs for nano processing, and an enabling technology in many aspects of microelectronic packaging (8).

During the last decade, the use of micro and nano scale electrochemical processing for fabrication of cost performance flip-chip interconnects and Cu chip interconnects enabled a paradigm shift in chip making (6-8). As the advances in transistor technology continue to follow an exponential progress represented by Moore's law, electrochemical processing is expected to continue to enable further miniaturization of high-performance chip interconnects, packages, and printed circuit boards. While the fabrication of a 20 nm transistor has been demonstrated (9), interconnecting these transistors is one of the key challenges that the electrochemical processing will face in near future. Microelectronic packaging solutions using advanced materials for microprocessor scaling, thermal management systems, and improvements in package substrates continue to drive major R&D efforts, while market constraints continue to exert significant cost pressures. According to the microelectronic technology roadmap, today's interactive computing is forecast to be transformed to proactive computing in near future. These developments require continued nano-scaling and transition to novel devices. Indeed, real-time proactive computing efforts have started to happen now, advances in electrochemical nano processing will accelerate the process.

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