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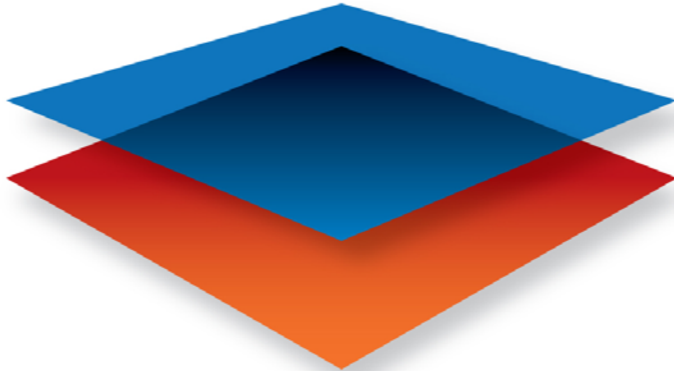
Presenting …



ECLIPS

Embedded Cooling Layer - Interactive Power System

LICENSED LOCKHEED-MARTIN TECHNOLOGY

A Very Cost Effective Printed Circuit Board Alternative to Co-Fired Ceramic and Hybrid Integrated Circuits

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- A system of manufacturing Printed Circuit Boards (PCBs) employing a thermally engineered metalized material layer to enable the integrated assembly of advanced electronic circuits using both surface mount (SMT) and unpackaged die components
- Provides a very low cost alternative to co-fired ceramics and hybrid MICs
- With superior thermal conductivity and ceramic matched CTE, the ECLIPS PCB allows for direct die attach and wire bonding of high power and sensitive IC components and also standard SMT assembly of all others without degradation from dissipated heat
- The result is a smaller, more reliable and producible and much **more less costly** system

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ISO 9001-2008
AS-9100 C
MIL-PRF-31032
IPC-6012
IPC-6013
IPC-6018

PERFORMANCE COMPARISONS

Characteristic	Co-Fired Ceramic	Hybrid MIC	ECLIPS PCB
co-location of die & SMT components on single substrate	YES	NO	YES
enables high density trace routing & signal interconnections	YES	NO	YES
thermal conductivity	POOR	EXCELLENT	EXCELLENT
CTE matching die attachment	NO	YES	YES
allows automated assembly	YES	NO	YES
housing material cost	LOW	HIGH	LOW
Material cost	$$$$	$$$	$$
Assembly cost	$$$	$$$$	$

DEVELOPMENT HISTORY

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- Thermally engineered material (Met-Graf) developed start-up MMCC – acquired 2015 by Parker Hannifin
- PCB fabrication technology developed and patented by Lockheed Martin under US Patent No. 8,245,390 B2 issued on 21 August 2012
- Cirexx involved in process and technology development through PCB manufacturing. First PCBs fabricated and tested in 2009.
- Cirexx licensed by LMCO M&FC in 2013. The technology is currently used on production programs
- Demonstration Reference System, White Paper and presentation available

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ESSENTIAL DETAIL

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MMIC

Outer Core

Thermally Engineered Metalized Layer

Inner Core

Inner Core

Inner Core

Inner Core

Inner Core

Thermally Engineered Metalized Layer

Outer Core

Multilayered PCB Structure with 2 Composite Cores and a Die-Attached MMIC

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- Technology Introduction

    High Power RF (millimeter wave)
    Phased Array Radar
    Missile Guidance
    Satellites & Space systems

- Product Maturity

    Super Computing/CPU
    "Down Hole" Sensors & Controls
    Electronic sub-systems (mezzanine)

- Mass Production

    Automotive/Sensors and Controls
    Consumer & Industrial LED & CCD
    Consumer Communications

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- Thermally engineered material is a graphite copper composite which acts essentially as a "metal-core". Available in 10, 20 and 40 mil thickness.
- Vacuum processing assures no residual organics for outgassing or corrosion
- Superior thermal conductivity competing with best currently available materials for PCBs
- Ceramic-matched CTE (especially Z axis) allows for direct-attach of GaAs & GaN die to PCB
- Thinner and lighter-weight heat sinking vs. aluminum or copper metal-core (6 g/cm³)
- CTE and "balanced stack up" reduces probability of PCB warping and twisting

