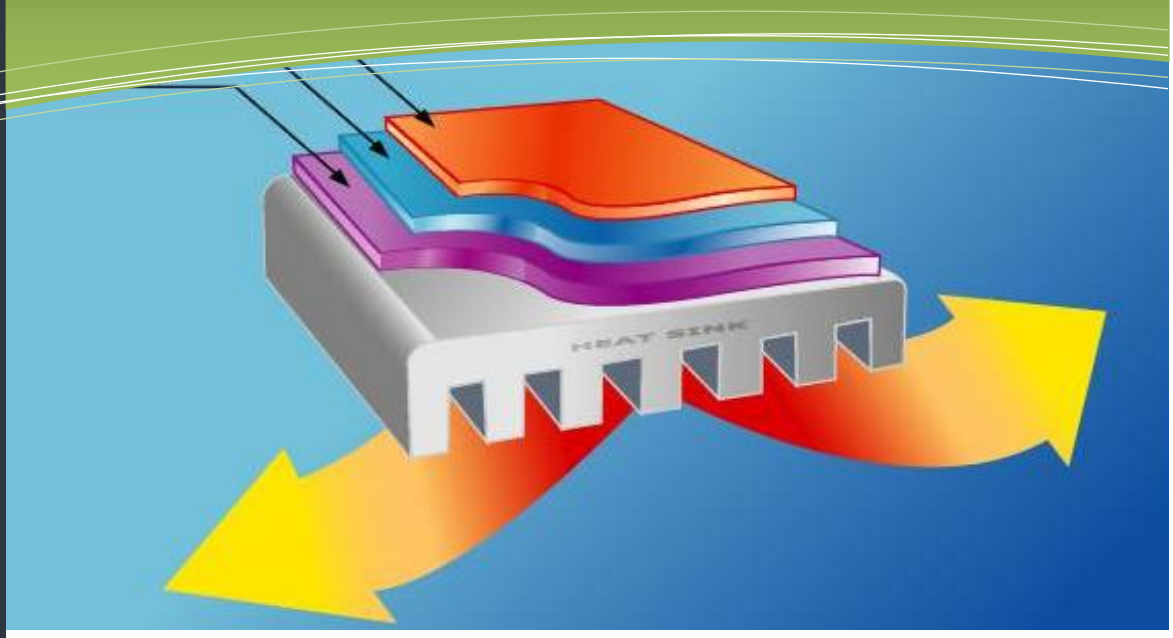
COOL-CLAD™ IMTS: INSULATED METAL THERMAL SUBSTRATE

METAL CLAD PRINTED CIRCUIT BOARD (MCPCB) FOR POWER MODULES AND DEVICES INCLUDING:

- ***>250°C CONTINUOUS USE HIGH TEMPERATURE CIRCUITS AND POWER DEVICES***
- ***>175°C CONTINUOUS USE FLEXIBLE CIRCUITS AND POWER DEVICES***



Metal Clad Printed Circuit Board Insulating Thermal Substrates

Choosing the proper thermal interface material from thermal greases, thermal gels, phase-change thermal pads and films or thermal adhesives is one of the most critical aspects of thermal management for long-term reliability. COOL-CLAD™ CXP and COOL-CLAD™ CXF represent the integration of the best dielectric adhesive with stress-relief capability and high temperature operation reliability that is embedded with the lowest thermal resistance interface material.

- CXP series of novel modified cyanate ester based thermal dielectric pre-preg and laminates have been proven for long term usage at temperature up to 250°C and beyond.
- CXF series is the flexible version of the novel cyanate ester based thermal dielectrics proven for continuous services at temperature up to 180°C and beyond.
- Ideal for automotive electronics and other more stringent requirements.
- 6-micron cut-off oxides and diamond particles for finest possible circuit traces and spacings.
- The only diamond based dielectric thermal adhesives that have been proven in first use in supercomputers more than 25 years ago.

