Improved dielectric developed for chip-level copper circuitry

March 29 2005

A new dielectric material, developed by researchers at the University of Illinois at Urbana-Champaign, could facilitate the use of copper circuitry at the chip level. The thermally stable aromatic polymer has a low dielectric constant of 1.85, good mechanical properties and excellent adhesion.

Replacing aluminum with copper as the multilayer interconnect structure in microelectronic devices could enhance both miniaturization and performance. Copper offers much higher electrical and thermal conductivity than aluminum. Placing narrow copper lines close together, however, requires a good dielectric to reduce cross talk between wires. Unfortunately, existing dielectric insulators can't withstand the rigors of the aggressive chemical-mechanical polishing step used to produce a smooth copper surface.

"We developed an aromatic thermosetting polymer for use as an insulating material in copper chip technology," said James Economy, a professor of materials science and engineering at Illinois. "The material has a high thermal stability, low moisture pick-up and can withstand chemical-mechanical polishing."

The material that Economy and former graduate student Youngqing Huang (now at DuPont) started with had a dielectric constant of 2.7. By adding porogens – materials that leave tiny holes when they evaporate – the researchers lowered the dielectric constant to 1.85, while maintaining an acceptably high level of hardness and stiffness.

“The pores are closed and about 5 nanometers in size,” Economy said. “They are formed when heat is applied to low molecular weight porogens dispersed through the film. The porogens break down into small gas molecules that can diffuse through the polymer structure. The resulting microporosity does not significantly reduce the mechanical integrity of the foamed material.”

The new dielectric can withstand temperatures up to 400 degrees Celsius, is easily applied in solution phase to form a submicron thin film, and adheres to substrates better than other candidate materials.

“We feel we have identified the critical problems confronting the development of a dielectric material to facilitate the use of copper chip interconnections,” Economy said, “and we have solved every one of them.”

Huang will describe the new material at the spring meeting of the Materials Research Society, to be held in San Francisco, March 28 through April 1. The researchers have applied for a patent.

Source: University of Illinois at Urbana-Champaign