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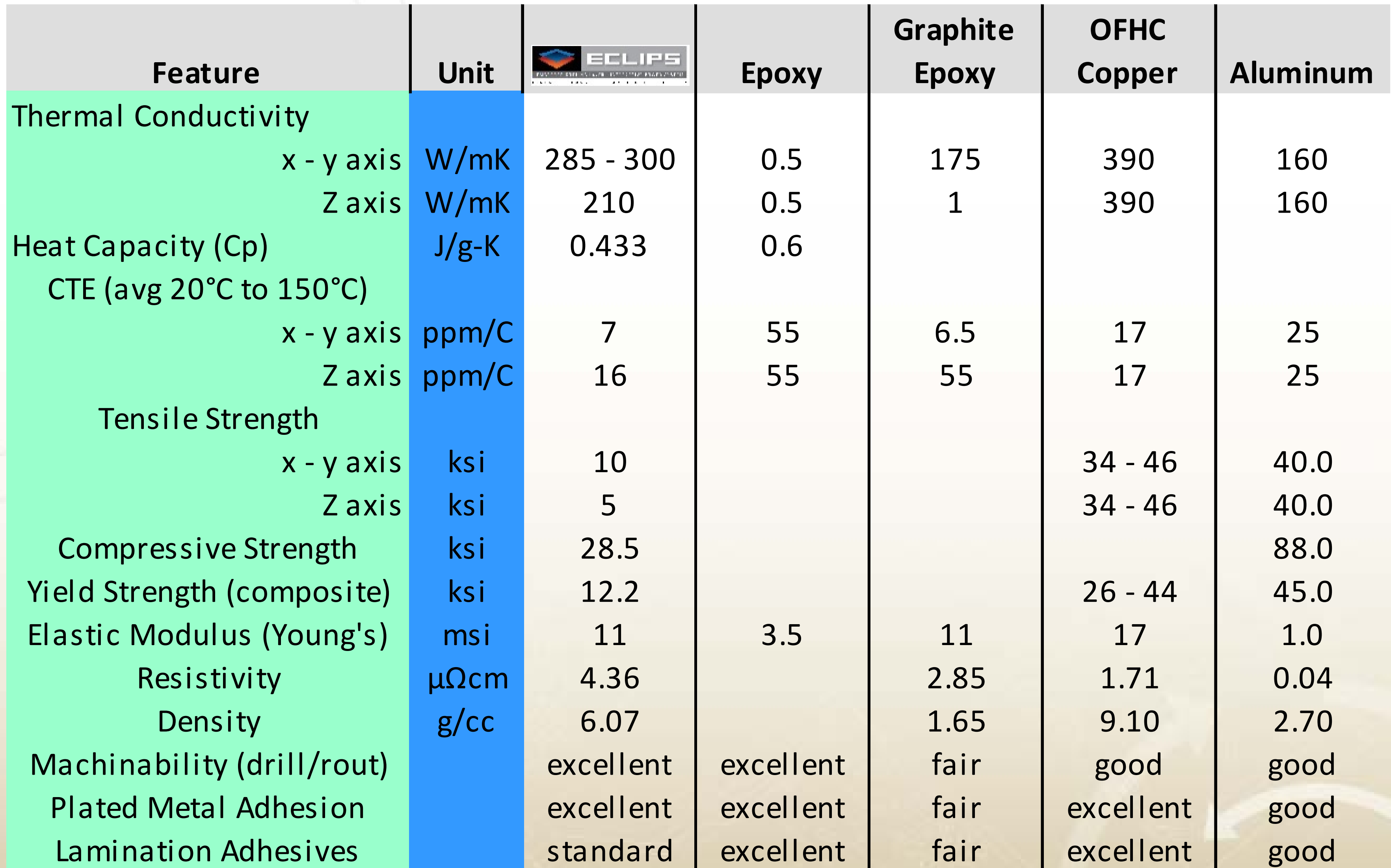
TECHNICAL DATA



Feature	Unit	ECLIPS	Epoxy	Graphite Epoxy	OFHC Copper	Aluminum
Thermal Conductivity						
x - y axis	W/mK	285 - 300	0.5	175	390	160
Z axis	W/mK	210	0.5	1	390	160
Heat Capacity (Cp)	J/g-K	0.433	0.6			
CTE (avg 20°C to 150°C)						
x - y axis	ppm/C	7	55	6.5	17	25
Z axis	ppm/C	16	55	55	17	25
Tensile Strength						
x - y axis	ksi	10			34 - 46	40.0
Z axis	ksi	5			34 - 46	40.0
Compressive Strength	ksi	28.5				88.0
Yield Strength (composite)	ksi	12.2			26 - 44	45.0
Elastic Modulus (Young's)	msi	11	3.5	11	17	1.0
Resistivity	μΩcm	4.36		2.85	1.71	0.04
Density	g/cc	6.07		1.65	9.10	2.70
Machinability (drill/rout)		excellent	excellent	fair	good	good
Plated Metal Adhesion		excellent	excellent	fair	excellent	good
Lamination Adhesives		standard	excellent	fair	excellent	good

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- PCB Constructions available with many common materials: polyimides, PTFEs, and ceramic-filled laminates
- “Cap Construction” with Arlon 85NT, or “Foil Construction with Taconic TPG30 are common
- Processing similar to standard PCB methods and equipment
- ENEPIG (electroless nickel, electroless palladium, immersion gold) best finish for wire bonding
- Composite backfilled – when required - with low CTE material
- End product complies with IPC-6013, 6018 and MIL-PRF-31032