Description of Cool-Clad™ Insulated Metal Substrate for Metal Clad Printed Wiring Board (MCPWB)

Insulated metal thermal substrates have been used to replace direct bonded copper (DBC) substrate for power modules and devices mostly for cost and flexibility. The effectiveness of the insulated metal, such as aluminum or copper as a thermal substrate, hinges on the dielectric adhesive layers to provide high thermal transfer from the POWER generated by the semi-conductor chip or component while maintaining high dielectric insulation. Any delaminating between the copper circuit trace from the metal heat spreading substrate will be detrimental for the performance in terms of temperature run away and thus dramatically shorten the useful life of the power device.

COOL-CLAD™ insulated metal thermal substrate (IMTS) is one of the proven thermal management material solutions that include COOL-BOND®, COOL-PAD™, COOL-SILVER™, COOL-GELFILM™, COOL-GAPFILL™, COOL-GREASE® and COOL-GEL® for the most stringent thermal dissipation applications.

AIT COOL-CLAD™ is comprised of a top circuit layer of 1-6 oz standard copper on either 62.5 mil thick aluminum or 30 mil copper. Other thicknesses of copper or aluminum are available on special order. COOL-CLAD™ CXP incorporates a novel high Tg and high strength thermally conductive cyanate ester based thermal dielectric at 25 to 75-micron thickness to provide 2-3 times better thermal transfer in comparison to traditional 75-micron thick modified cyanate ester-based insulated metal substrate.

What distinguishes AIT COOL-CLAD™ CXP and CXF is the special dielectric layer that provides the following unparalleled thermal, dielectric and mechanical properties:

1. Ultra-low thermal resistance from copper circuit traces to the heat-spreader layer that is 20-100% lower than that achieved via an extra thin thermally conductive dielectric bond-line.
2. COOL-CLAD™ CXP series is one of the first products in the industry with the capability to withstand processing of up to 350°C. The high Tg dielectric thermal bonding layer ensures the COOL-CLAD™ IMTS for robust manufacturability and unparalleled long-term reliability at up to 250°C.
3. The mechanical peel strength of over 6 lb-in maintains the highest mechanical integrity.
4. Dielectric constant of less than 4.5 balances with high thermal conductivity of >2.0 W/m-K and more than 750V/mil dielectric strength to provide superior performance for even high frequency applications.
5. RoHS compliant that meets UL94V-0 rating.
6. Availability of thermal adhesive pre-preg to produce multi-layer circuits with the same high thermal conductivity and low thermal resistance between circuit layers.
7. COOL-CLAD™ CXF is a flexible cyanate ester-based version available for high power and high temperature flexible circuits applications. CXF series of thermal dielectric adhesive have been proven for 180°C for continuous usage.

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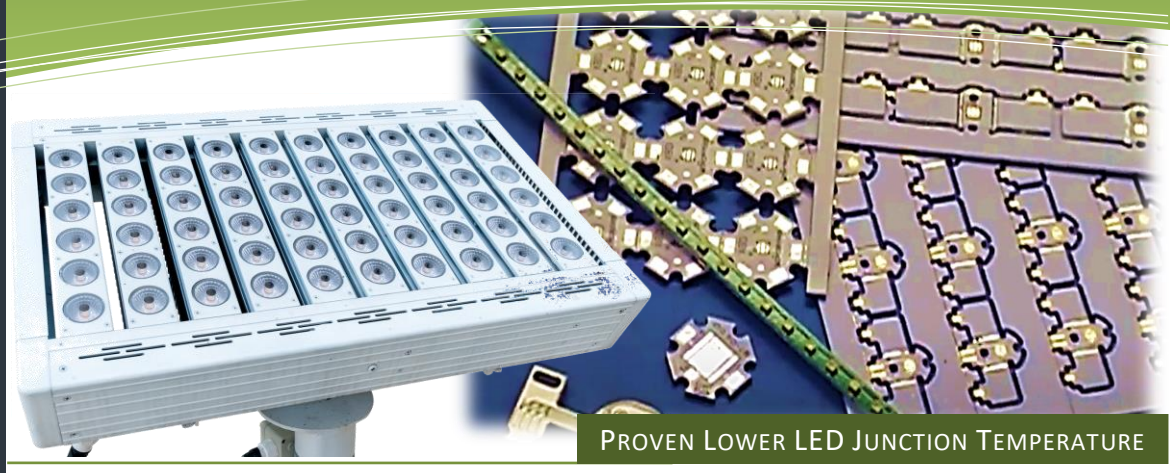
Cool-Clad™: Insulated Metal Thermal Substrate

