Microcircuit Circuit 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 the thermal conductivity expressed in W/mK (watts per mil kelvin) at room temperature or 25°C.

The following charts are handy references for materials commonly used for packages, substrates and organic substrate/semiconductor die attachment materials.

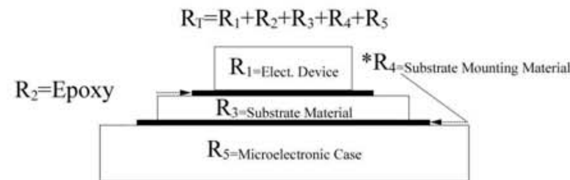
CTE, W/mK of common materials used for microelectronic packages.

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
Ceramics (substrates)		
Alumina	6.7	24
Beryllia	8.0	298
Aluminum Nitride	4.5	160
Silica	0.8	2
Organic Material (substrates)		
FR-4 (epoxy-glass)	16	0.1
Polyimide	30-60	0.1-0.2

Organic Materials (die/substrate attach)		
MATERIAL	**CTE** 10^{-6}/@ 25°C	**W/mK** @ 25°C
Epoxy (non-Cond)	125	0.8-0.9
Epoxy (Conductive)	125	1.4-4.0
Silicon (RTV)	250-800	0.02-0.07

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 devise 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 conductivitiy of the material in: W/(°C-in)

A=Cross-sectional area of the material (in^2)

Typical materials T/C in W/°C/Inches					
Silicon	2.3	**Alumina**	0.69	**Epoxy Nc**	0.01
Kovar	0.36	**Beryllia**	5.5	**AuSi**	5.7
Moly.	3.9	**Epoxy Cd**	0.04	**AuSn**	4.5

"Your Job"
Innovation and Marketing

"Our Job"
Quality Manufacturing
Quick Turnaround
Low Cost

With over 25 years of microelectronics experience, Natel understands and has participated in most of the dramatic changes that have taken place in the manufacturing of products for the Defense, Medical, Opto-electronic and RF/Microwave industries, meeting the need for lower cost, high quality components produced by innovative techniques.

With automatic and, in most cases, hands-free assembly capabilities for modules, hybrids, MCM and chip-on-board, Natel has pioneered the precision capabilities necessary for 10G-40G high frequency products -- products such as DWDM, clock drivers, transmitters/receivers and limiting amplifiers.

This level of automation has allowed Natel to address the market's need for cost, performance and size with increased levels of reliability never before possible. Due to our quick response, we are able to shorten "time-to-market" for your prototype as well as "time-to-volume" for your production needs. We realize how critical it is to your success.

Natel stands ready as your Manufacturing Partner!

Hydrogen Reflow Furnace

To be placed on our mailing list to receive other issues of "Quick Reference Design Guide" simply call, fax or e-mail.

NATEL

ISO 9001 *Your Source for* **MCM - COB - HYBRID** MIL-PRF-38534

www.natelengr.com
dguide@natelengr.com
9340 OWENSMOUTH AVE., CHATSWORTH, CA 91311
FAX: (818) 734-6530 TEL: (818) 734-6500

How can we help?

So that we can tailor an information package specific to your needs, please answer the following questions and **fax this page to Natel at 1-800-590-5764.**
For urgent need please call 1-800-590-5774.

What stage is your microcircuit module in?

- ☐ Initial design
- ☐ Prototype
- ☐ Product redesign
- ☐ Production

Would you consider packaging assistance?

- ☐ Essential
- ☐ Nice but not required
- ☐ No thank you

What type of module are you considering?

- ☐ Hybrid
- ☐ MCM
- ☐ Chip on board
- ☐ Flipchip/BGA
- ☐ Other ______________________________

What type of package are you considering?

- ☐ Hermetic
- ☐ Non hermetic
- ☐ Metal
- ☐ Other ______________________________

Comments:

____

____

____

____

____

YOUR
Name: ________________________________
Phone: _______________________________
email: ________________________________

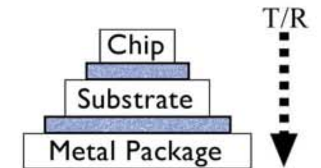
Please make necessary changes on the address label.

NATEL Engineering Co., Inc.

NATEL Engineering Co., Inc.
9340 Owensmouth Ave.
Chatsworth, CA 91311

Design Guide #5

Quick Reference Design Guide



Thermal Management

NATEL Engineering Co., Inc.
9340 OWENSMOUTH AVE., CHATSWORTH, CA 91311
FAX: (818) 734-6530 TEL: (818) 734-6500
www.natelengr.com
dguide@natelengr.com