



IMPROVED THERMAL PERFORMANCE WITH POLYIMIDE BASED LAMINATE SUBSTRATES

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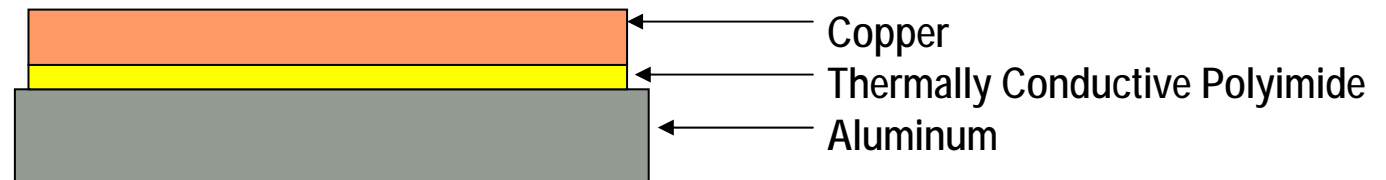
CooLam™ - A Polyimide Based Laminate Material System

- **Material Properties**
- **Thermal Characteristics**
- **Performance and Reliability Testing**
- **Conclusions**

Thermal Management and Performance

- Has always been important in electronics packaging, however, new demands are being created by:
 - Higher power dissipation devices
 - Higher power density
 - Increased reliability
 - Electrical, mechanical and thermal property stability and uniformity
 - Stringent Environmental requirements
- All resulting in a need for new and improved materials and design approaches

DuPont™ Coolam™ Constructions



- **Copper Thickness: 1/2 to 4 ounce**
- **Copper Type: ED or RA**
- **Polyimide Thickness: 17 to 50 μ m**
- **Aluminum Thickness: 1 to 1.6mm**
- **Aluminum Type: 5052**

DuPont™ Coolam™

**DuPont™ Coolam™ is Based on Polyimide,
a Widely Used Material with
Proven Performance and Reliability**

CooLam™ Offers:

- Very Low Thermal Impedance
- Excellent Reliability Performance
- Excellent Durability and Stability at High Temperature
- Uniform Thermal, Mechanical and Electrical Properties Under Environmental Stress Conditions
- Lead Free Solder and Wirebond Process Compatibility
- Halogen Free
- Meets UL 94 V-0
- Construction Variations to Meet Thermal Management Needs

