

TWENTY-FOURTH ANNUAL



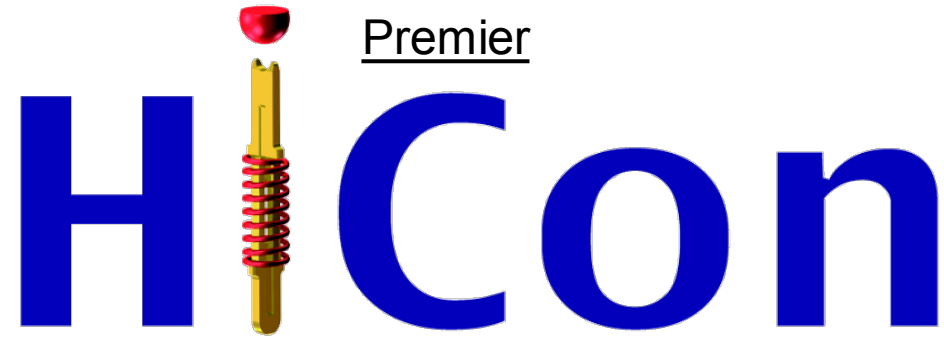
TestConX™

Archive

DoubleTree by Hilton
Mesa, Arizona
March 5-8, 2023

With Thanks to Our Sponsors!

Premier



Honored



With Thanks to Our Sponsors!

Distinguished



Industry Partners



COPYRIGHT NOTICE

The presentation(s) / poster(s) in this publication comprise the Proceedings of the TestConX 2023 workshop. The content reflects the opinion of the authors and their respective companies. They are reproduced here as they were presented at the TestConX 2023 workshop. This version of the presentation or poster may differ from the version that was distributed at or prior to the TestConX 2023 workshop.

The inclusion of the presentations/posters in this publication does not constitute an endorsement by TestConX or the workshop's sponsors. There is NO copyright protection claimed on the presentation/poster content by TestConX. However, each presentation / poster is the work of the authors and their respective companies: as such, it is strongly encouraged that any use reflect proper acknowledgement to the appropriate source. Any questions regarding the use of any materials presented should be directed to the author(s) or their companies.

“TestConX”, the TestConX logo, and the TestConX China logo are trademarks of TestConX. All rights reserved.

www.testconx.org

Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

Kristoffer Martinsen, Lars Almhem, Hongfeng Zhang, Johan Liu
Smart High Tech AB



Mesa, Arizona • March 5-8, 2023



TestConX 2023

Overview

- Definition of thermal interface material (TIM)
- What is a graphene TIM?
 - Physical properties
- Cases
 - Thermal conductivity measurement (ASTM 5470)
 - Power cycling
 - Computer tests
 - Reliability tests



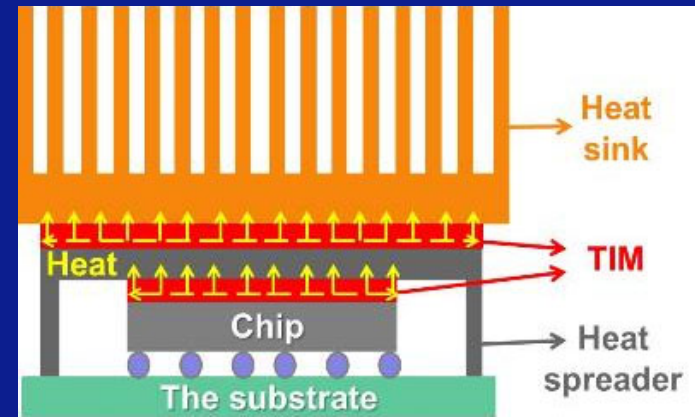
Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

2 **2023**

TestConX 2023

Thermal interface materials (TIM)

- Gap filler facilitating heat transfer
- Desirable properties
 - High thermal conductivity
 - Soft
 - Reusable
 - Inexpensive