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IPC-6013
IPC-6018

PCB CONSTRUCTION

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Through Via

Wire/Ribbon Bonding

Layer 1 Signals & Pads

Via Fill

MMIC

Outer Core

Pre-Preg

Exposed for Chasis Ground

Thermally Engineered Metalized Layer

Layer 2

Pre-Preg

Micro Via

Layer 3 Signals

Inner Core

Layer 4 Signals

Buried Via

Pre-Preg

Layer 5 Signals

Inner Core

Layer 6 Signals

Pre-Preg

Layer 7 Signals

Blind Via

Inner Core

Layer 8 Signals

Pre-Preg

Edge Plating

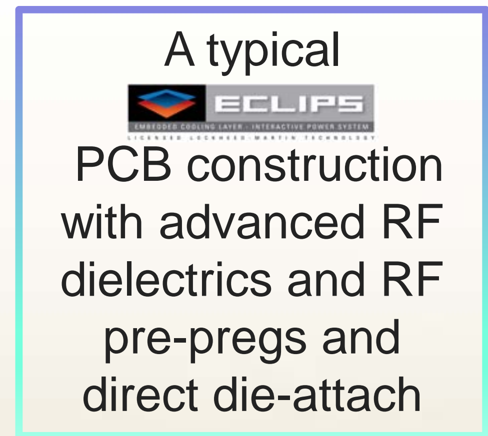
Thermally Engineered Metalized Layer

Layer 9

Pre-Preg

Outer Core

Layer 10 Signals & Pads



PCB CONSTRUCTIONATION

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Smallest standard drill hole diameter is 10:1 ratio between D:T (drilled hole diameter to overall board thickness)

Smallest standard Via pad is D + 25 mils (drill diameter plus 0.025")

Smallest standard Signal Via pitch is D + 30 mils (drill diameter plus 0.030")

Smallest standard Thermal Via pitch is D + 15 mils (drill diameter plus 0.015")

Minimum Met-Graf clearance hole drill is D + 35 mils (drilled hole daimeter plus 0.035")

Minimum Thermal Via clearance hole drill (though sequential lam set) is D + 30 mils (drilled hole daimeter plus 0.030")

PCB CONSTRUCTION

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MMIC

MMIC

1	0.5 oz copper	RF Signals
	TPG-30 pre-preg 5 mils	
2	0.5 oz Copper	GND
	CLTE-XT core 5.1 mils	
3	0.5 oz Copper	Signals
	CLTE-XT core 5.1 mils	
4	0.5 oz Copper	Signals
	pre-preg	
5	Met-Graf 7-300 40 mils	GND
	pre-preg	
6	0.5 oz copper	Power
	core 5 mils	
7	0.5 oz Copper	GND
	pre-preg	
8	0.5 oz Copper	Power
	core 5 mils	
9	0.5 oz Copper	Signals
	pre-preg	
10	Met-Graf 7-300 40 mils	GND
11	0.5 oz copper	GND
	CLTE-XT core 5.1 mils	
12	0.5 oz copper	Signals
	CLTE-XT core 5.1 mils	
13	0.5 oz copper	GND
	CLTE-XT core 5.1 mils	
14	0.5 oz copper	Signals
	CLTE-XT core 5.1 mils	
15	0.5 oz copper	GND
	CLTE-XT core 5.1 mils	
16	0.5 oz copper	Signals
	CLTE-XT core 5.1 mils	
17	0.5 oz copper	GND
	CLTE-XT core 5.1 mils	
18	0.5 oz copper	Signals

An Advanced ECLIPS PCB Design

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engineering metalized material layers

Pad on Top Layers

Internal Ground Connections

Pad on Bottom Layer

Cross-section of typical thermal via through ECLIPS PCB

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Pad on Top Layers

engineering metalized material layers

Internal metalized layer pre-drilled and backfilled

Internal Signal Connection

(Bottom Layer not shown)

Cross-section of typical signal via through ECLIPS PCB

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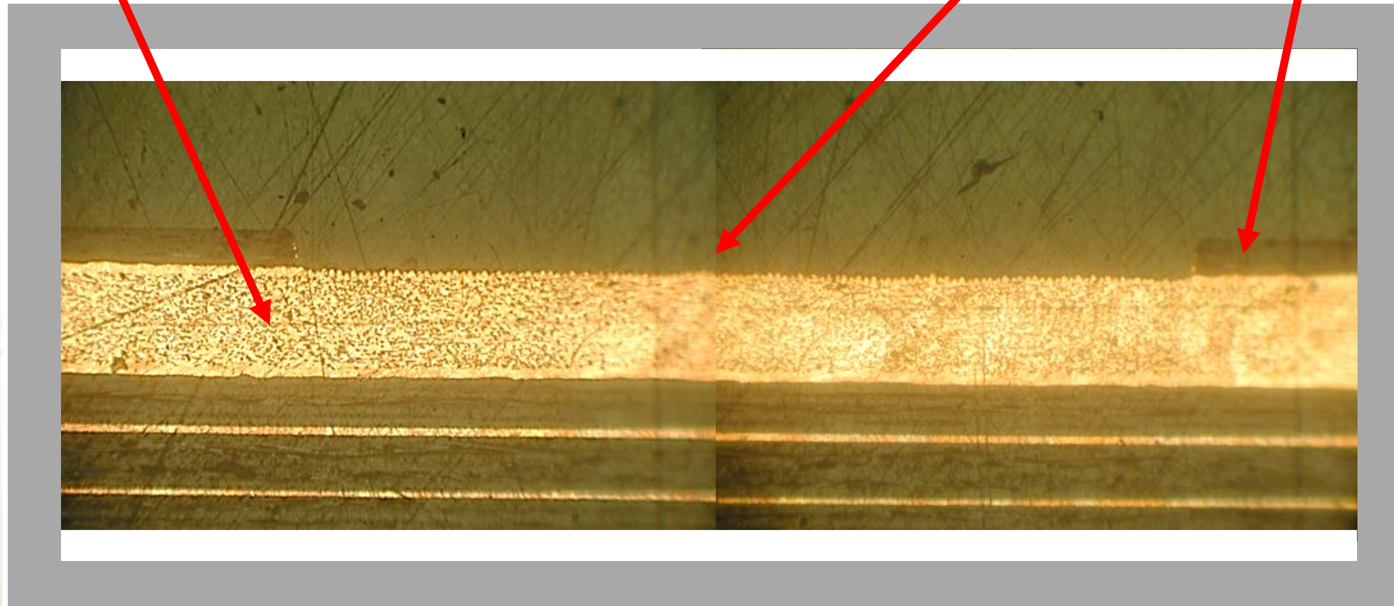
engineering metalized material layer