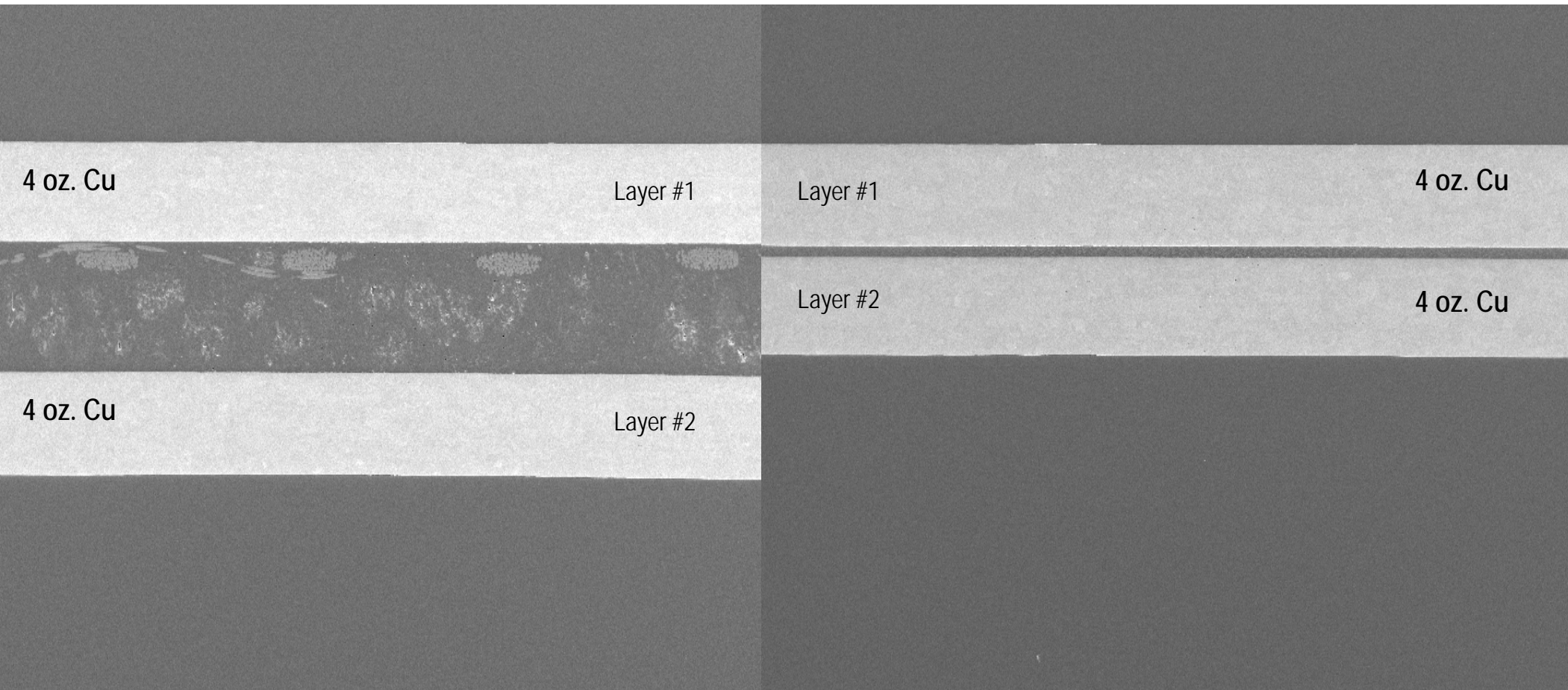
Very Low Thermal Impedance

	Thickness	Thermal Conductivity	Thermal Impedance	Thermal Impedance
	(mils)	(W/m-K)	C°-in ² /Watt	C°-m ² /Watt
Coolam™	0.68	0.8	0.033	215 x 10 ⁻⁷
Epoxy "A"	3	2.2	0.053	346 x 10 ⁻⁷
Epoxy "B"	6	3.0	0.078	508 x 10 ⁻⁷

CooLam™ Property Comparison

	Units	CooLam™ TCI (17μm)	Epoxy "A" (75 um)	Epoxy "B" (150 um)
Thermal Conductivity	W/m-K	0.8	2.2	3.0
Thermal Impedance (Dielectric)	°C-m ² /watt °C-in ² /watt	215 x 10 ⁻⁷ 0.033	346 x 10 ⁻⁷ 0.053	508 x 10 ⁻⁷ 0.078
Dielectric Strength	VAC/mil	4300	2000	800
Dielectric Constant (Dk)	1 MHz	5.53	No data available	No data available
Moisture Absorption	%	1.0	No data available	No data available
Tg	°C	225 °C	150 °C	105 °C
CTE (in-plane)	ppm/°C	31	25	37
Flammability	UL94	Meets V-O (clad)	V-O (clad)	V-O (clad)
Copper to PI Adhesion	PLI	> 16 (1 oz. Cu)	8	6

