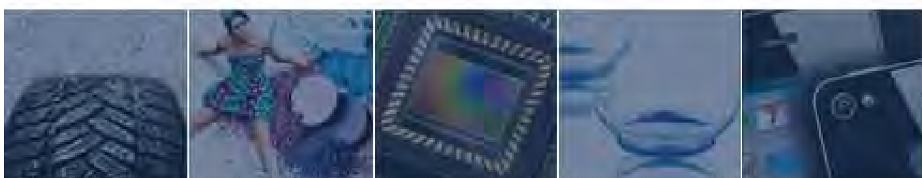
TIA241GF – 2 Part Gap Filler (Preliminary Data)

(4.1 W/mK – Low Temperature, Fast Cure, Thixotropic Gap Filler)



Cristian De Santis – ADE Electronics EU

May 2017

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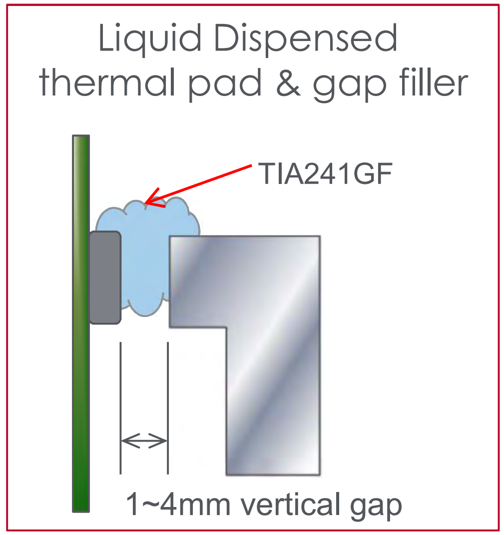
Introduction

Characteristics of MPM Liquid Dispense Gap Fillers:

- 2-Part Addition Cure
- Low Temperature Fast Cure
  - 70C x 30 minutes
  - Ability to Cure @ Room Temperature
- Stay-in-Place post-dispense shape retention
- Offer Best-In-Class levels of softness and stress-relief during thermal cycling
- V-0 UL certified



Advantages **vs.** Thermal Pads

- Thinner Bond Lines
- Conforms to non-planar surfaces
- Can conform to 3D designs
- Less stress on components
- No need for pre-cut / die-cut
- No tearing or damage during use

Advantages **vs.** Thermal Grease

- Elimination of Pump-Out
- Elimination of Dry-Out
- Easier reparability

Introduction

Description

TIA241GF is a 2-component, thermally conductive silicone material that is dispensed as a liquid and cured in place to create a heat path for efficient heat transfer. After being applied, its non-slumping pasty consistency provides physical stability to prevent run-off after dispense. TIA241GF can be used as a liquid dispensed alternative to pre-fabricated Thermal Pads, and as a Gap Filler for a broad array of thermal designs in electronic components.

KEY FEATURES

- Good thermal conductivity
- Fast, low temperature cure
- Retains softness after cure to contribute to stress relief during thermal cycling
- Easy to use 1:1 mixing ratio
- Conforms to complex shapes of 3-dimentional interface designs
- Repairable
- flame retardant: UL94V-0 equivalent

APPLICATIONS

Thermal interface for electronic components in Consumer, Telecommunications, Automotive and Lighting applications.

Material Properties

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Uncured Properties (23°C)	TIA241GF (A)	TIA241GF (B)
Appearance	Blue	Pale blue
Viscosity [Pas]	250	120
Mix ratio by weight	1 : 1	
Viscosity after mixing [Pas]	130	
Pot Life [h]	2	
Cure condition @ 100°C [h]	0.5	
Cure condition @ 23°C [h]	24	
Cured Properties (0.5h @100°C)		
Appearance	Blue	
Density [g/cm³]	3.14	
Thermal conductivity *1 [W/mK]	4.1	
Thermal resistance *2 [mm^2K/W]	30 (BLT: 80μm)	
Hardness [Type E]	45	
Tensile strength [MPa]	0.2	
Elongation [%]	40	
Volume resistivity [MΩ･m]	4.0×10^6	
Dielectric strength [kV/mm]	16	
CTE [ppm/K]	110	
Low volatile (D_4-D_{10}) [ppm]	150	
Flame retardant (UL94)	V-0 (planned)	
Shelf Life [months]	9 (planned)	
Relative temperature index (RTI)	150°C (planned)	

*1:Hotdisk
*2: Laser Flash

Material Appearance

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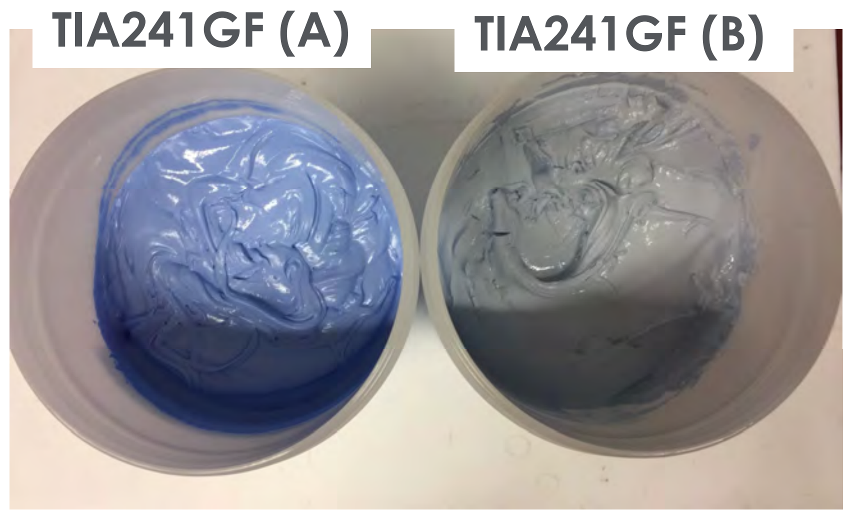


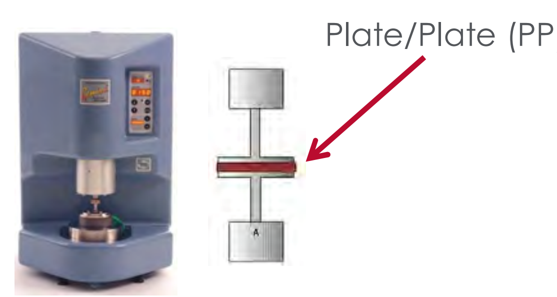
A-Component:
→ Blue, slightly flowable component

B-Component:
→ Light blue, thixotropic component

Viscosity Testing

TIA241GF - 161111			
	A	B	Mix
Viscosity @ 10°C [Pas - 10 1/s]	345	143	166
Viscosity @ 20°C [Pas - 10 1/s]	257	117	**125**
Viscosity @ 30°C [Pas - 10 1/s]	203	98	101
Viscosity @ 10°C [Pas - 1 1/s]	504	425	389
Viscosity @ 20°C [Pas - 1 1/s]	388	383	**342**
Viscosity @ 30°C [Pas - 1 1/s]	338	331	330
Thixotropic Index 10°C	1,46	2,97	2,34
Thixotropic Index 20°C	1,51	3,27	**2,74**
Thixotropic Index 30°C	1,66	3,37	3,26