Metal Core Printed Wiring Boards (MCPWB) For Power Modules and Devices Including:

- ***>250°C Continuous Use Power Devices***
- ***High Power LED Lighting, Inverters, Converters, Controllers, Drivers, etc.***



Proven Lower LED Junction Temperature

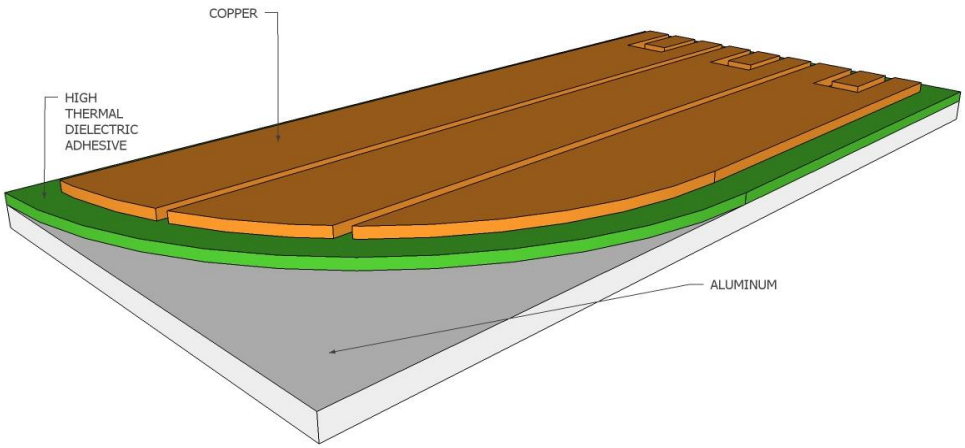
AIT patents (US patent# 7,154,046; 6,717,819; 6,580,035; 6,581,276; 6,108,210; 6,297,564; 6,665,193; 6,973,716) are applied to AIT's Insulated Metal Thermal Substrate to provide the following distinct advantages over traditional Insulated Metal Substrates:

- Instead of a rigid fiberglass thermally conductive epoxy laminate, we use our proprietary flexible thermal dielectric insulating layer resulting in stress and warp-free thermal copper-clad laminates.
- Unparalleled thermal conductivity in the insulating layer by eliminating the fiberglass fabrics.
- High temperature stability to withstand soldering at 300°C.
- Multi-layer capability with the same flexible dielectric copper-clad pre-preg that can be laminated at less than 14 psi pressure and at 125°C or higher.
- Base metal plates with choice of aluminum and copper from 35 mils to 350 mils.
- Thinner insulated metal substrate and pre-preg are available in rolls of 12-inch width.
- Thicker insulated metal substrate and pre-preg are available in sheets of 18-20 inches by 24 inches.
- Ideal for power and LED components and modules.

Properties of Cool-Clad™ CXP High Strength Series (Al or Cu Base Plate)

PROPERTY/PARAMETER: CXP7885-FP	VALUE
Electrical Resistivity of Dielectric Layer	$>10^{14}$ ohm-cm
Dielectric Strength of Dielectric Layer @ 25 micron	>1000 V/mil
Glass Transition Temp. of Dielectric Layer (°C)	200
Peel Strength of Dielectric Layer (Pound/inch)	>6
Device Push-off Strength of Dielectric Layer (psi)	>3000
Hardness of Dielectric Layer (Type)	> 95 (D)
Cured Density of Dielectric (gm/cc)	2.5
Thermal Conductivity (Dielectric Layer)	3.0 W/m-°C
Linear Thermal Expansion Coefficient of Laminate (ppm/°C)	19
Maximum Continuous Operation Temp. (°C)	> 250
Cut-Off Particle Size of Thermal Alumina Powders	5-micron