Very Low Thermal Impedance



Epoxy "B" 6mil (150 μ m) dielectric

CooLam™ 17 μ m dielectric

Performance and Reliability Testing

Dielectric Strength - *Film* Dielectric Strength per ASTM-D-149

Thermal Aging - *Film* Breakdown Voltage per IPC-TM-650 2.5.6.3

Copper Adhesion - Peel Strength per IPC-TM-650 2.4.9

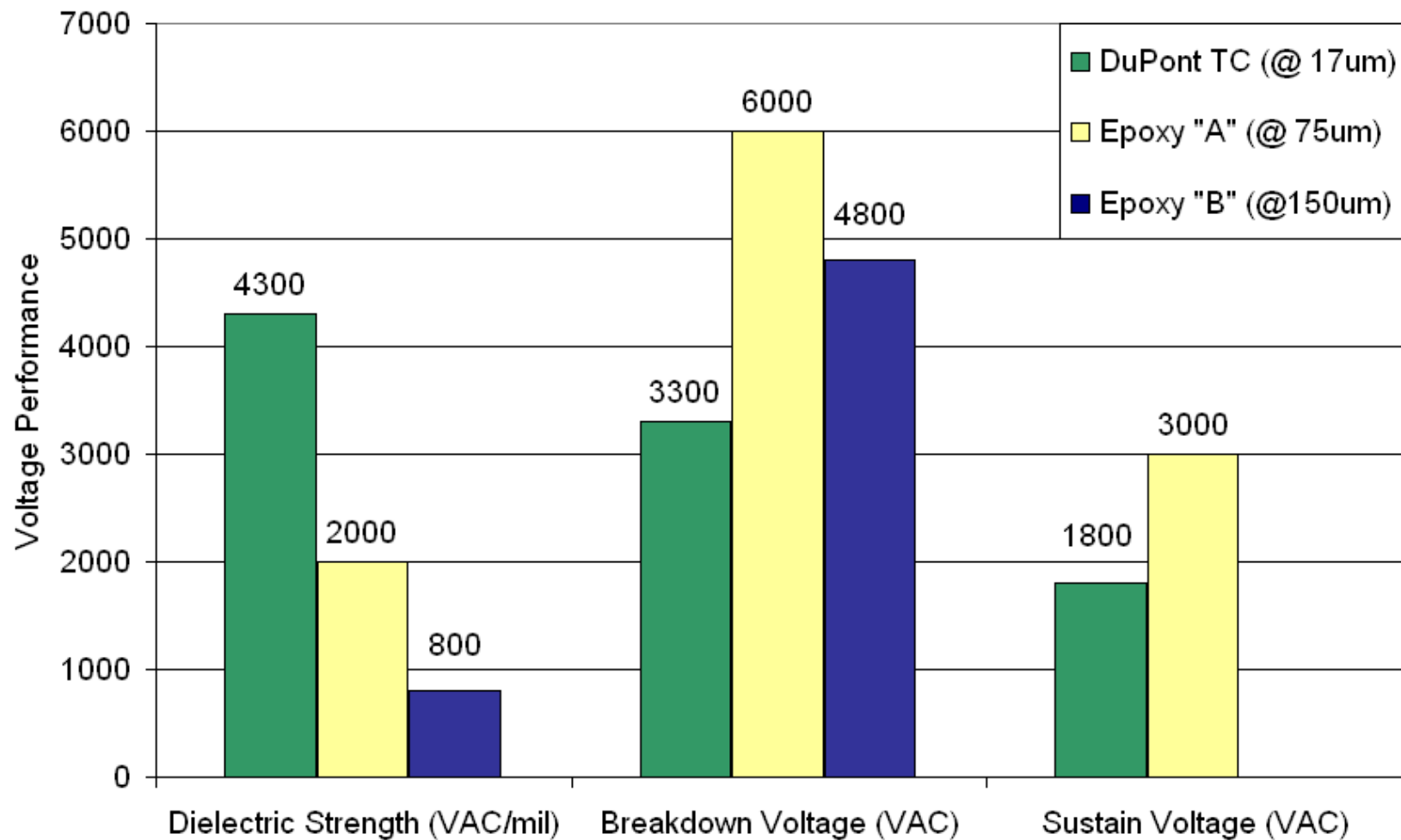
Thermal Conductivity - per ASTM E1461

Wire Bond Shear per JESD22-B116 and Pull Testing per Mil-Std-883

Environmental Stress Conditions

- 1000 Hours exposure to 85°C/85%RH
- 1000 Hours exposure at -40°C
- 1000 Hours exposure at +150°C
- 1000 Thermal cycles, -40°C to +150°C