Laser Ablated Cavity

Top Layer



Cross-section of typical laser cavity through ECLIPS PCB

(Remainder of board not shown)

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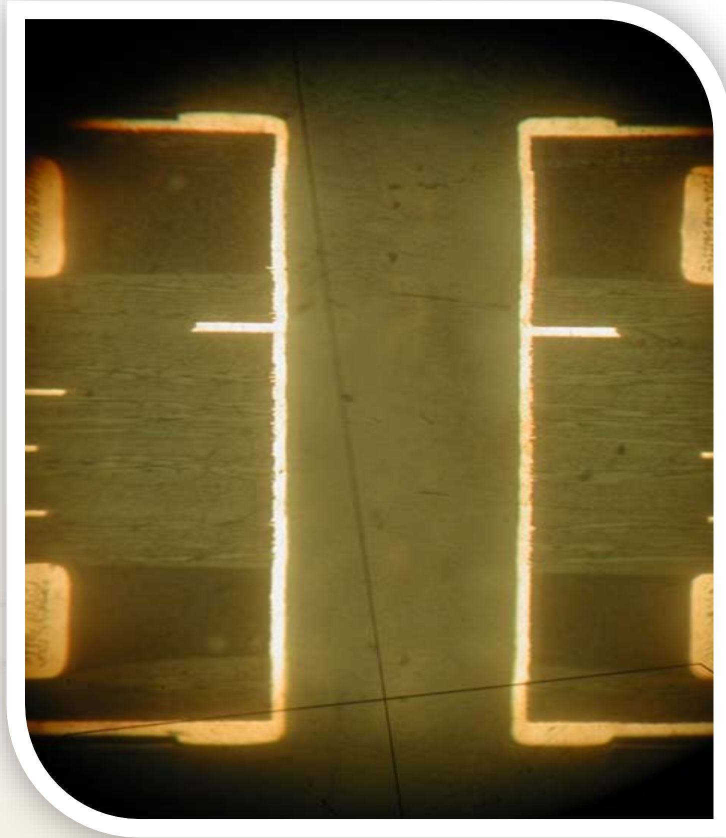
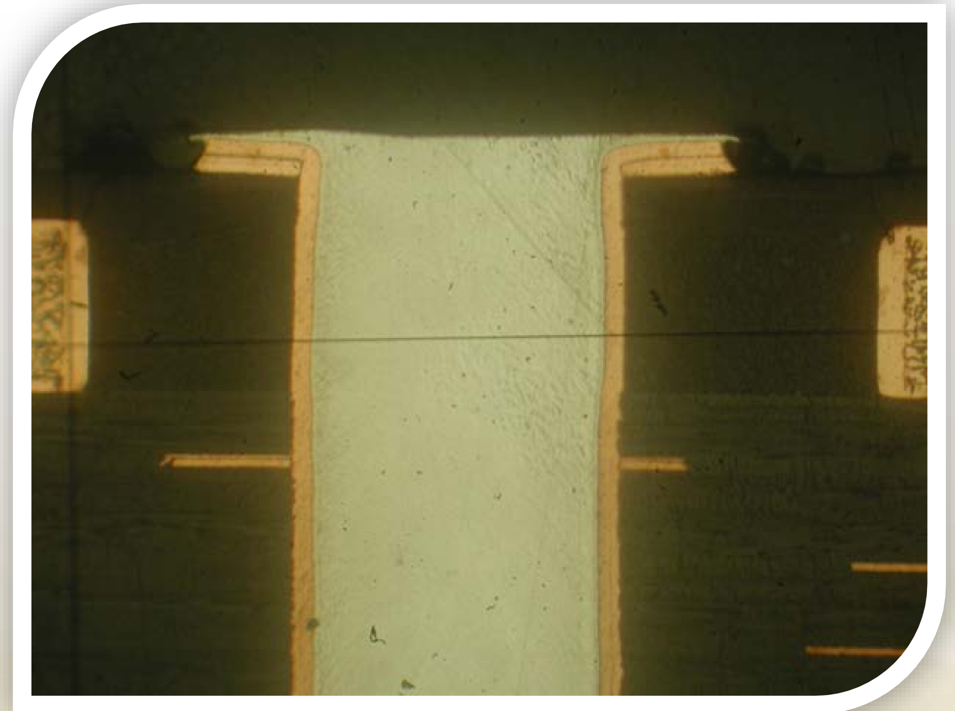


