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High-Temperature Superconducting Multi-chip Modules

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Operation of semiconductor devices at liquid nitrogen temperatures continues to be investigated as computer manufacturers try to increase the speed of their devices. Multichip modules (MCMs) use more compact unpackaged chips spaced closely together, thus allowing a much higher areal density of function than printed circuit boards. However, a potential limitation on increases in functional density is that imposed by the resistivity of the interconnects. For applications using complementary-metal-oxide-semiconductor (CMOS) or GaAs circuits whose performance can be enhanced by cooling to liquid nitrogen temperatures, one option is the use of high-T_c superconducting materials for the MCM interconnects. As high-T_c materials such as $YBa_2Cu_3O_{7-\delta}$ remain superconducting at 77K carrying currents up to typically 1-5 x 10^6 A/cm^2 (10-50 mA/μm^2), present HTS materials have the potential to allow the operation of MCM line widths down to 1-2μm and 3-6μm pitches. Such small linewidths would enable a reduction of the number of interconnect layers needed in the MCM, which might increase the ease of manufacturing an MCM for a given level of functionality. While it remains to be seen if superconducting MCMs are an economical atlernative to cooled copper MCMs for cryoelectronic applications, much technical progress has been made. The present status of epitaxial multilayer MCMs made using $YBa_2Cu_3O_{7-\delta}$ will be discussed.