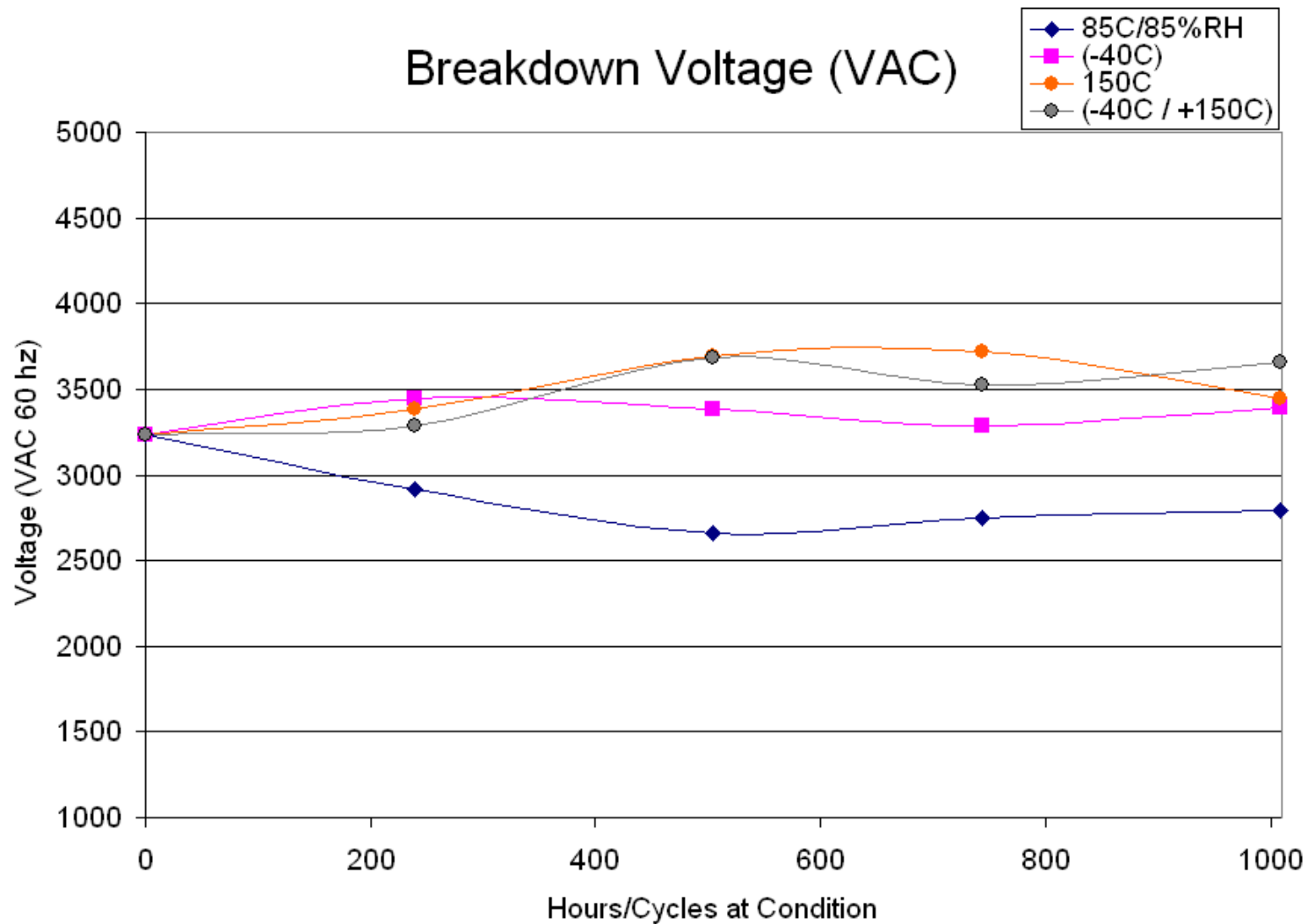
Dielectric Performance Comparison



Excellent Reliability: 17 μ m film Breakdown Voltage

- ASTM-D149 (in air)
- 500 VAC/sec. ramp rate

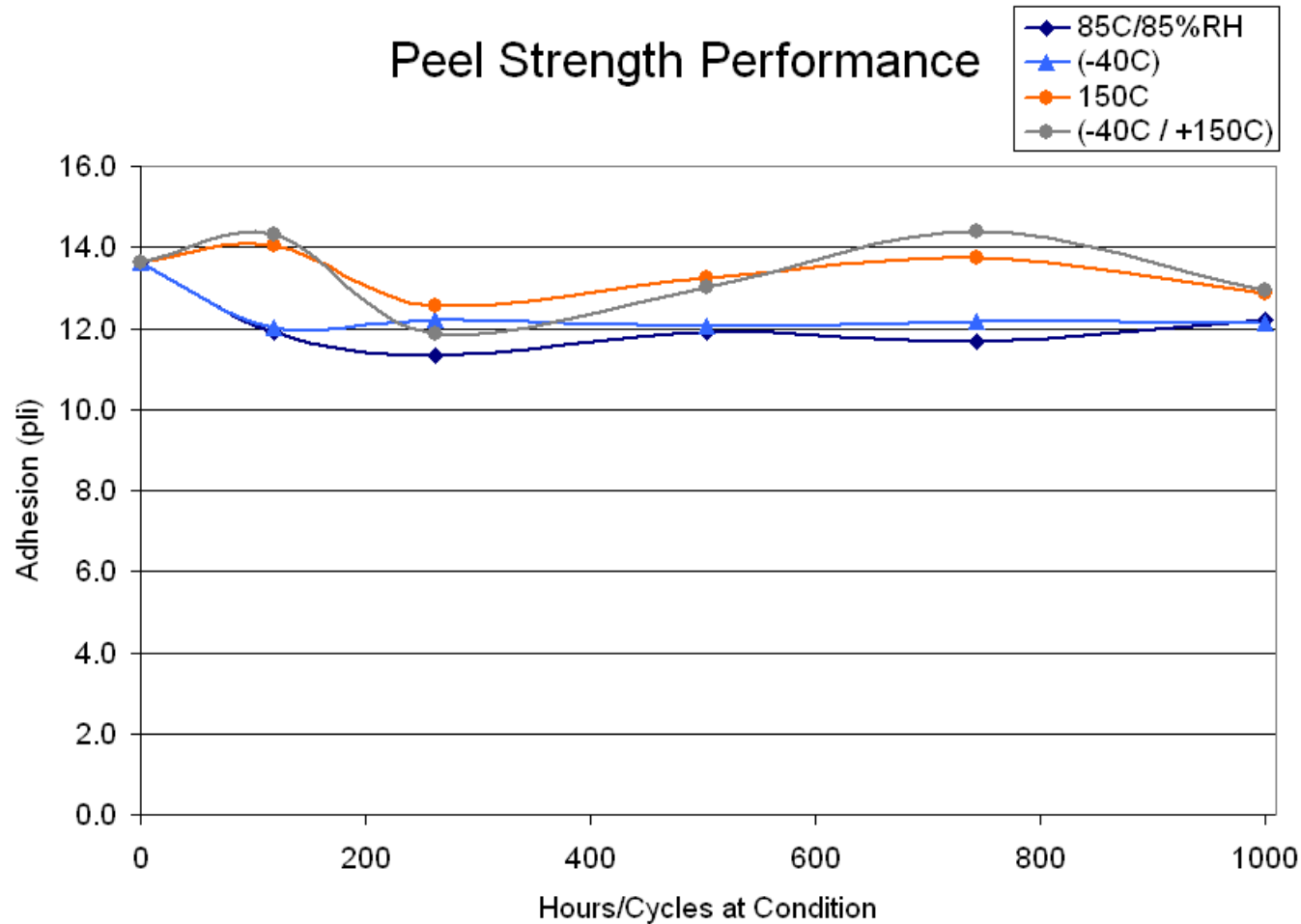
	Initial	85°C/85%RH after 1000 hr	(- 40°C) after 1000 hr	(+ 150°C) after 1000 hr	Thermal Cycle after 1000 cycles
BDV (VAC)	3240	2800	3392	3450	3654



Excellent Reliability: Adhesion

- IPC 2.4.9, Method B
- 2 in. / min peel rate_90° flat table
- 0.120 in. trace width
- Fails at PI - Al interface