After Copper Plating Process



After Thermal Stress Test

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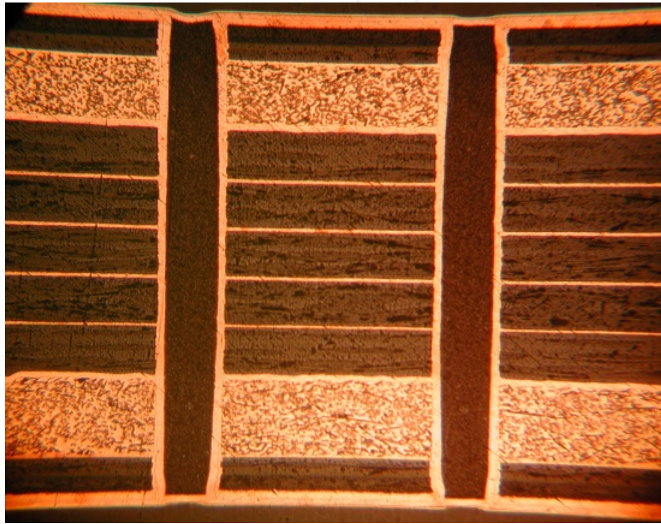
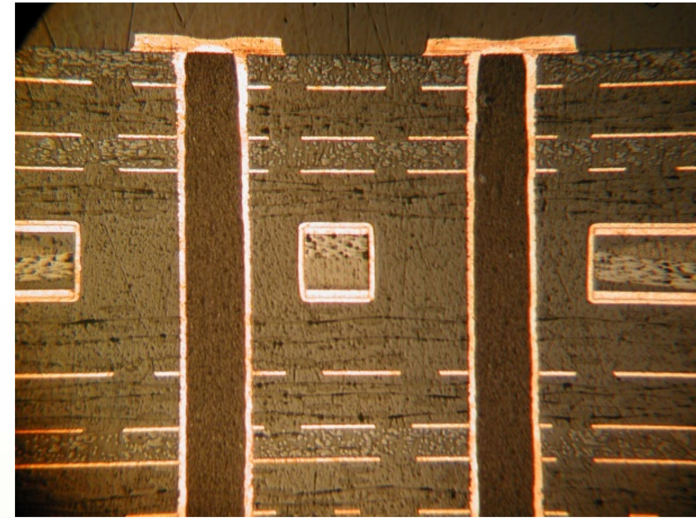
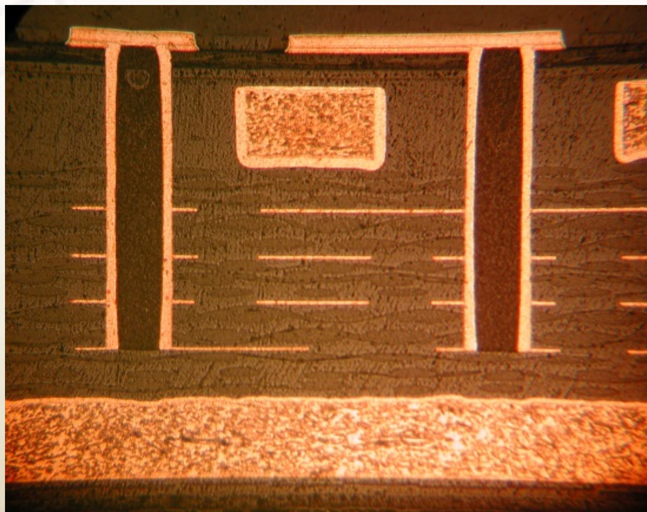
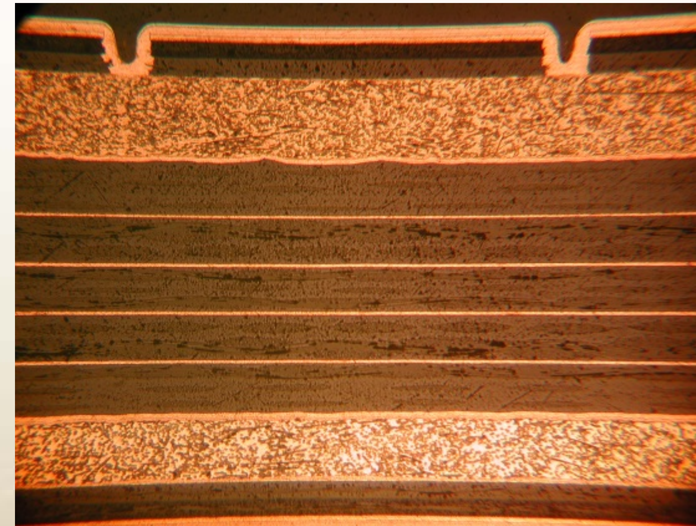