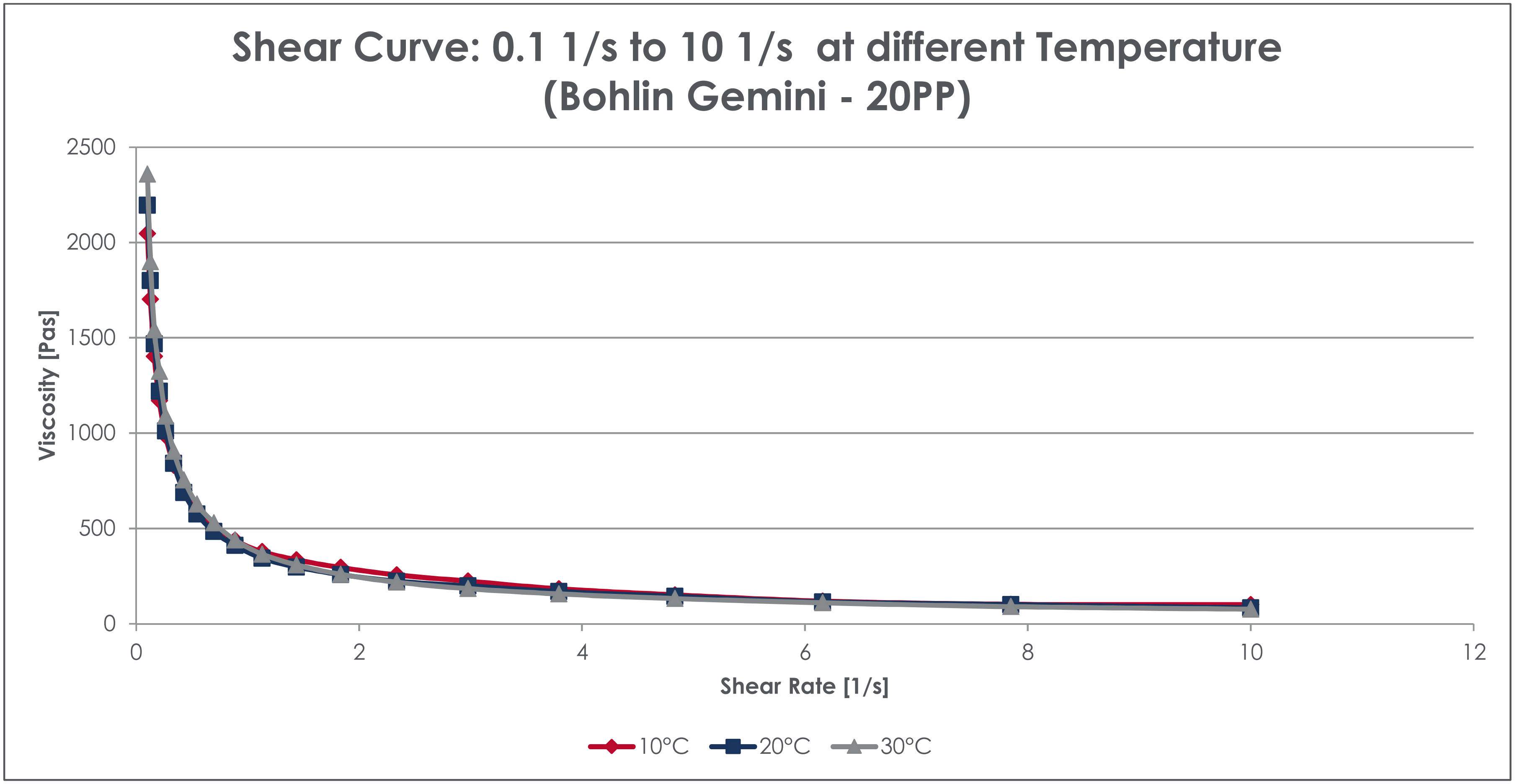
Test Condition: Bohlin Gemini Rheometer, 20mmPP; Mixed with static mixer 21 elements