PROPERTY/PARAMETER: CXP7889-FP	VALUE
Electrical Resistivity of Dielectric Layer	$>10^{14}$ ohm-cm
Dielectric Strength of Dielectric Layer @ 25 micron	>1000 V/mil
Glass Transition Temp. of Dielectric Layer (°C)	200
Peel Strength of Dielectric Layer (Pound/inch)	>6
Device Push-off Strength of Dielectric Layer (psi)	>3000
Hardness of Dielectric Layer (Type)	> 95 (D)
Cured Density of Dielectric (gm/cc)	2.5
Thermal Conductivity (Dielectric Layer)	>12.0 W/m-°C
Linear Thermal Expansion Coefficient of Laminate (ppm/°C)	20
Maximum Continuous Operation Temp. (°C)	> 250
Cut-Off Particle Size of Thermal Diamond Powders	6-micron



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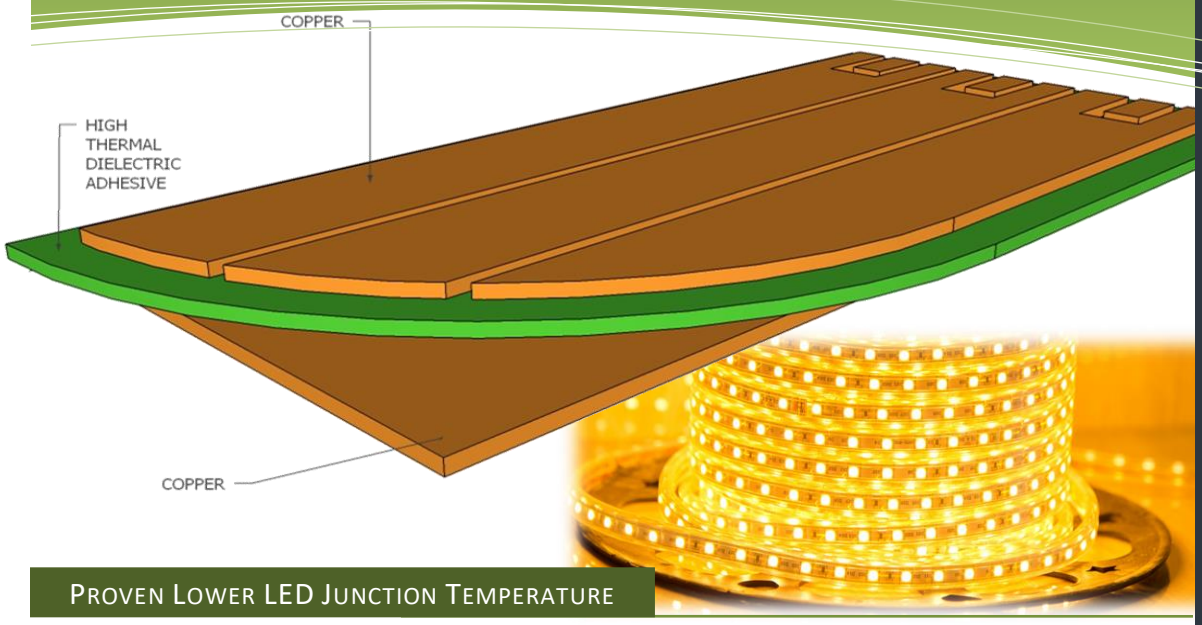
COOL-CLAD™: INSULATED METAL THERMAL SUBSTRATE

METAL CLAD PRINTED WIRING BOARDS (MCPWB) FOR POWER MODULES AND DEVICES INCLUDING:

- ***>175°C CONTINUOUS USE FLEXIBLE CIRCUITS FOR AUTOMATIC APPLICATIONS***
- ***>175°C CONTINUOUS USE FLEXIBLE LED LIGHTING, AND POWER DEVICES***