Thermal Via Spacing


Center-Core Construction


Signal Via Spacing


Micro Vias

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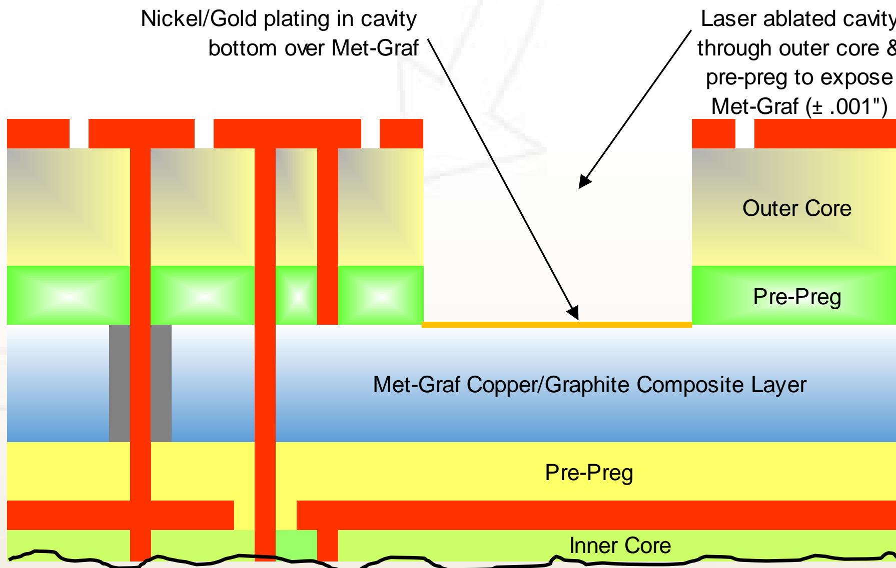
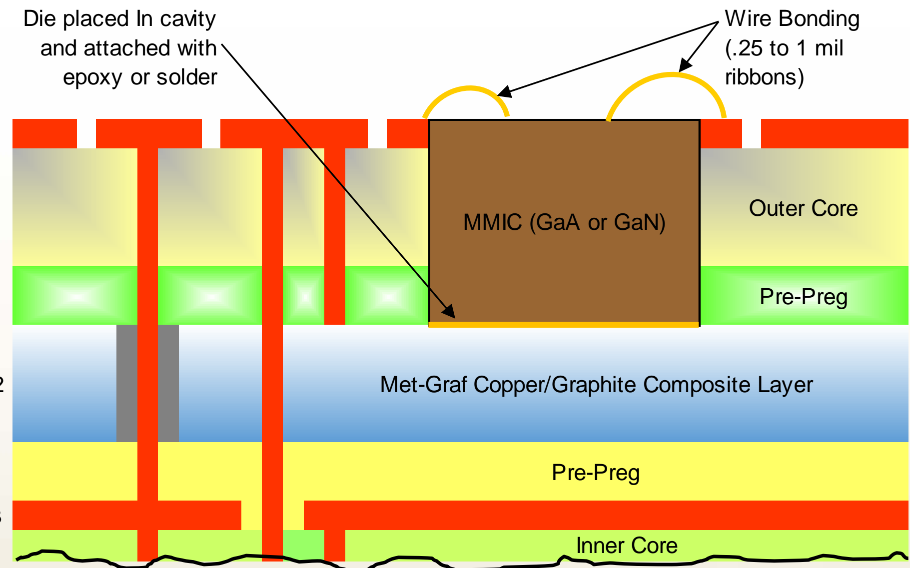


Cross-section of typical ECLIPS PCB after Laser Cavity Ablating Operation



Cross-section of typical ECLIPS PCB with MMIC die-attached

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- "Chip & Wire" die attached into outer core cavity directly onto composite layer with solder (AuSn) or silver epoxy paste eliminated the need for exotic heat sinking
- 1 mil Au wire bonding for DC; .25 mil wire for RF connectivity
- Standard SMT assembly of "plastic parts" for remainder of PCB - vapor phase soldering
- Low CTE assures component survival and reliability at higher temperatures
- Housing can be easily machined from anodized aluminum

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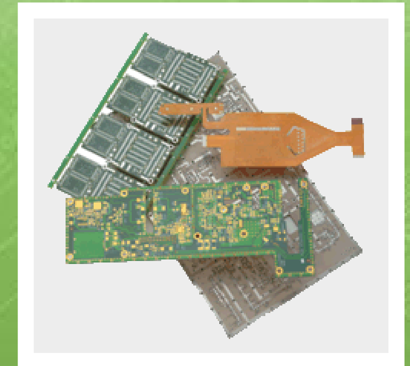
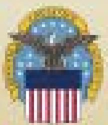