→ **Material shows high TI (Thixo index)**

→ **Low in Viscosity, but still thixotropic**

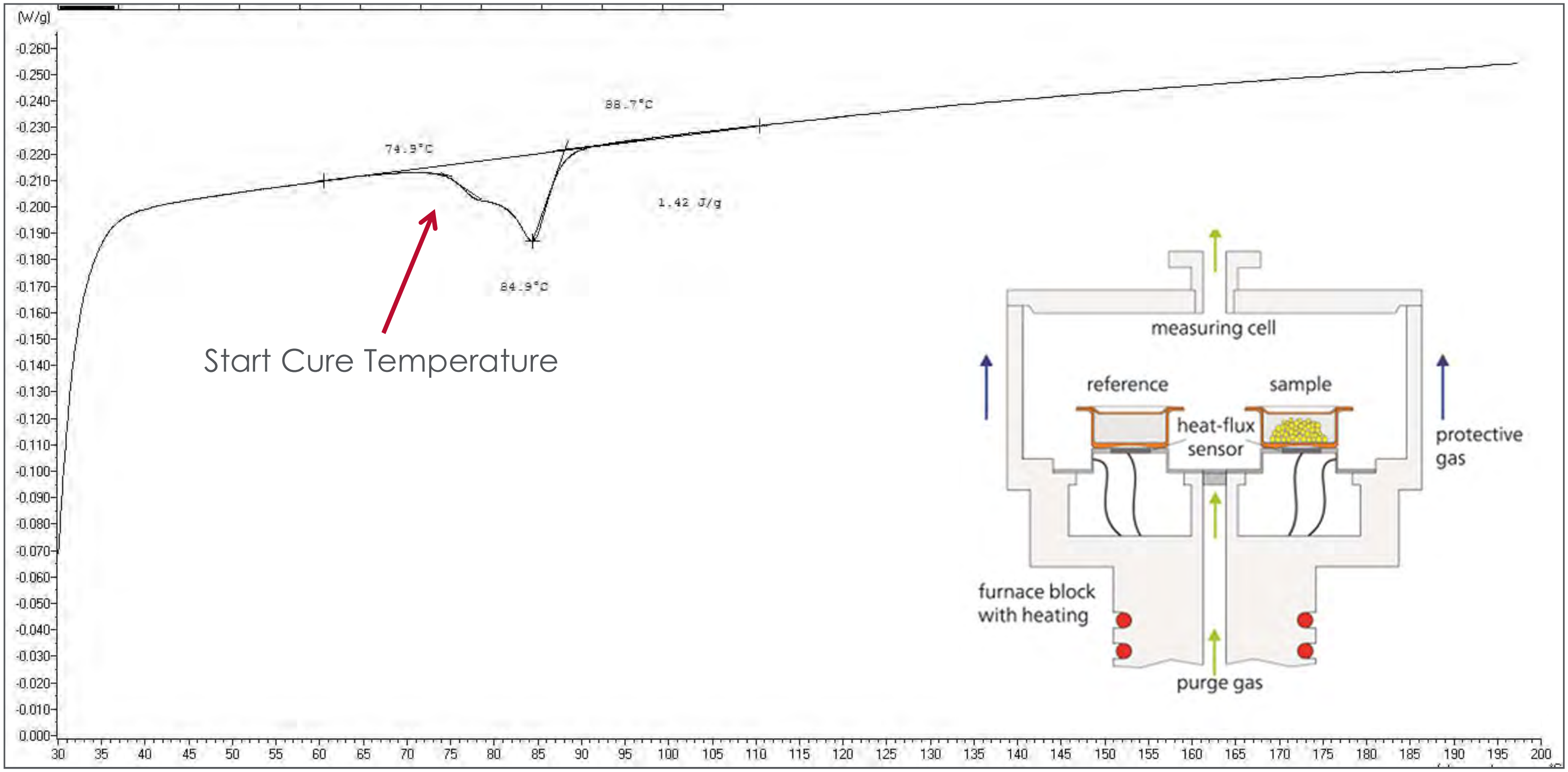
Viscosity Testing – Shear Curve



→ TIA241GF shows a shear thinning effect

→ Similar Viscosity at different shear rates

DSC Measurement (30°C – 200°C / 10K/min)



DSC: Differential Scanning Calorimeter: Mettler Toledo

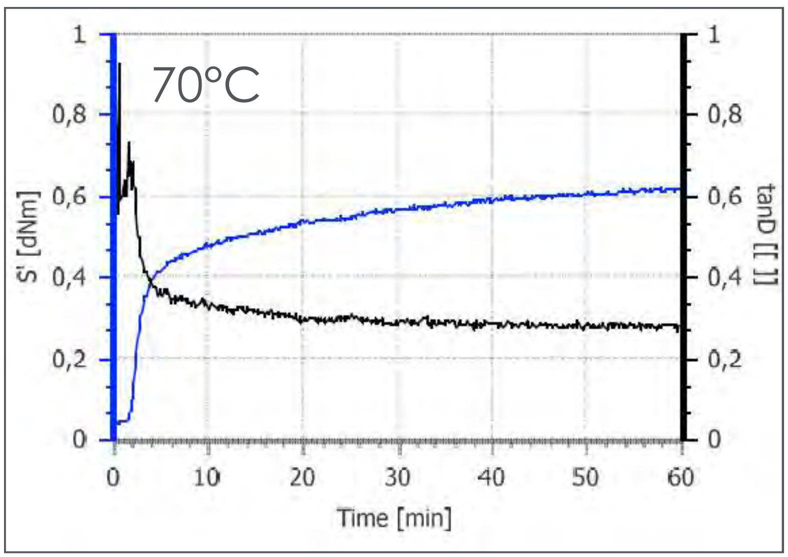
→ **Cure Start Temperature (T-Onset) at 75°C**

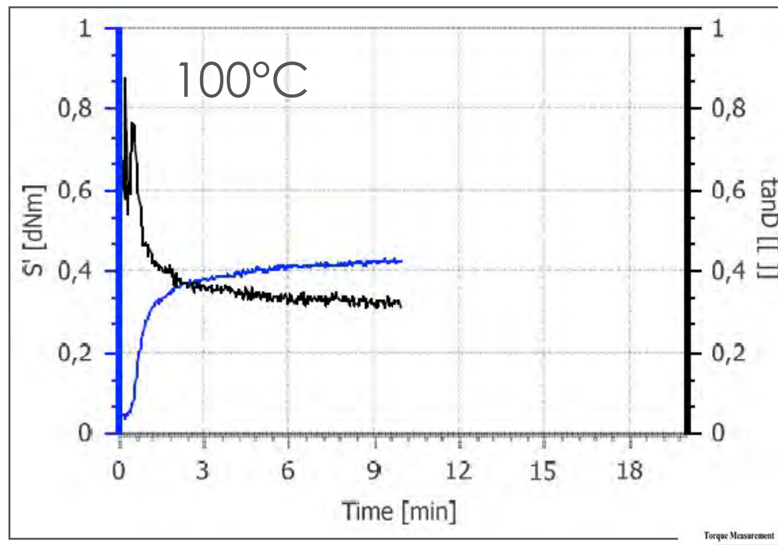
→ **Heat Flow (exothermic – cure) of 1.42J/g**

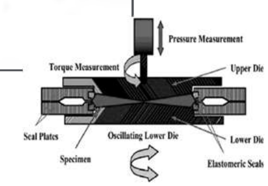
Cure Speed

	TIA241GF - 161111	
	70°C	**100°C**
T10 @ X°C [min]	1,97	0,27
T60 @ X°C [min]	4,02	0,31
T90 @ X°C [min]	26,44	0,43

Test Condition: RPA2000LV, 1:1 by weight; material hand mixed







→ TIA241GF cures quickly at elevated temperatures (here 70°C / 100°C)

Flowability - Test

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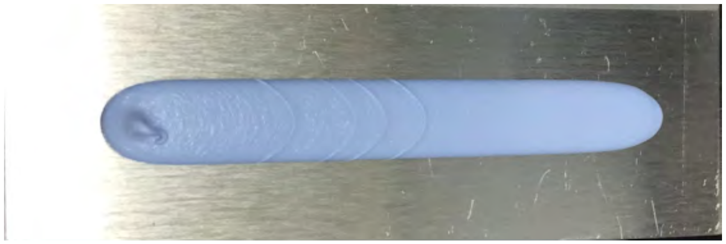
TIA241GF applied to Al substrate and two spacer added with 2 and 4mm



Nordson DN2403; Equalizer Device; Mixed with static mixer 21 elements

Second Al substrate applied and fixed

Vertical Storage at RT and check for dripping

→ No outflow from TIA241GF visible after 24 storage @ RT

Flowability – Test (continued)

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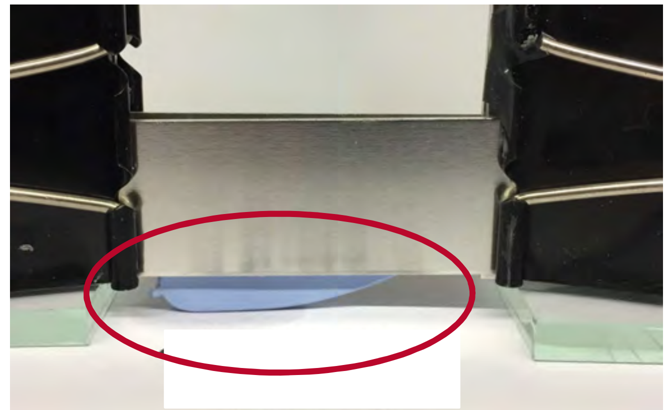
TIA241GF