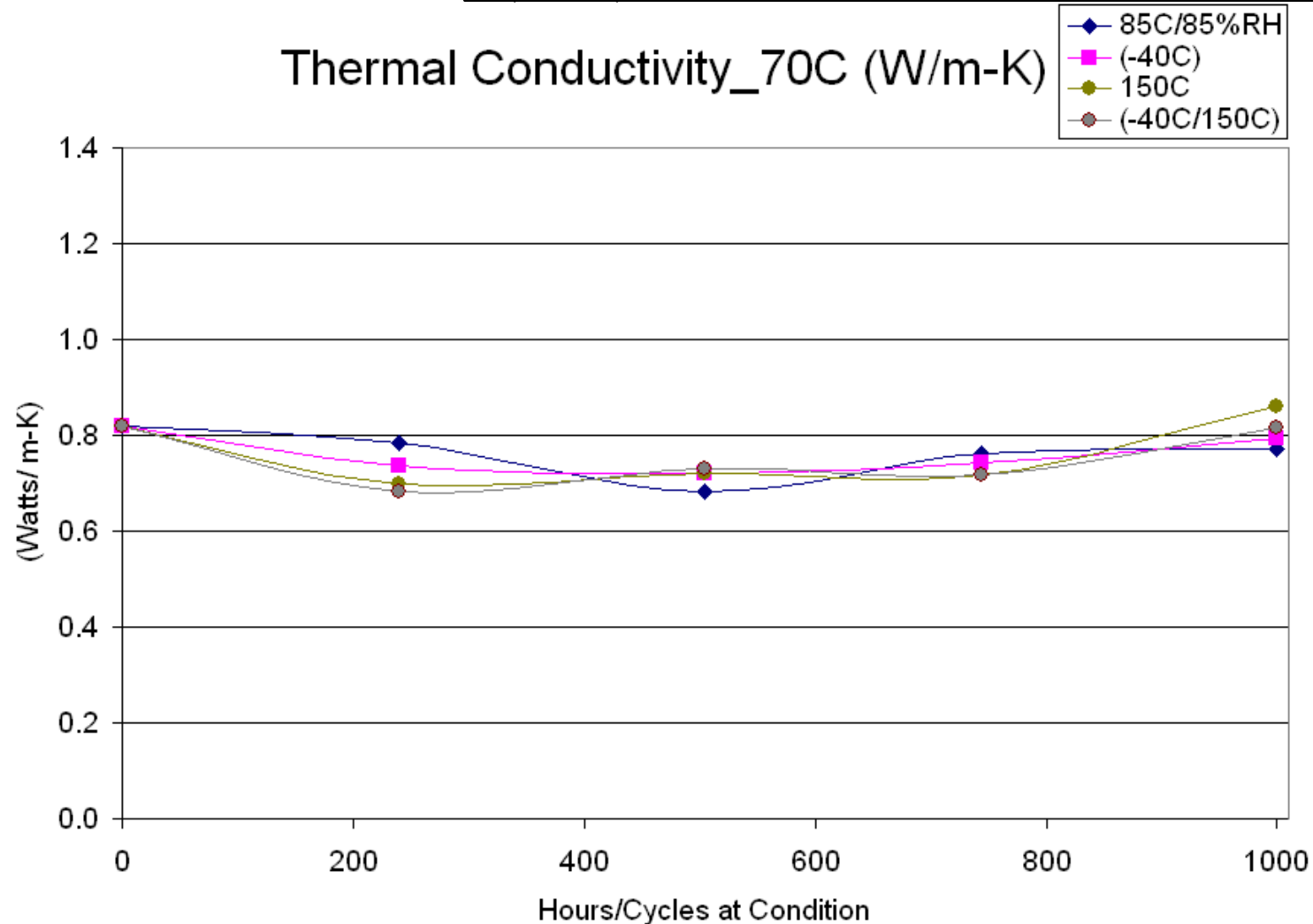
	Initial	85°C/85%RH after 1000 hr	(- 40°C) after 1000 hr	(+ 150°C) after 1000 hr	Thermal Cycle after 1000 cycles
Peel Strength (pli)	13.64	12.21	12.14	12.78	12.94