Wire/ribbon bonding of direct die-attach to PCB



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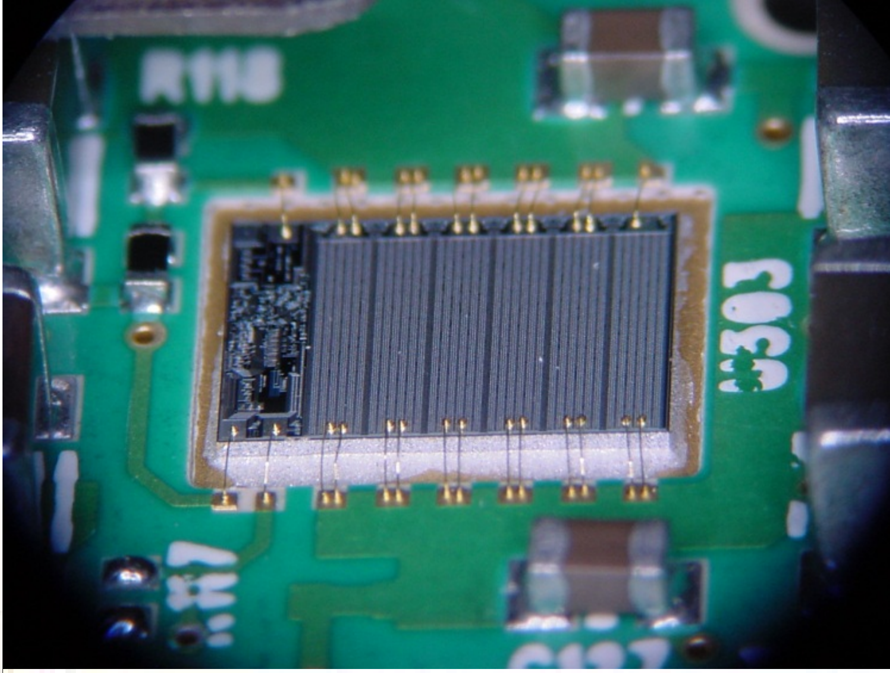