Competitor 1 (4W/mK)



No outflow/dripping visible at 4mm gap

Outflow/dripping visible at 4mm gap

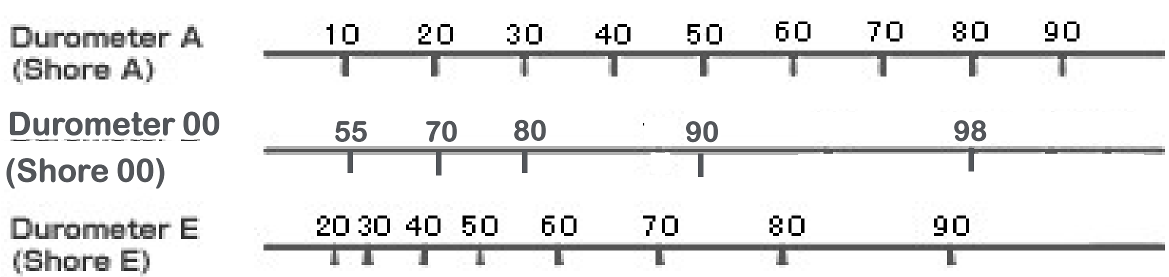
Hardness Test

Cure Time	Shore E	Shore 00
24h @ 24h	~36	~60
30min @ 70°C	~36	~60
60min @ 70°C	~36	~60
30min @100°C	~36	~60

→ **TIA241GF shows similar hardness values if cured at different temperatures**

→ **Material cured to a soft and stress absorbing material**

Hardness Conversion Table:



Thermal Conductivity

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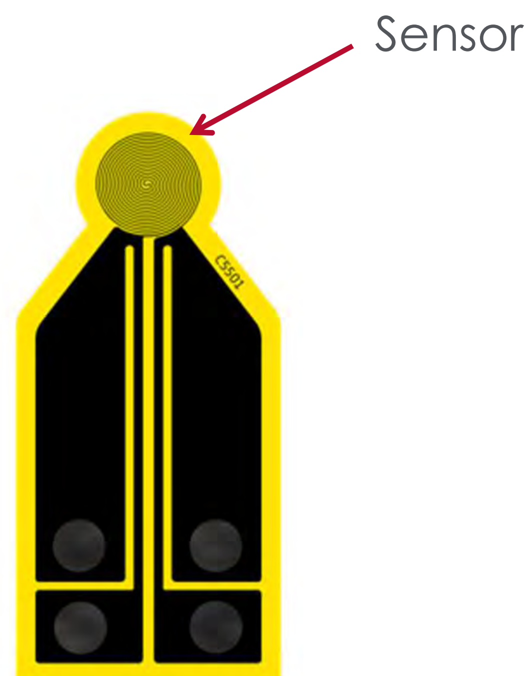
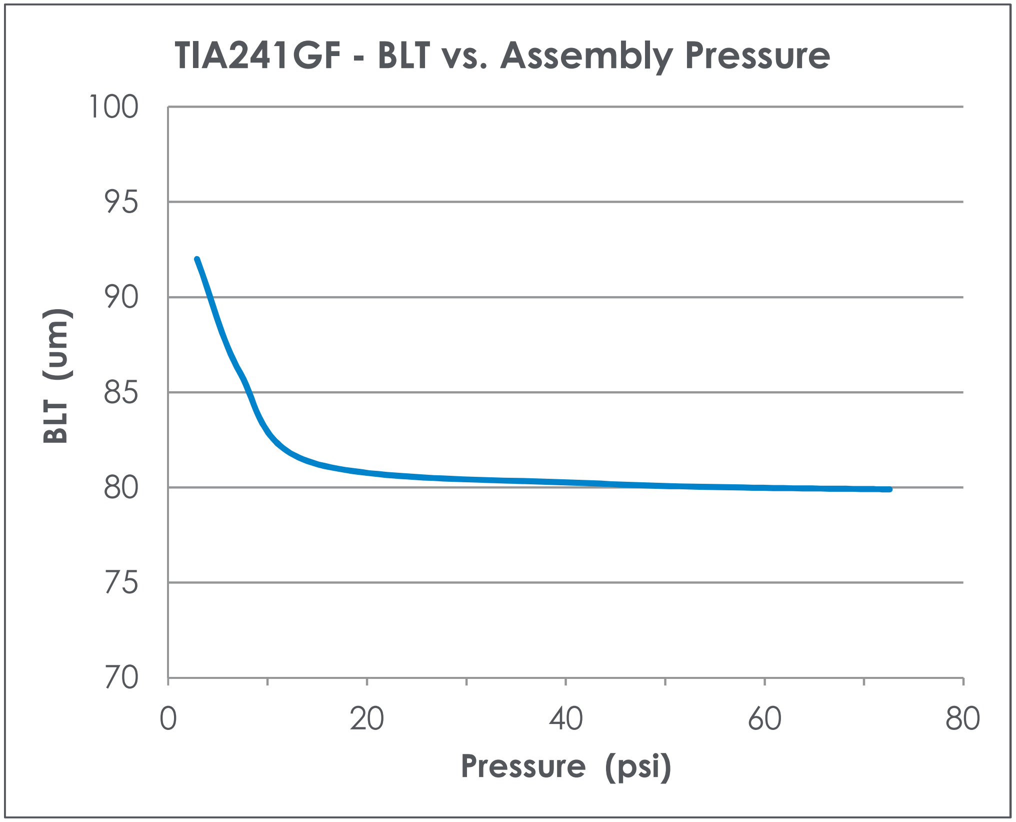
Measurement Device: TPS3500
Sensor: Kapton Sensor 6,4mm with cable
Sample: Cured TIA241GF Sheets (~9mm height; 40mm diameter; 30min @ 100°C (pressed)

