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DATA SHEET

Beryllium Metal for High Performance Electronic Packaging Applications

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ABSTRACT

This paper presents the significance of hot cross-rolled beryllium sheet. The combined properties of beryllium provide the electronic design engineer with the solution to thermal management challenges in a multitude of high reliability electronics applications including:

- Constraining metal core printed circuit boards employing Surface Mounting Technology/Leadless Ceramic Chip Carriers (LCCC)
- Constraining substrates or heat sinks platform in distributed printed circuit board assemblies, employing SMT/LCCC's;
- Frames for modules and packages
- Substrates for hybrid circuits and power devices

Beryllium can satisfy the demands of modern high density packaging of integrated circuits and electronic devices. Beryllium metal supplies a moderating coefficient of thermal expansion (CTE), high thermal conductivity, low density and high stiffness.

METALLIC BERYLLIUM CORE BOARDS FOR HIGH PERFORMANCE ELECTRONICS

Beryllium is used in alloys for electronic applications due to combined attributes or electrical conductivity, thermal conductivity, high strength, fatigue and corrosion resistance, & formability. Beryllia ceramic is also an attractive choice for design engineers. Beryllia has the dielectric properties inherent in an oxide, yet possesses a thermal conductivity which exceeds many metals. Since 1982, hot cross-rolled beryllium sheet has been employed in a military aerospace constraining core Printed Circuit Board (PCB). Beryllium metal's excellent thermal conductivity, low density, high specific stiffness, and moderate CTE is a desirable thermal mounting plate material for PCB's integrating LCCC's. In this application, PCB's are adhesively bonded to one or both sides of a beryllium core. Beryllium offers a thermal mounting platform uniquely different from competitive metal constraining core materials: it is 5 times lighter per unit volume. Weight penalties in air and spaceborne electronic systems can be avoided with beryllium.

Beryllium has four key properties which qualify the metal for constraining core board applications. A few of these attributes are:

- a moderate CTE
- high thermal conductivity
- low density
- high modulus of elasticity

Other factors of possible utility include high specific heat, and a very low interaction with magnetic fields.

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Thermal Coefficient of Expansion (CTE)

To increase speed in electronic packages, component spacing has shrunk and LCCC's soldered to PCB's have been developed. Alleviating mechanical stressing at the solder joints caused by CTE mismatch between the alumina leadless chip carriers, with CTE's from 5-7ppm°C, and polyimide/glass substrates of 20ppm°C(x,y), is of prime importance. Beryllium acts as a CTE moderator in this application.

Figure 1 displays CTE of selected electronic materials.

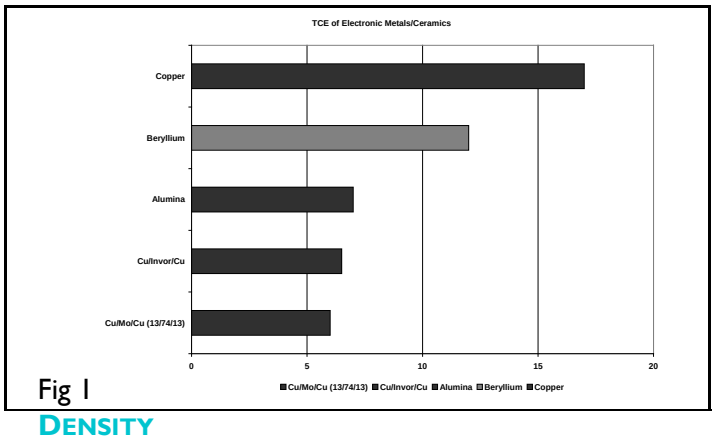

Fig 1

Thermal Conductivity

Heat dissipation capabilities of the substrate is equally as important as CTE. Very High Speed Integrated Circuit (VHSIC) applications, and Gams chips generate more heat per cubic inch than previous packaging technologies. The thermal conductivity of beryllium is comparable to that of Cu/Mo/Cu, and slightly better than Cu/Invar/Cu, which ranges from 2.0 to 3.4. A comparison of the thermal conductivity of beryllium and other constraining core metals is shown in Figure 2.

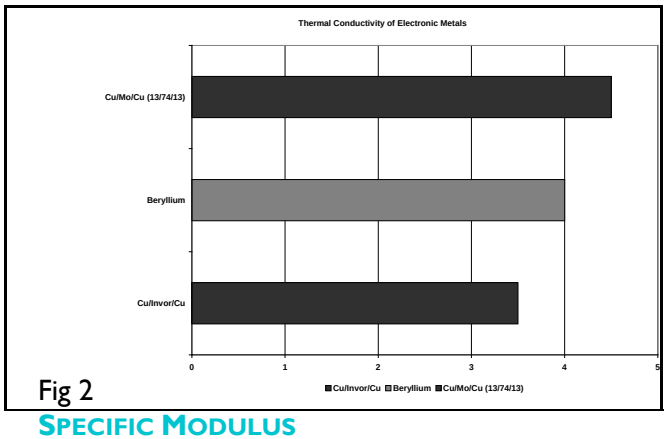

Fig 2

Density

Air- and spaceborne electronic applications are weight-sensitive. A rule of thumb is 1 lb. saved in electronics is equal to 7 lbs. of increased fuel or payload. New platforms are required to fly faster and farther and, therefore, must be lighter. Small size and light weight are the driving forces behind military/aerospace requirements. Beryllium's density is unequalled, as noted in figure 3 below.

