MCM & Hybrid Packaging

Use this section to support the design and selection of MCMs and Hybrids.

Hybrid Packaging

Hybrid designs have encompassed a variety of packaging techniques, e.g., cordwood, stacked flat packs, compartmentalized modules, multi stacked substrates, stick modules, and folded modules (flex circuits). The mixture of dice and discretes are mounted on a substrate PCB contained in a protective case, that might be hermetic sealed, potted (filled), or plastic encapsulated. These have specific advantages and disadvantages over conventional devices. Generally, all have circuit uniqueness, with size reduction as primary assets. Disadvantages are high fabrication costs, test and repair difficulty, and difficulty in achieving cost-effective sparing. Component obsolescence is also a problem, as Hybrids are usually custom designs of relatively low volume, often containing discontinued product. Further, reliability uncertainty can be a concern as internally packaged devices may be an unknown or nonstandard product.

The two basic packaging classifications for Hybrids are planar array (two-dimensional) and stacked array (three-dimensional). There were many other hybrid packaging designs too numerous to cover but all had a common design objective of saving space. Early planar arrays were usually contained in hermetically sealed TO cans and flat-packs. Stacked arrays usually consisted of cordwood or compartmentalized construction. Military and NASA products were predominately hermetically sealed; however, stacked arrays of commercial design were often plastic encapsulated. Because of vastly improved encapsulating material compounds and cost considerations, modern hybrid packages for military applications may be either hermetic or encapsulated.

MCM Packaging

The two major categories of MCM packages are hermetically sealed and encapsulated. Early designs were simply the packaging of multiple chips in a standard TO can or flat-pack, interconnected by standard bond wires. Today there are a variety of package designs within each category. However, the following paragraphs discuss the most common designs, most of which are considerably larger, with many more pinouts than the standard TO cans and flat packs used in the past. The elimination of one tier of bond wires from the die to I/O terminals represents a probable and significant increase in reliability, as bond wires have always been a major source of failures. Modern MCM packaging requires interconnecting circuitry be precisely laid out and controlled as it contributes to both circuit function and performance. The interconnecting circuitry, through the deposition technique, provides controllable parameters directly affecting DC resistance, capacitance, inductance, and minimizing the problems of crosstalk, propagation time, and impedance mismatch. The interconnects, by being an integral part of the circuit design, contribute to the ability of the circuit to function at faster propagation times and at higher frequencies. The following examples explain MCM and hybrid device packaging characteristics:

a. Hermetically sealed, all ceramic. The traditional designs consist of a ceramic substrate, which is fired to a glass frit and is gold plated. The opposite side of the substrate has a metallized ring, which is soft soldered to a ceramic cover, which also has a metallized area matching the substrate ring. The soft solder operation results in a hermetically sealed, all ceramic package. The I/O terminals are usually fired-on molymanganese and are gold plated for good conductivity.

b. Hermetically sealed, metal package. Similar to the all ceramic package design, except the lid is metal and soft soldered to the gold plated molymanganese edge of the substrate, producing an all-metal-to-glass hermetic seal.

c. Encapsulated package. Essentially uses the same fabrication techniques and design criteria for the die and substrate as hermetic designs. However, the protective enclosure is accomplished by encapsulating the internal elements with a thermosetting epoxy, containing fillers and additives to enhance its thermal conductivity, match its TCE to the die and substrate, and provide an effective barrier to moisture ingression. When required, a heat spreader or heat sink material (Cu, BeO, Al, AlN, etc.) may be used as an integral part of package design. A heat spreader would normally be internally attached directly to affected die, while the heat sink would normally be attached to the entire substrate on one side with its opposite side exposed. In addition, die passivation, e.g., Si_3N_4 or SiC, can be implemented in non-hermetic packaging to increase resistance to moisture ingression (atmospheric contamination) and chemical intrusions from any adjacent materials.

Adverse Effects of Packaging

Normally the Hybrid and MCM packages have an inherent space saving advantage, however, there are some potentially adverse effects of high-density packaging:

a. Tight/close physical proximity reduces isolation reduction, resulting in cross-talk/inter-circuit interference; repair is difficult.

b. Concentrated areas of power dissipation makes cooling more difficult, effecting reliability and performance.

c. Buried/embedded elements limit test points and inspection.

d. High potential circuits make insulating more difficult, corona, arcing, high impedance leakage, etc.

e. Dissimilar adjacent materials/metals reduce reliability under temperature extremes (TCE problems) and increases corrosion possibilities.

f. A unique style may provide an ideal configuration for a specific application, but it can adversely effect availability and cost, especially for future buys.

Unwanted signals, electrostatic, electromagnetic or cosmic/nuclear radiation can adversely affect the performance and reliability of the Hybrid or MCM In the case of tantalum capacitors, they can present a health hazard as tantalum is activated by thermal-neutron bombardment (tantalum has a half life of 111 days). Generally commercial components are more susceptible to radiated noise, transients, and ground loops when used in environments containing radiating elements. Effective preventative techniques are:

a. Circuit designed for maximum desired signal with minimum spurious signals.

b. Elements selected that do not radiate unwanted signals and are minimally affected by radiated signals.

c. Proximity and layout of elements to minimize coupling of unwanted signals.

d. Grounding practices that minimize radiated signals and ground currents.

e. Shielding materials, as required to avert unwanted signals, when above methods are unattainable or ineffective.

Electrostatic radiation is most likely to be the concern in modern microelectronic designs and is primarily high frequency (RF) interference from transmitters, local oscillators, high voltage apparatus, and fast switching devices. Excessive noise in ground planes can also be a problem. The design should avoid close proximity to these sources and provide signal levels well above ground noise. The use of highly conducive material as a screen or solid shield may be in order. Even small openings and unsealed joints may require additional shielding in the form of mesh or conductive gaskets.

Typically, electromagnetic radiation is not a concern in modern microelectronic designs except in some special circuits and very high current applications.

Electromagnetic radiation is most common with low frequency apparatus and can be shielded effectively only by high permeability materials, by significant separation of the component from the radiating source(s), and avoidance of ground loop (high current applications). Aluminum, however, may be an effective electromagnetic shield in a high frequency application.

Applications in space, at very high altitudes or near any nuclear apparatus may require radiation tolerant (RAD-HARD) circuit designs, or an appropriate shielding technique against high-energy protons, electrons, neutrons and gamma radiation. This radiation can be hazardous to electronic components, materials, and a health concern (secondary radiation effects from activated tantalum). Dense materials (lead and depleted uranium) and very thick layers of other materials are also effective shields. Commercial devices can be more susceptible to this type of radiation than military devices. Electronic components can be designed to be radiation tolerant (RAD-HARD); however, being produced for the cost-conscious, highly competitive commercial market, this feature is not a normal consideration in routine product design.

Reliability

When passive structures are used in microwave device applications there are specific reliability and application issues to consider concerning microwave device packaging. Transmission lines, vias, airbridges and thin-film resistors are considered a part of overall MMIC device design and must be able to meet all reliability and performance requirements, from a packaging standpoint, that the MMIC device itself is required to meet. Specific packaging issues for microwave components are discussed in the Microcircuits section.