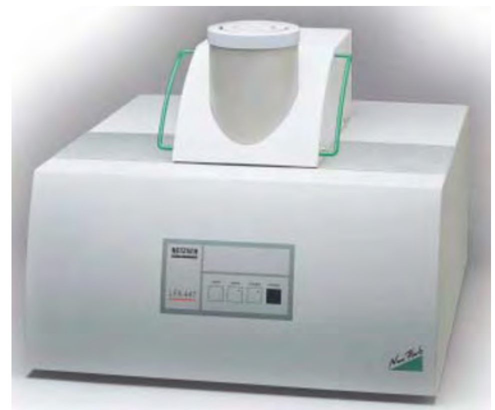
→ Thermal Conductivity: 4.1 W/mK



Thermal Resistance Measurement



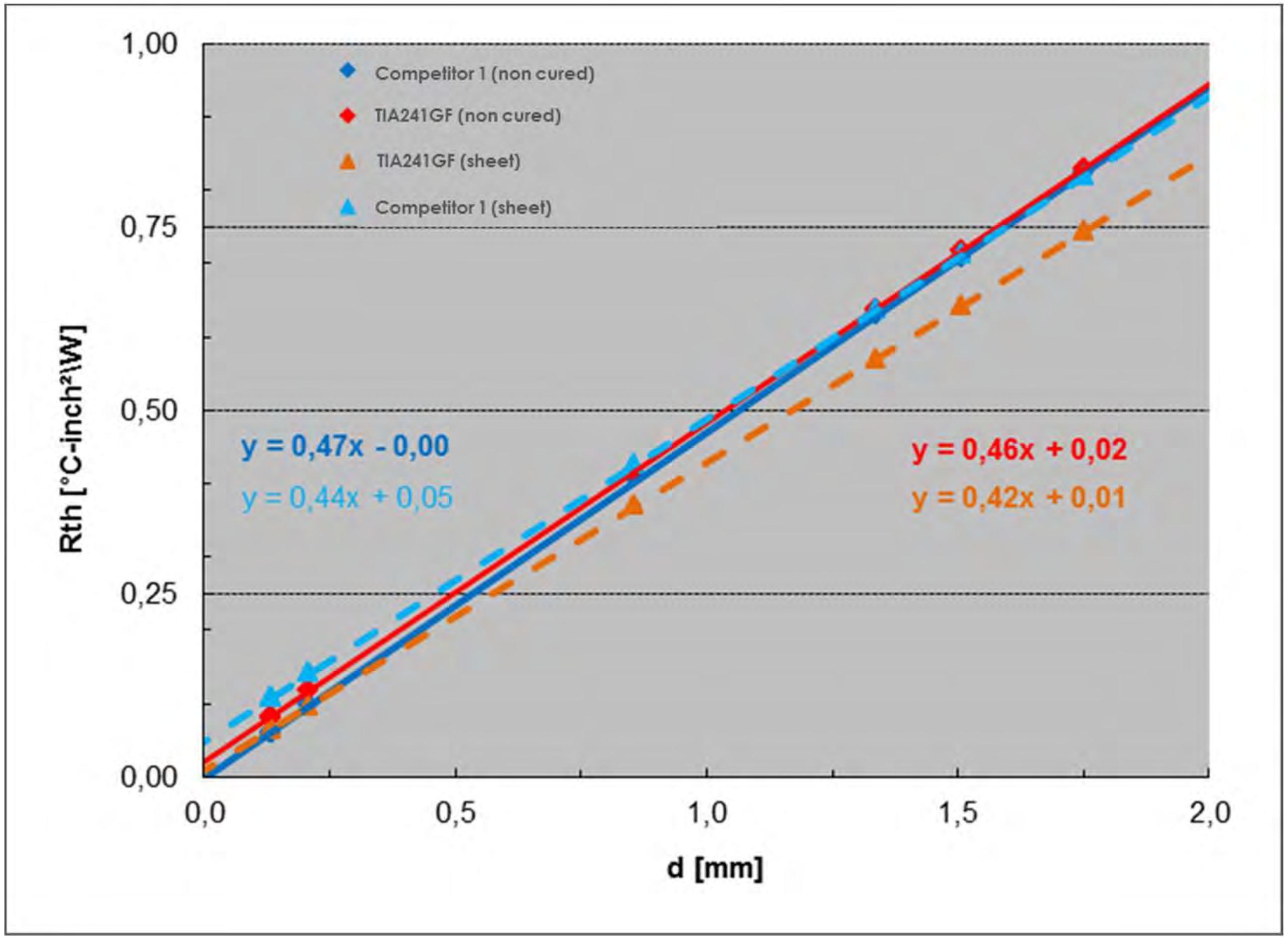
Pressure (psi)	Thermal resistance ($mm^2 \cdot K/W$)	BLT (um)
10	31	83
15	30	81
50	30	80



Test Conditions:
Sandwich 0.02ml of TIA241GF between 10mmX10mm silicon dies, and apply desired pressure for 30 sec. The sandwiched specimens are heated at 100C for 0.5 hour to cure TIA241GF.
Measure BLT.
Measure thermal resistance using laser flash.

→ **The thermal resistance of 30 mm^2K/W is reached at a BLT of 80µm**

Thermal Resistance Measurement

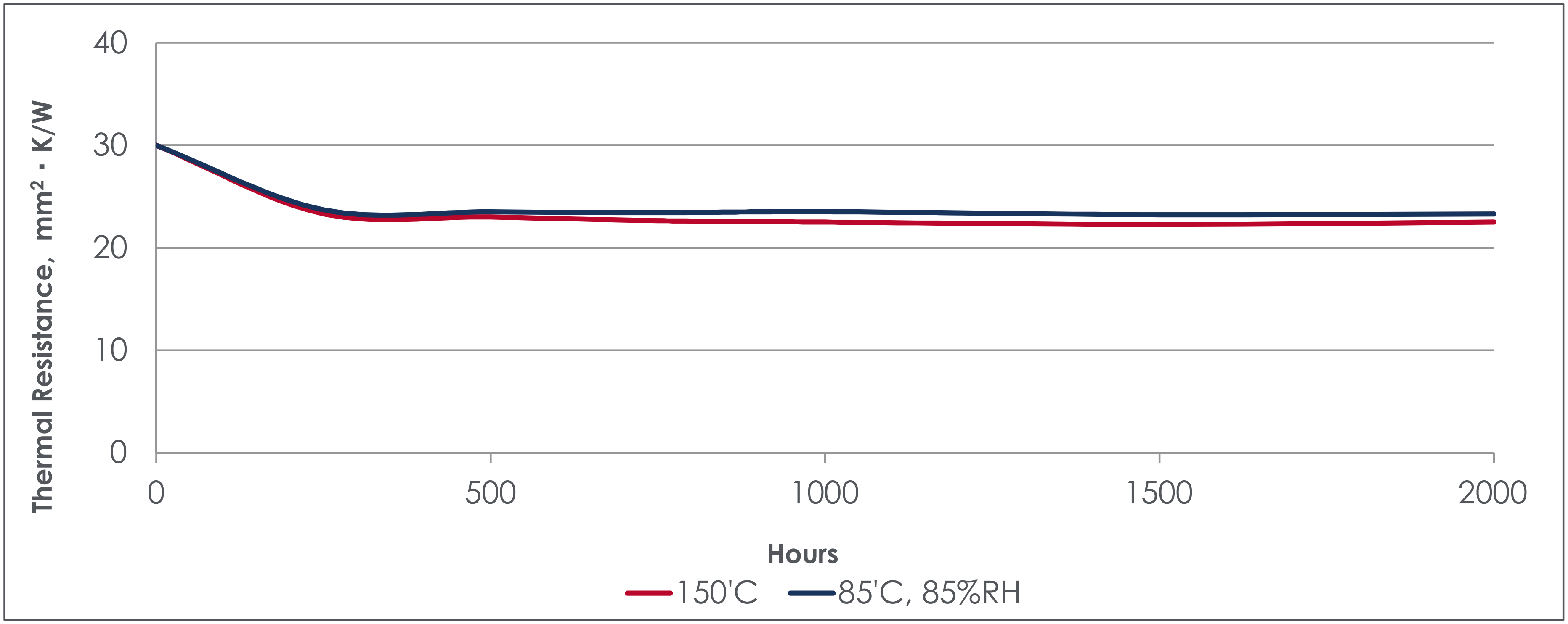


External Measurment

→ **TIA241GF shows a lower thermal resistance compared to the competior material (with the same TC value)**

LI-82-17144

Thermal Resistance – Reliability Data



Test Conditions:
Sandwich 0.02ml of TIA241GF between 10mm x10mm silicon dies, assemble at 500kPa pressure and cure at 100’C for 0.5 hour.

