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Microcircuit Thermal Considerations

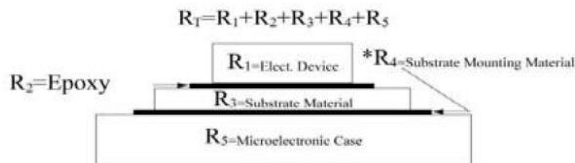
Microelectronic circuits, irrespective of type, are made of dissimilar materials that expand, contract, and transfer heat at different rates. This movement of materials is dependent on the heating and cooling of the circuit.

It is therefore necessary to consider the CTE (coefficient of thermal expansion) of these different materials prior to the design of any microelectronic package. Additionally, it is important to know what the thermal conductivity expressed in W/mK (watts per meter Kelvin) at room temperature (25°C).

The chart to the right is a handy reference for materials commonly used for packages, substrates and organic substrate/semiconductor die attachment materials.

Total thermal resistance of a package.

The total thermal resistance is calculated by summing the thermal resistance of each material in the thermal path between the device and the microelectronic case.



The thermal resistance of a particular material is calculated as: $R = t / KA$

Where R=thermal resistance of a particular material layer (degrees C/W)

t =Thickness of the material

K=Thermal conductivity of the material in: W/(°C-in)

A=Cross-sectional area of the material (in²)

CTE, W/mK of common materials used for microelectronic packages:		
Metals		
Material	CTE 10⁻⁶/@25°C	W/mK @25°C
Kovar (FeNiCo)	5.5	17
Copper	17	400
Molybdenum	5.2	139
Nickel	14	90
Semiconductors		
Silicon	2.8	145
Gallium Arsenide (GaAs)	5.7	33
Germanium	5.8	60
Ceramic Substrates		
Alumina	6.7	24
Beryllia	8.0	298
Aluminum Nitride	4.5	160
Silica	0.8	2
Organic Material Substrates		
FR4 (epoxy-glass)	16	0.1
Polyimide	30-60	0.1-0.2
Organic Materials (Die/Substrate Attach)		
Epoxy (Nonconductive)	125	0.8-0.9
Epoxy (Conductive)	125	1.4-4.0
Silicon (RTV)	250-800	0.02-0.07

About NATEL

NATEL is a major independent manufacturer of a wide variety of electronic products, providing low to high volume production for its customers. As one of the largest and oldest privately held EMS company in the U.S., NATEL is known for high-reliability, high-quality manufacturing that delivers solutions to customers in medical, defense, transportation and industrial fields. Through a recent acquisition of EPIC Technologies, NATEL is favorably positioned among mid-tier EMS manufacturers to “make amazing things happen.” NATEL holds and maintains industry specific certifications that include ISO/TS 16949, ISO 13485, and AS9100. Its MIL-PRF-38534 Class H and K certifications certify NATEL’s expertise in designing and manufacturing microelectronic assemblies for space and mission-critical defense programs placing it in an elite group of aerospace industry manufacturers. NATEL, headquartered in Chatsworth, CA, has manufacturing locations in California, Nevada, Ohio, and internationally in Mexico. To learn more, visit www.NatelEMS.com or on Twitter @NATEL.