PROVEN LOWER LED JUNCTION TEMPERATURE

Properties of Cool-Clad™ CXF Series for High Temperature Flexible Circuits

PROPERTY/PARAMETER: CXF7455-FP	VALUE
Electrical Resistivity of Dielectric Layer	$>10^{14}$ ohm-cm
Dielectric Strength of Dielectric Layer @ 75 Micron Thickness (Volts/mil)	>1000 V/mil
Glass Transition Temp. of Dielectric Layer (°C)	-55
Peel Strength (Pound/inch)	>3
Device Push-off Strength of Adhesive Layer (psi)	>1500
Hardness of Adhesive Layer (Type)	> 80 (A)
Cured Density of Dielectric of Adhesive Layer (gm/cc)	2.5
Thermal Conductivity of Adhesive Layer	3 W/m-°C
Linear Thermal Expansion Coefficient of Laminate (ppm/°C)	19
Maximum Continuous Operation Temp. (°C)	> 180
Cut-Off Particle Size of Thermal Alumina Powders	5-micron

PROPERTY/PARAMETER: CXF7459-FP	VALUE
Electrical Resistivity of Dielectric Layer	$>10^{14}$ ohm-cm
Dielectric Strength of Dielectric Layer @ 75 Micron Thickness (Volts/mil)	>1000 V/mil
Glass Transition Temp. of Dielectric Layer (°C)	-55
Peel Strength (Pound/inch)	>3
Device Push-off Strength of Adhesive Layer (psi)	>1500
Hardness of Adhesive Layer (Type)	> 80 (A)
Cured Density of Dielectric of Adhesive Layer (gm/cc)	2.5
Thermal Conductivity of Adhesive Layer	3 W/m-°C
Linear Thermal Expansion Coefficient of Laminate (ppm/°C)	19
Maximum Continuous Operation Temp. (°C)	> 180
Cut-Off Particle Size of Thermal Diamond Powders	6-micron

AIT Cool-Clad™ copper-clad laminate substrate and copper-clad pre-preg panels used for multi-layered insulated metal substrate circuits can be handled in exactly the same method and infrastructure as commonly used in standard PWB and flex circuit. CXF series of modified cyanate ester based flexible circuit thermal dielectrics enable high temperature use beyond 180°C automatic electronic applications.

Panel & Roll Copper-clad Material Handling

- Cool-Clad™ copper-clad laminate substrates can be stored in ambient conditions for at least 12 months.
- Cool-Clad™ pre-preg can be stored in ambient conditions for at least 6 months.

Panel Prep

- Tooling/Registration
- Scrubbing
- Chemical Cleaning
- Base Metal Protection

Imaging

- Dry Film Application
- Wet Film Application
- Screened Image
- Application

Wet Chemistry Processing

- Etching
- Stripping
- Post Etch/Strip Clean

Solder Mask Application

- Screen, Spray or Curtain Coat
- Thermal Solder Mask
- UV Cured Solder Mask

Second Step Drill or Punch

Finishing Operation

- HASL
- OSP
- Tin
- Ni/Au

Finishing Fabrication

- Rout
- Score

Precision circuitry of 1-mil line and 1-mil spacing can easily be etched with the CHIP-COUPLER™ substrate technology for solder-able and moisture resistant interconnections.

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COOL-CLAD™ IMTS: INSULATED METAL THERMAL SUBSTRATE

METAL-CLAD PRINTED CIRCUIT BOARD SUBSTRATE FOR POWER MODULES AND DEVICES INCLUDING:

- ***>250°C CONTINUOUS USE HIGH TEMPERATURE CIRCUITS AND POWER DEVICES***
- ***>175°C CONTINUOUS USE FLEXIBLE CIRCUITS AND POWER DEVICES***

Typical Multi-Layer Processing Parameters for Cool-Clad™

PRE-PREG PROCESSING FOR COOL-CLAD CXP	**CXP High Strength Thermal Dielectric Series**
Storage and Shelf Life	Ambient in original package
Lamination Temperature, Pressure and Time	150-175°C/10-15 psi/>30 second
Post Curing (Without Pressure)	Same temperature as lamination