Measure thermal resistance using Laser Flash method.

→ **Thermal resistance decreased during the aging period to value of about 22 mm^2K/W**

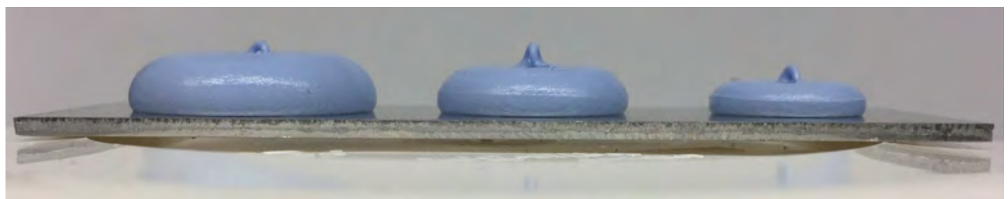
Dispensing Trials

	TIA241GF
Cartridge Type	50cc side by side
Static Mixer	21 Mixing Elements
Dispensing Speed	5-20mm/s
Nozzle Tip (Oilve)	1,6mm ID

Test Condition: Nordson DN2403; Equalizer Device;

→ **TIA241GF is easy to apply**

→ **No flow / sagging visible after curing**



Dispensing Trials (Continued)

Nordson DN2403; Equalizer Device; Mixed with static mixer 21 elements olive nozzle

→ **TIA241GF is easy to dispense**

→ **No flow / sagging visible after curing**

→ **very thixotropic**

Thermal Conductivity – Aging Data at different Temperature TC

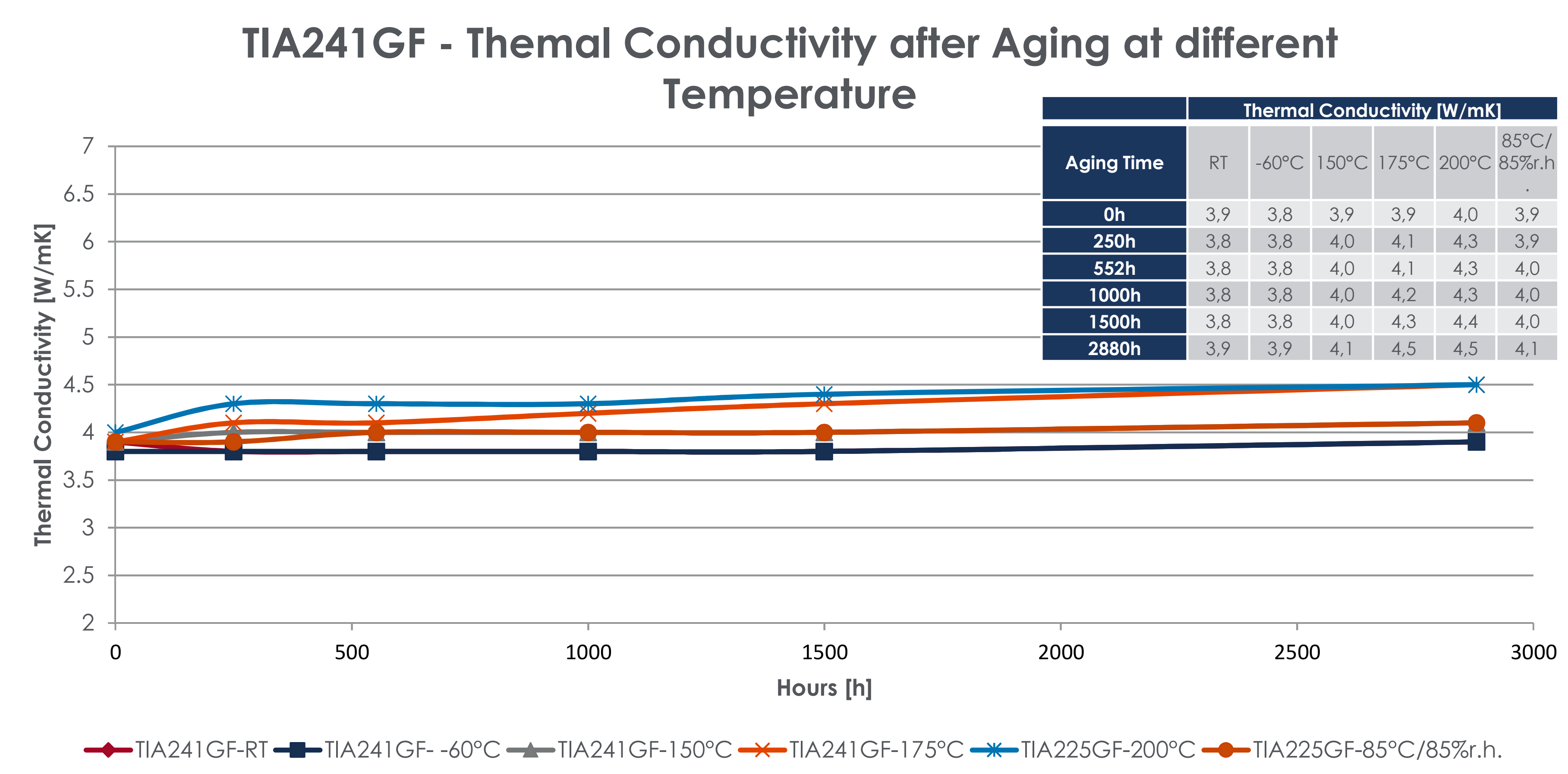
	0h						250h						552h						1000h						1500h						2880h					
	RT	-60°C	150°C	175°C	200°C	85°C/85%r.h.	RT	-60°C	150°C	175°C	200°C	85°C/85%r.h.	RT	-60°C	150°C	175°C	200°C	85°C/85%r.h.	RT	-60°C	150°C	175°C	200°C	85°C/85%r.h.	RT	-60°C	150°C	175°C	200°C	85°C/85%r.h.	RT	-60°C	150°C	175°C	200°C	85°C/85%r.h.
Thermal Conductivity [W/mK]	3,9	3,8	3,9	3,9	4,0	3,9	3,8	3,8	4,0	4,1	4,3	3,9	3,8	3,8	4,0	4,1	4,3	4,0	3,8	3,8	4,0	4,2	4,3	4,0	3,8	3,8	4,0	4,3	4,4	4,0	3,9	3,9	4,1	4,5	4,5	4,1
Thermal Diffusivity [mm²/s]	1,4	1,4	1,4	1,5	1,5	1,4	1,4	1,4	1,4	1,5	1,6	1,4	1,5	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,5	2,1	1,4	1,5	1,4	1,4	1,4	1,4	1,4	1,5	1,4	1,6	1,8	1,7	1,5
Specific Heat [MJ/m³K]	2,8	2,8	2,8	2,8	2,7	2,8	2,8	2,7	2,9	2,7	2,7	2,8	2,5	2,7	2,7	2,9	2,9	2,8	2,8	2,7	2,9	2,8	2,1	2,8	2,5	2,7	2,7	2,9	2,9	2,8	2,7	2,8	2,7	2,6	2,7	2,8
Heat Capacity [J/gK]	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,8	0,9	0,8	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,7	0,9	0,8	0,9	0,9	0,9	0,9	0,9	0,8	0,9	0,8	0,8	0,9	0,9
Thermal Resistance (mm²K/W) –calculatued*	26	26	26	26	25	26	26	27	25	24	23	26	26	26	25	24	23	25	26	27	25	23	22	25	26	26	25	24	23	25	26	26	24	22	22	25

