NEW APPLICATIONS

& RECENT RESEARCH

edited by
Prof. Demetrios Michalopoulos
California State University, Fullerton

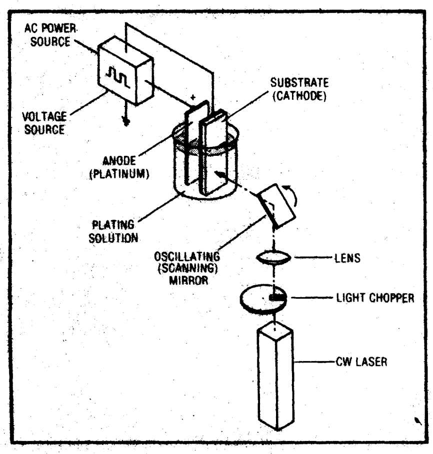
Laser technique plates down to four micrometers

IBM scientists have developed an experimental laser-enhanced electroplating technique that could eliminate the need for the overlaid masks currently employed in conventional IC fabrication.

With conventional electroplating, electrons supplied at the cathode under the influence of an applied electric field combine with positively charged metal ions in solution to form a metal layer, while metal is dissolved on the anode to supply the solution with fresh metallic ions. In IC fabrication, this process is combined with photographic and lithographic techniques to define metallic and nonmetallic structures.

With the new technique, a finely focused laser beam heats up a small surface area on which metallic material is to be deposited. The heating enhances deposition, allowing researchers to electroplate regions as small as 4 μm in diameter. Because of the fineness of the details that may be directly plated, the laser technique could supplant the use of masks in certain applications.

The IBM scientists who developed the technique—Robert J. von Gutfeld, Eugene E. Tynan, Robert L. Melcher, Samuel E. Blum, and Lubomyr Romankiw—have evolved a conceptual model for the laser-enhanced plating effect. They believe that it stems from sharply defined thermal gradients—sharp changes in temperature over distance—produced by the highly focused beam of laser light. Although the absolute change in temperature is not great (roughly 50 degrees centigrade for an incident 500 mW beam 300 μm in diameter), it occurs over such a small distance as to produce intense convective effects.



IBM's laser-enhanced electroplating system—A finely focused laser beam heats up a small surface area on which metallic material is to be deposited and enhances deposition at that region. A conceptual model for the phenomenon suggests that sharply defined thermal gradients—sharp changes in temperature over distance—produce intense convection effects promoting the inflow of new, ion-rich solution to replace the ion-depleted solution next to the cathode.

This convection is believed to act much as it does over a household radiator: the heated air above the radiator rises, drawing in unheated air to promote circulation throughout the room.

In the usual electroplating process, the scientists think, the layer of solution next to the cathode rapidly becomes depleted of metal ions as the ions are deposited, thus limiting the rate of deposition. In the new process, according to the model, laser-induced convection causes this layer to move from the cathode, thus promoting the inflow of new, ion-rich solution.

The researchers have also demonstrated that the process can be reversed to produce electro-*etching*. Here, the material on the substrate becomes positively charged and the convection currents induced by the focused laser light promote a differential migration of material away from the area exposed to the laser beam.

Technical background. Cathodes used in the experiments were of tungsten, molybdenum, or nickel, in layers approximately 1/10 μm thick, predeposited on glass substrates. Anodes can be of platinum and be chemically inactive in the plating process, or they can be of the metal being deposited.

Continuous-wave argon (1.5W output power) or krypton (about 1/10W) lasers were employed, with a mechanical light-chopper supplying millisecond optical pulses when desired.

A 1.5V plating voltage was used in solutions of dissolved salts of gold, nickel, or copper to provide ions.

The focused laser beam can be applied to the cathode either through the transparent substrate or through the plating solution itself. In the latter case, however, there are various constraints on the laser used, since different solutions have different optical absorptions. The argon laser is particularly appropriate for nickel and copper plating solutions, while the krypton is suitable for gold.

Results. One example of the enhancement furnished by the technique showed roughly 600 to 1000 times more nickel deposited on laser-irradiated areas of tungsten (at an incident optical power of about 5000 W/cm^2) than on nonirradiated areas. In etching stainless steel, the etching rate for the irradiated region was as much as 10,000 times greater than for the nonirradiated region.