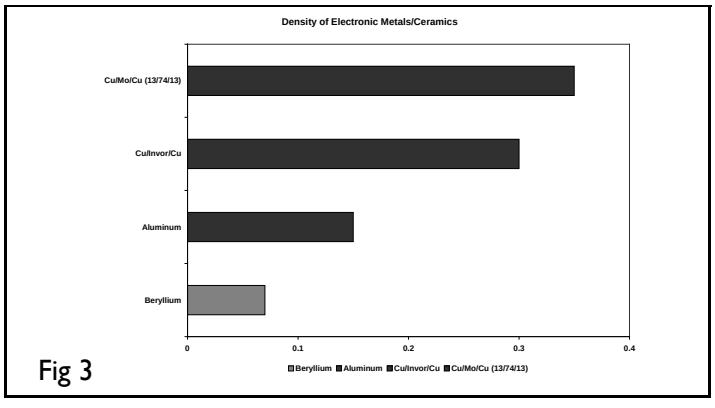

Fig 3

Specific Modulus

Although CTE, thermal conductivity and light weight are most important, stiffness, flatness and dimensional stability of the metal core or substrate material is nearly as important as the first three requirements. Vibration, shock and flexure resistance are paramount in order to keep the chip carriers on the PCB. Figure 4 illustrates the superior specific modulus of beryllium compared to Cu/Mo/Cu and Cu/Invar/Cu.

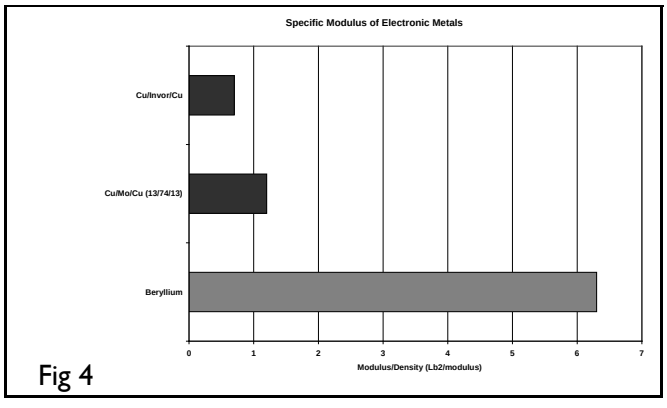

Fig 4

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Specific Heat

The ability of a material to absorb heat on a comparable weight comparison basis, is important in airborne electronics. The specific heat of beryllium (826 w,s/lb°C) is four times that of Cu/Invar/Cu and six times that of Cu/Mo/Cu.

Magnetic Susceptibility

The magnetic susceptibility of the metallic core material may be relevant to device design. Beryllium has a very low magnetic susceptibility level of: $-9x10^{-6}$ cgs.

Machinability

Generally, beryllium is easily machined to intricate forms maintaining excellent surfaces, close tolerances and dimensional stability by conventional machining, CNC machining & wire EDM. Machining practices for beryllium parallel those of cast iron.

Drilling

The key to successful drilling of wrought products involves control of feed rate and selection of drill points which minimize tool pressure. The use of CNC drilling is recommended. This drill utilizes an automatic torque-sensing device which varies the speed and feed in order to maintain the cutting force within the safe limits for both the drill and beryllium.

Sheet Cutting

An abrasive sawing technique is used with a resin-bonded, semi-friable aluminum oxide wheel rotating to give a surface speed at 7000 to 9000 fpm. A wheel with an abrasive gain size at 80 grit and "L" bond grade is recommended.

Conclusion

Military/aerospace electronic design engineers require fast solutions to their thermal management problems. Beryllium's light weight, CTE, thermal conductivity and stiffness make this metal the ideal candidate to handle future airborne and other application heat removal and CTE mismatch challenges.

References

1.Michael L. McLaren, "Beryllium Utilization in Spaceborne Microelectronic Equipment," General Electric Aircraft Electronics Division (AED). Utica, New York; July 15, 1987.

NOTE: Handling beryllium in solid form poses no special health risk. Like many industrial materials, beryllium-containing materials may pose a health risk if recommended safe handling practices are not followed. Inhalation of airborne beryllium may cause a serious lung disorder in susceptible individuals. The Occupational Safety and Health Administration (OSHA) have set mandatory limits on occupational respiratory exposures. Read and follow the guidance in the Material Safety Data Sheet (MSDS) before working with this material. For additional information on safe handling practices or technical data on Aluminum Beryllium, contact Materion Beryllium & Composites.

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