Test Condition:
Measurement Device: TPS3500
Sensor: Kapton Sensor 6,4mm with cable
Sample: Cured TIA241GF Sheets (~8mm height; 30mm diameter; 30min @ 100°C (pressed)

*Formula: 1/Thermal Conductivity *100

- → **TIA241GF has a constant thermal conductivity after RT/-60°C storage**
- → **TIA241GF shows a thermal conductivity increase if samples are stored at higher temperature**
  - → **At 150°C a TC increase of 6% after 2880h**
  - → **At 175°C a TC increase of 18% after 2880h**
  - → **At 200°C a TC increase of 14% after 2880h**

Thermal Conductivity Change – Aging at different Temperature

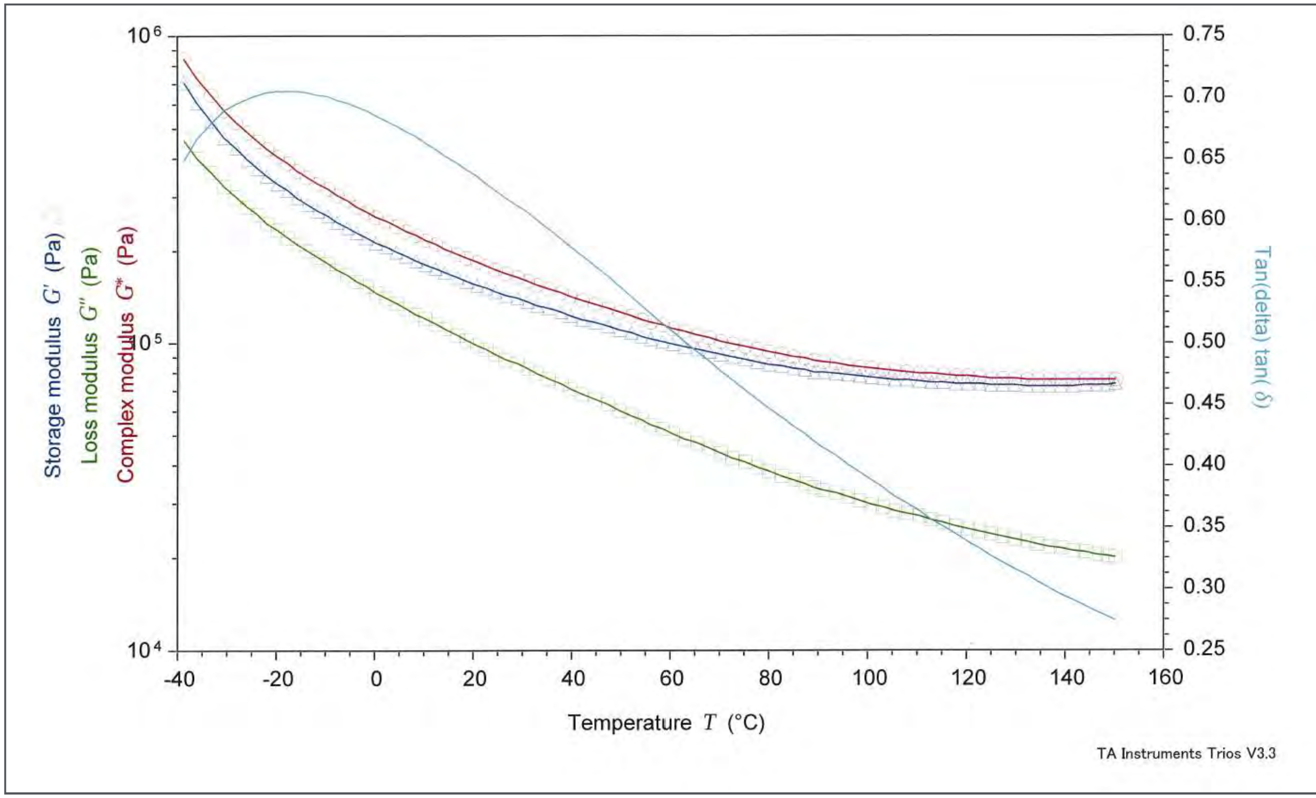


	Thermal Conductivity [W/mK]					
Aging Time	RT	-60°C	150°C	175°C	200°C	85°C/ 85%r.h.
0h	3,9	3,8	3,9	3,9	4,0	3,9
250h	3,8	3,8	4,0	4,1	4,3	3,9
552h	3,8	3,8	4,0	4,1	4,3	4,0
1000h	3,8	3,8	4,0	4,2	4,3	4,0
1500h	3,8	3,8	4,0	4,3	4,4	4,0
2880h	3,9	3,9	4,1	4,5	4,5	4,1

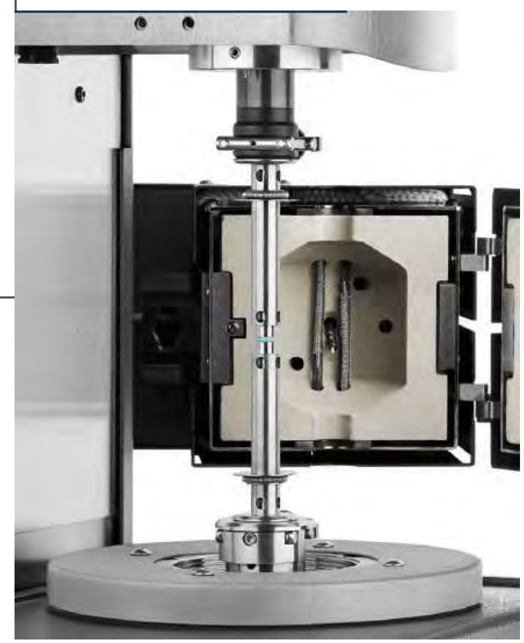
→ **TIA241GF has a constant thermal conductivity after RT/-60°C storage**