Excellent Reliability: Thermal Conductivity

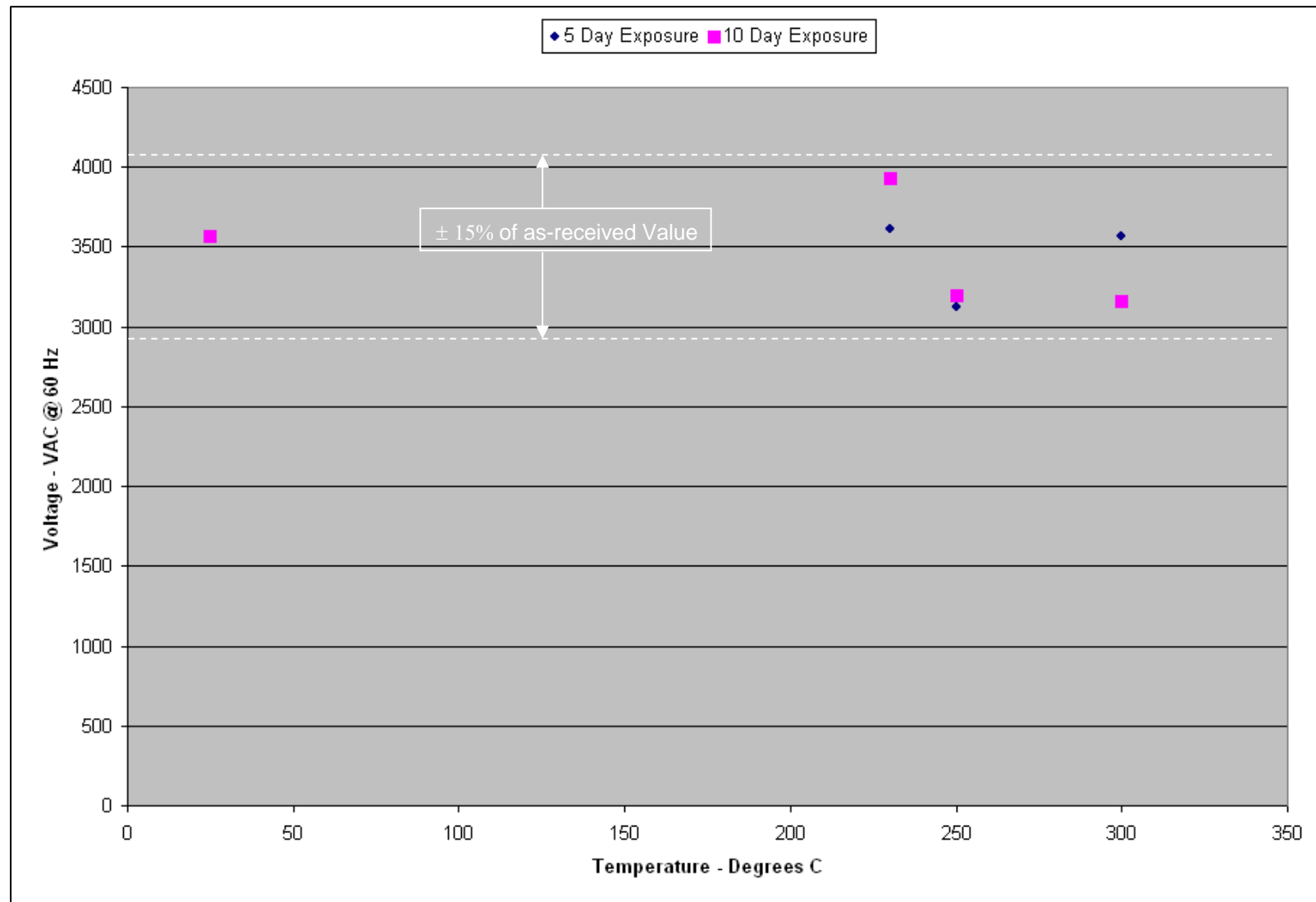
- ASTM E1461
- Model LFA 447_Nano-Flash Method
- Sample size: 15mm x 0.25mm thick
- 70°C Test Temperature

	Initial	85°C/85%RH after 1000 hr	(- 40°C) after 1000 hr	(+ 150°C) after 1000 hr	Thermal Cycle after 1000 cycles
Thermal Conductivity (W/m-°K)	0.82	0.81	0.79	0.86	0.82



Excellent Reliability: Thermal Aging

Dielectric Breakdown Voltage | PC-TM-650 Method 2.5.6.3



Conclusion: Coolam™ Provides:

- Very Low Thermal Impedance
- Excellent Reliability Performance
- Excellent Durability and Stability at High Temperature
- Uniform Thermal, Mechanical and Electrical Properties Under Environmental Stress Conditions
- Lead Free Solder and Wirebond Process Compatibility
- Halogen Free
- Meets UL 94 V-0
- Construction Variations to Meet Thermal Management Needs

