ELECTRONIC PACKAGING

Materials and Their Properties

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CRC Press
Boca Raton London New York Washington, D.C.

Table 24. High density substrates and selected attributes (Blood and Casey 1991)

Substrate*	MCM-L	MCM-C	MCM-D	MCM-D/C	MCM-Si
Description	laminated high density PCB	cofired ceramic	deposited organic thin film on Si, ceramic or metal	deposited thin film on cofired ceramic	SiO_2 dielectric with Si substrate
Maturity	good	very good	limited	limited	limited
Cost	medium	medium	high	high	medium
Number of metal layers	>15	>50	5	>50	5
Minimum metal pitch(μ m)	100–150	250–450	25–75	50–75	25
Substrate I/O	array	array	peripheral	array	peripheral
Heat transfer	fair	poor	good	poor	good
Dielectric constant	3.0–3.5	9.7	<3.0	<3.0	3.5

* MCM - Multi Chip Module; L - Laminate; C - Ceramic; D - Deposit; SiO_2 - Silicon dioxide

These substrates can be easily designed as a hermetic package using a built-in seal ring around the periphery. MCM-Cs using high-temperature cofired ceramic are characterized by high line resistance due to the low conductivity of tungsten. MCM-C works well for high-I/O, medium-performance modules such as 50MHz to 100MHz processor clocks. MCM-Cs with glass-ceramic dielectric materials fabricated with LTCC technology have low dielectric constants, low coefficients of thermal expansion (CTEs), and compatibility with low-resistivity conductor materials at low firing temperatures. Cost effectiveness remains questionable because the conductor screen printing process limits the achievable interconnect density.

MCM-D consists of a substrate deposited with thin film on silicon, ceramic, or metal. MCM-D substrates are used in applications that require high electrical performance and high interconnection densities with a minimum number of substrate layers. The thin-film processing is accomplished on a rigid base material, usually silicon, alumina, or metal. Commonly used thin-film materials in MCM-D include lower-conductivity aluminum and organic dielectric materials because the processing is easy and reliable. Copper is used sometimes for its better conductivity. However, there is a reliability problem when uncured polyimide comes into contact with copper. The problem can be eliminated by adding barrier metals such as chromium or nickel.

MCM-Si substrates use a silicon wafer, with a deposited thin-film of silicon dioxide as the dielectric, and aluminum or copper as the conductive materials. Small geometries, improved reliability (over organic dielectrics), the ability to incorporate decoupling capacitance (up to 42nF/cm sq) in the substrate, and high thermal conductivity of the substrate are the major

advantages. Additionally, the coefficient of thermal expansion match of a silicon substrate to silicon chips is a great advantage.

MCM-D/C, with deposited thin film on cofired ceramic technology, is currently being produced only in Japan. It offers the best of ceramic and thin-film technologies and is an ideal choice for all types of modules. High cost is perhaps its only disadvantage.