→ **TIA241GF shows a thermal conductivity increase if samples are stored at higher temperature**

Viscoelasticity Properties



ARES
Sample Geometry
Diameter 25.0mm
Gap 1.0mm
Test Condition
Frequency 10Hz
Initial Temp. -40.-0C
Final Temp. 150.0C
Ramp Rate 5.0C/min
Strain 3.0%



Temperature	Tan(delta)	G'	G"	G*	Young's modulus
°C		Pa	Pa	Pa	MPa
-40	0.65	7.05E+05	4.58E+05	8.41E+05	2.5
-20	0.71	3.30E+05	2.33E+05	4.04E+05	1.2
0	0.69	2.13E+05	1.46E+05	2.58E+05	0.77
25	0.62	1.47E+05	9.17E+04	1.73E+05	0.52
50	0.55	1.10E+05	6.02E+04	1.26E+05	0.38
80	0.45	8.52E+04	3.81E+04	9.33E+04	0.28
100	0.39	7.69E+04	2.98E+04	8.25E+04	0.25
120	0.34	7.34E+04	2.48E+04	7.75E+04	0.23
150	0.27	7.32E+04	2.00E+04	7.59E+04	0.23

Flammability Test Results (Internal Test)

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UL 94 VERTICAL BURNING TEST FOR CLASSIFYING MATERIALS V-0, V-1 OR V-2

METHOD

Specimens were tested in accordance with UL 94, Fifth Edition. Room conditions during testing were maintained at 23 ± 2 ℃ and 50 ± 5% R.H.

RESULTS

Material: TIA241GF (3.0mm) Color: Blue (Radius<1.3 mm X Width 13.0 ± 0.5mm X)

Min. 48 h Cond. at 23 ± 2 ℃ and 50 ± 5%R.H.					Conditioned 168 h at 70 ±1 ℃				
Speci-men	Thk mm	t_1 s	t_2 s	$t_2 + t_3$ s	Speci-men	Thk mm	t_1 s	t_2 s	$t_2 + t_3$ s
1	3.08	0 (2)	0	1 (2)	1	3.05	0 (2)	0	1 (2)
2	3.07	0 (2)	0	0 (2)	2	3.07	0 (2)	0	1 (2)
3	3.09	0 (2)	0	1 (2)	3	3.08	0 (2)	0	1 (2)
4	3.05	0 (2)	0	1 (2)	4	3.07	0 (2)	0	1 (2)
5	3.03	0 (2)	1	0 (2)	5	3.00	0 (2)	0	1 (2)
Avg.	3.064	Total Flame Time ($t_1 + t_2$), s: 1			Avg.	3.054	Total Flame Time ($t_1 + t_2$), s: 0		

FLAME CLASS

V-0

(2) Specimen did not drip.

→ Internal Flammability Test led to a UL classification of UL94-V0 (at 3mm)

Summary

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inventing possibilities

- → TIA241GF is a soft silicone gap filler material
- → Material shows a high thixotropic behavior
- → Material cures fast at low temperature (70°C)
- → Easy 1 to 1 mix ratio
- → high thermal conductivity of 4.1W/mK
- → Easy to apply
- → Useful Temperature: -60°C to 200°C

Packaging / Storage Condition / Shelf-Life

Packaging
3.2kg 20Oz Semco Kit (1.6kg A / 1.6kg B) (planned)
Plastic Mauser Pail Kit (25kg A / 25kg B) (planned)

Shelf Life:
270 days (planned)

Minimum Remaining Shelf Life:
90 days (planned)

Storage Condition:
<43°C

Term Definition

Definition of Thermal Diffusivity

Thermal diffusivity (*a* with the unit mm²/s) is a material-specific property for characterizing unsteady heat conduction. This value describes how quickly a material reacts to a change in temperature.

In order to predict cooling processes or to simulate temperature fields, the thermal diffusivity must be known; it is a requisite for solving the Fourier Differential Equation for unsteady heat conduction.

Material	Thermal Conductivity / W/(m•K)	Thermal Diffusivity / mm²/s
Aluminum	237	98.8
Steel	81	22.8
Copper	399	117
Fused Silica	1.40	0.87
Gypsum	0.51	0.47
Polyethylene	0.35	0.15
Marble	2.8	1.35

Definition of Thermal Conductivity

Thermal conductivity (λ with the unit W/(m•K)) describes the transport of energy – in the form of heat – through a body of mass as the result of a temperature gradient. According to the second law of thermodynamics, heat always flows in the direction of the lower temperature.

The relationship between transported heat per unit of time (dQ/dt or heat flow Q) and the temperature gradient (ΔT/Δx) through Area A (the area through which the heat is flowing perpendicularly at a steady rate) is described by the thermal conductivity equation.

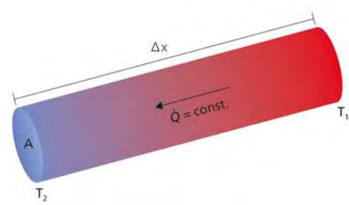
Thermal conductivity is thus a material-specific property used for characterizing steady heat transport. It can be calculated using the following equation:

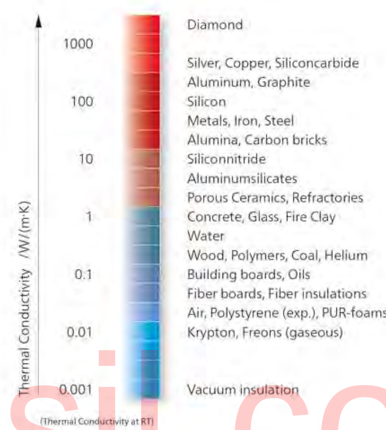
$$\lambda(T) = \rho(T) \cdot c_p(T) \cdot a(T)$$

Where *a*: Thermal diffusivity

c_p: Specific heat capacity

ρ: Density





Term Definition

Specific Heat / Heat Capacity
The specific heat is the amount of heat per unit mass required to raise the temperature by one degree Celsius (J/g°C)

Heat capacity is defined as the ratio of the amount of energy transferred to a materials and the change in temperature that is produced:

$C = Q / \Delta T$

where C is heat capacity, Q is energy (usually expressed in joules), and ΔT is the change in temperature (usually in degrees Celsius or in Kelvin). Alternatively, the equation may be written:

$Q = Cm\Delta T$

Specific heat and heat capacity are related by mass:

$C = m * S$

Where C is heat capacity, m is mass of a material, and S is specific heat.

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