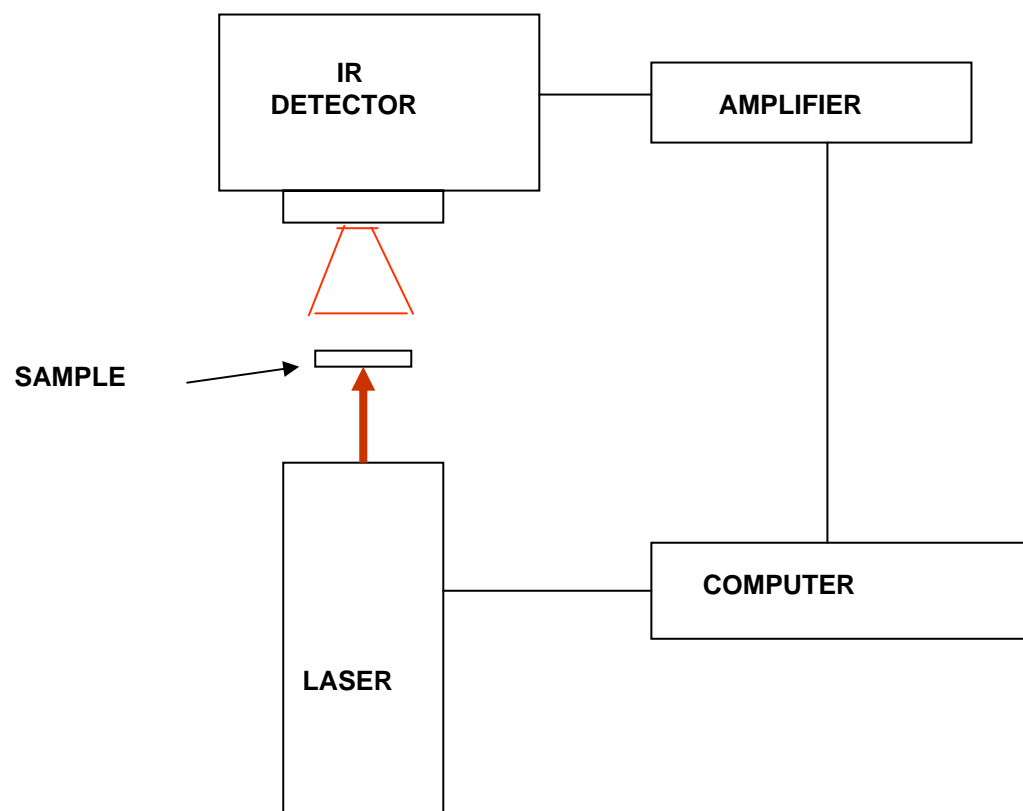


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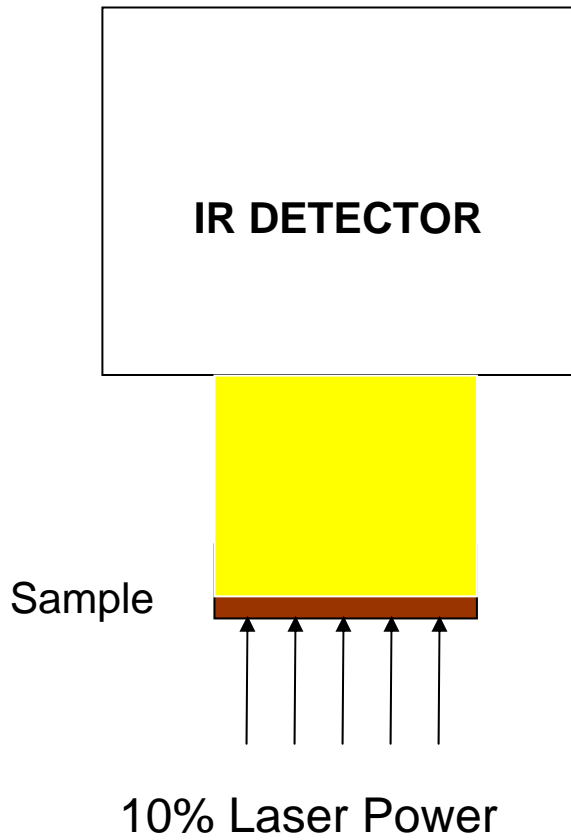
THERMAL CONDUCTIVITY TESTING

- **NETZSCH INC THERMAL PROPERTIES TEST INSTRUMENT**
- **LASER FLASH TECHNIQUE - ASTM E1461**
- **THRU-PLANE AND IN-PLANE CAPABILITY**
- **0.5" SQUARE SAMPLE FOR THROUGH-PLANE TESTING (0.4" SPOT SIZE)**
- **1" SQUARE SAMPLE FOR IN-PLANE TESTING**
- **CALIBRATE WITH KNOWN REFERENCE MATERIALS**
- **SIX TO NINE MEASUREMENTS ON EACH SAMPLE**

LASER FLASH BLOCK DIAGRAM



Through-Plane



In-Plane