PRE-PREG PROCESSING FOR COOL-CLAD CXF	**CXF Flexible Thermal Dielectric Series**
Storage and Shelf Life	Ambient in original package
Lamination Temperature, Pressure and Time	150-175°C/10-15 psi/>30 second
Post Curing (Without Pressure)	Same temperature as lamination

AIT Thermal Interface Materials for IMTS, High Power Devices, HB LED Applications:

FUNCTION	AIT PART #	THERMAL, ELECTRICAL & other RELEVANT PROPERTIES
Die-Attach Adhesive	PRIMA-BOND™ MC7665-LED	• Thermally conductive, white reflective, electrically insulating die-attach for HB LED chips • Lowest thermal resistance, ambient storable single component
Thermal Adhesive Film	COOL-BOND™ CB7135	• Low thermal resistance, electrically insulating interface pad • Compressible, instant melt-bonding phase-change adhesive
Thermal Epoxy Film	COOL-BOND™ RTK7555	• Low thermal resistance, electrically insulating interface pad • Compressible, rapid heat curing tacky film adhesive
Thermal Paste Adhesive	COOL-BOND™ HB-2	• Low thermal resistance, electrically insulating interface paste adhesive • Flexible for large area bonding & field repair, 1:1 mix, ambient curing
Compressible Thermal Pad	COOL-PAD™ CPR7065-LB	• Low thermal resistance interface, electrical insulating pad • Compressible, phase-change interface pad
Thermal Interface	COOL-SILVER™ PAD	• Lowest thermal resistance, electrically non-conductive interface • Compressible, phase-change interface pad
Conductive Grease	COOL-GREASE™ CGR8550	• Non-curing, electrically conductive interface grease for moving parts • Lowest thermal resistance non-silicone grease, proven reliability
Thermal Grease	COOL-GREASE™ CGR7559-LB	• Lowest thermal resistance, electrically insulating interface grease • Non-curing, non-silicone, proven long-term stability
Gel like film to replace grease	COOL-GELFILM™	• Lowest thermal resistance, electrically insulating interface tape • Non-curing, non-silicone, proven long-term stability to replace grease
PSA on passive side	COOL-GAPFILL™	• Lowest thermal resistance, electrically insulating interface gap filling pad of 10-100 mils thickness • Non-curing, non-silicone, proven long-term stability

Call AI Technology at 609-799-9388 for more information on this product and our full line of electronic processing and packaging materials!

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About AI Technology, Inc.

Since pioneering the use of flexible epoxy technology for microelectronic packaging in 1985, AI Technology (AIT) has been one of the leading forces in developing advanced materials and adhesive solutions for electronic interconnection and packaging.

Besides pioneering the use of "phase-change" materials (PCM) as thermal interface materials (TIM), AIT has provided the microelectronic packaging industry with its flexible epoxy thermal adhesives. By managing interfacial stress induced by differential coefficient of thermal expansion between bonding adherents, these thermal materials have found extensive success in military and aerospace applications.

The same stress-free dielectric adhesives are now adapted for use in insulated metal substrates with copper and aluminum clad. The key advantage of these thermal management materials is their unparalleled long-term reliability attributed to their ability to withstand repeated thermal cycling and stress-free bonding between the heat-spreader plate and the circuit layer. AIT also offers the same flexible modified cyanate ester pre-preg with high thermal conductivity for more advanced multilayer insulated metal substrate circuits and modules. This novel class of thermal management materials provides a platform and infrastructure for large area thermal management of power modules such as solar cells, LED panels, etc.

AIT has a full line of die and substrate attach films and pastes, thermal interface materials, (EMI/RFI) mitigation material solutions, conductive caulks and adhesives and advanced flexible and Insulated Metal Circuit Substrates. AIT is located in a ISO9001:2000 certified manufacturing and R&D on a 16-acre and 18-acre campus in Princeton, NJ. Sales support includes company direct offices in Shenzhen-HK China and sales reps in Europe and Asia.