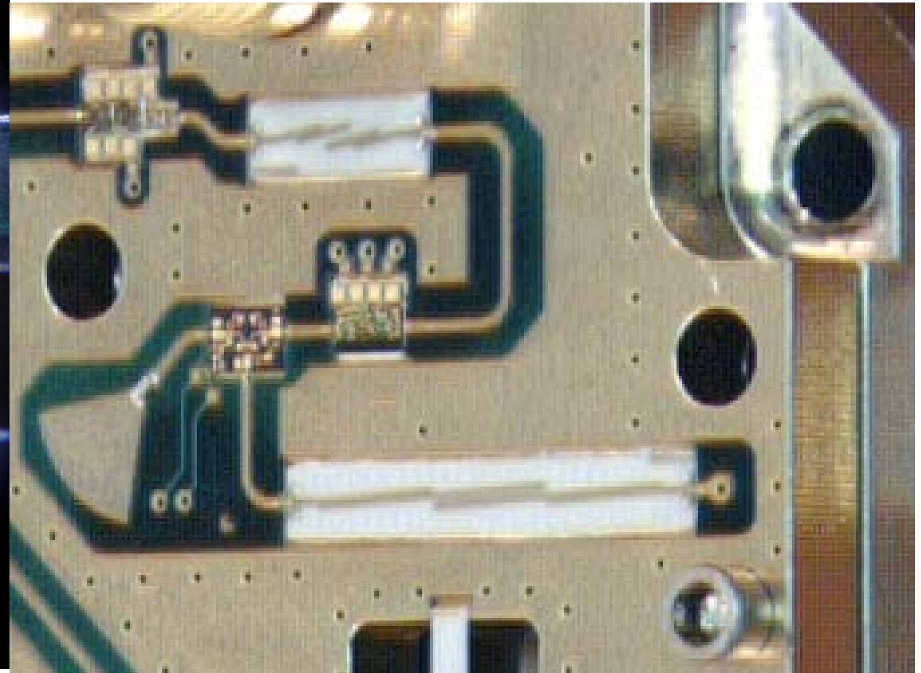

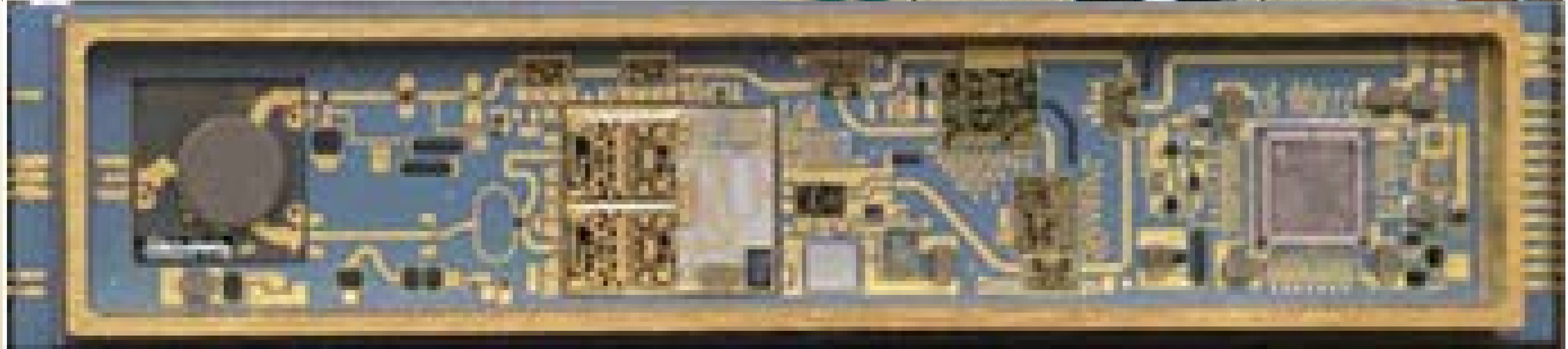

ASSEMLBY DETAIL

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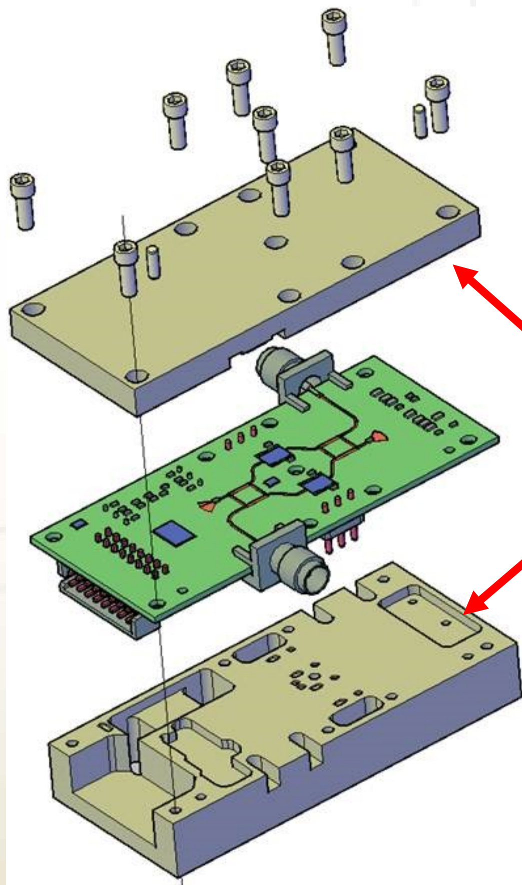
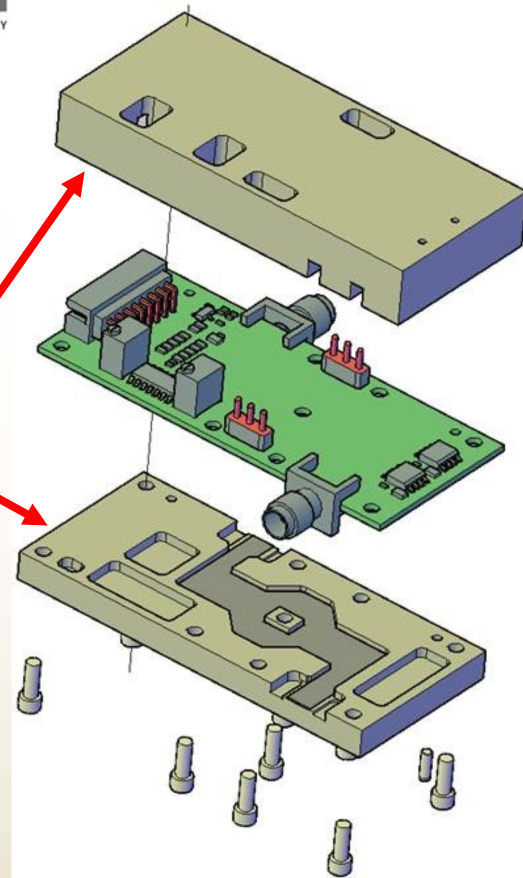


Exploded view of high power amplifier with ECLIPS PCB – GaN die side up

Aluminum milled chassis is electrical and thermal common ground



Exploded view of high power amplifier with ECLIPS PCB – GaN die side down

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- ECLIPS Technology provides a lower cost, more reliable alternative to Co-Fired Ceramic or Hybrid MIC when needing to use both direct die-attach and SMT components
- Alternatives unreliable and expensive:
  - Ceramics are very high cost
  - Hybrid MIC (w/glass feed-through) are labor intensive and much larger
- Cirexx engineers are prepared and able to convert your existing designs to an ECLIPS Technology or help you to develop a new one
- ECLIPS Technology meets all current standards and specification

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EXPERIENCED TEAM: UNDERSTANDS THE UNIQUE REQUIREMENTS OF RF/MICROWAVE

ENGINEERING SUPPORT: AVAILABLE TO WORK CLOSELY WITH YOUR TEAM

HIGH TECHNOLOGY: BROAD EXPERIENCE WITH STATE-OF-THE-ART PCB TECHNOLOGIES

SEAMLESS INTEGRATION: OUR SYSTEMS WILL COMPLY WITH YOUR SYSTEMS

QUICK TURNAROUND: THE LEADED IN HIGH TECHNOLOGY PCB QUICK-TURN

MANAGEMENT COMMITTMENT: TO YOUR COMPLETE SATISFACTION