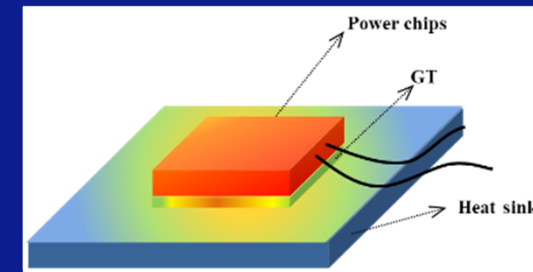
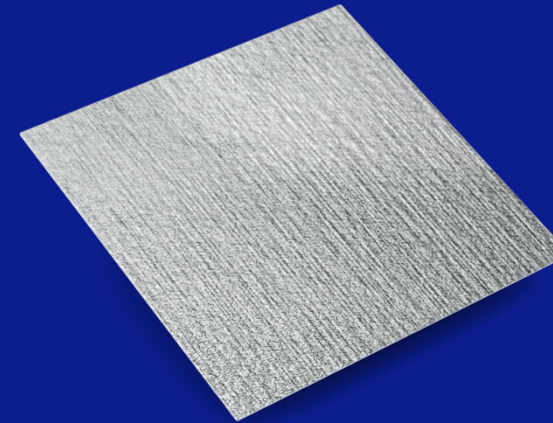


TestConX 2023

Graphene TIM

Why graphene?

- Carbon allotrope
- Low thermal resistance
- High thermal conductivity
- Excellent compressibility
- Cost competitive



Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

4

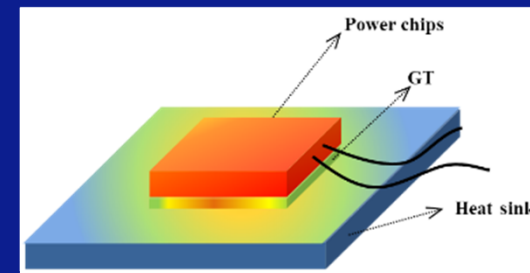
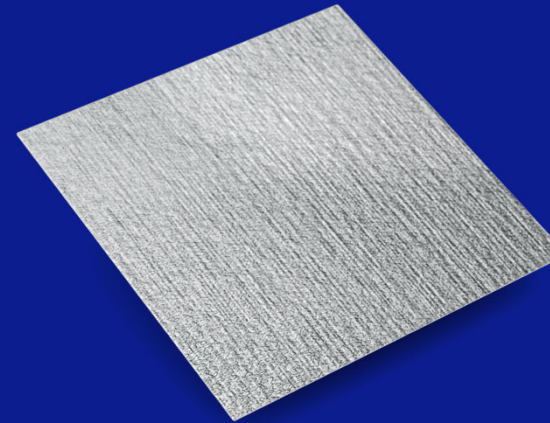
2023

TestConX 2023

Graphene TIM

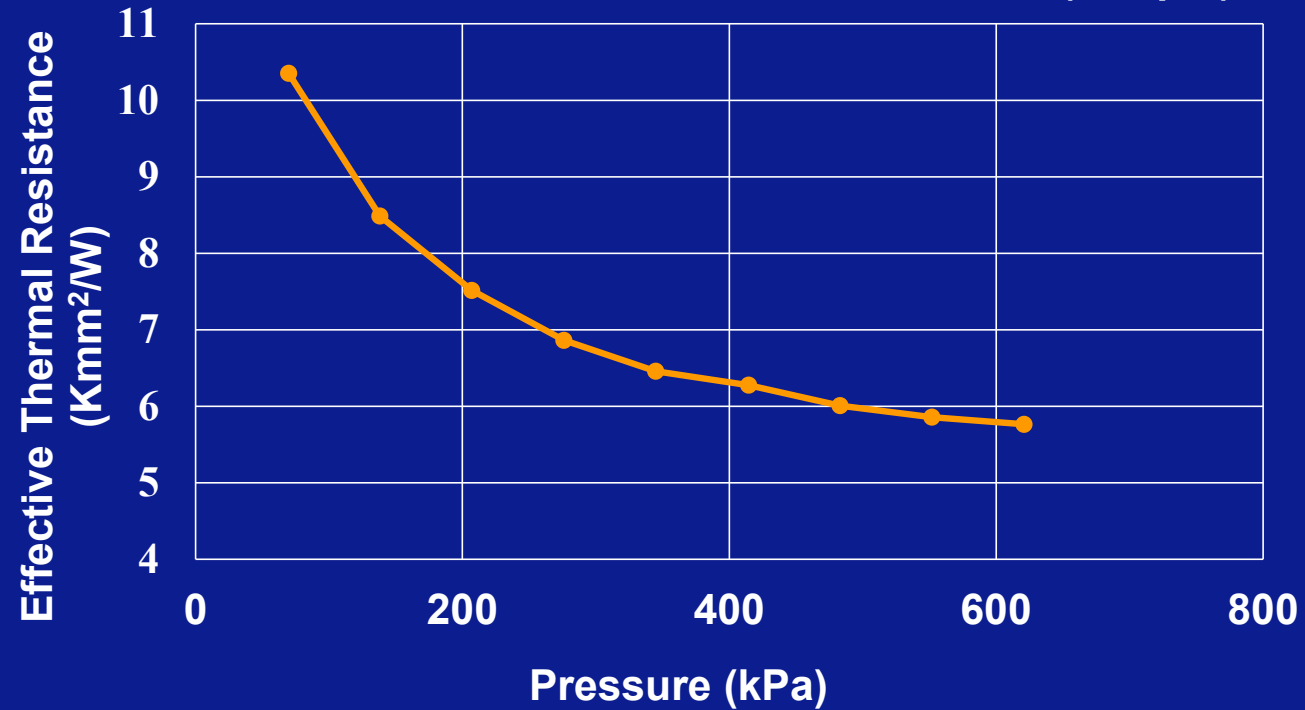
Potential areas of use:

- Thermal burn-in
- Computer components
 - Computer Processing Units, (CPU)
 - Graphic Processing Units, (GPU)
- Servers
- Portable devices (e.g Steam Deck)



Graphene TIM

Effective Thermal Resistance vs Pressure (300 μm)



Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

6 **2023**

TestConX 2023

Graphene TIM

Properties	GT-50	GT-70S	GT-90S	GT-90SPRO	GT-100S	Units
Thickness range	0.20-2	0.30-1	0.20-2	0.20-2	1.5	mm
Compressibility	> 30	> 50	> 50	> 50	> 30	%
Recovery	> 50	> 70	> 60	> 50	> 50	%
Temperature Range	-40 to 150	- 40 to 150	- 40 to 150	- 40 to 150	- 40 to 150	°C
Thermal conductivity	50 ± 5	70 ± 10	90 ± 10	90 ± 10	100 ± 10	W/mK
Thermal resistance (0.3 mm, 100 or 275 kPa)	30 ± 10	25 ± 5	20 ± 5	20 ± 5	14 ± 0.5 (275 kPa)	Kmm ² /W
	12 ± 1	8.5 ± 1.5	6.7 ± 0.5	6.7 ± 0.5		
Pressure at 50% displacement	1100 ± 50	200 ± 50	690 ± 50	500 ± 50	1500 ± 100	kPa



Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

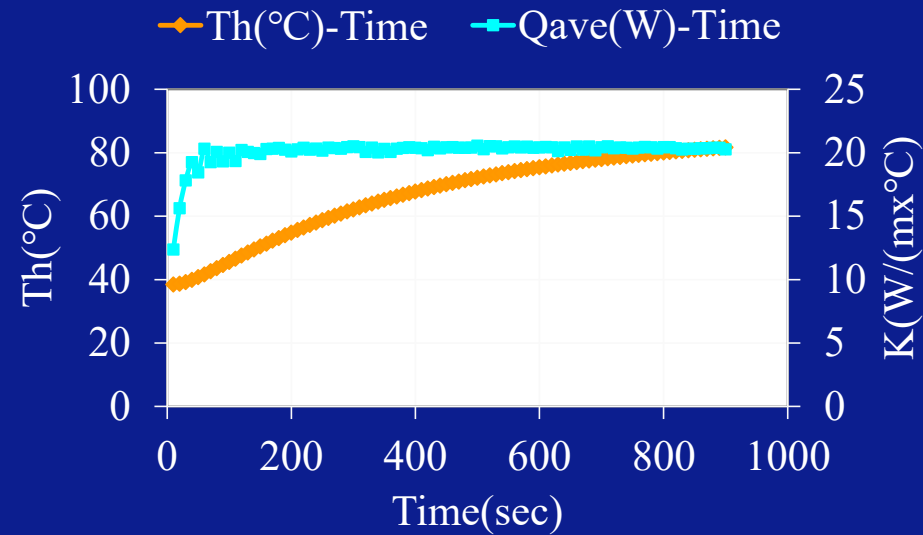
7

2023

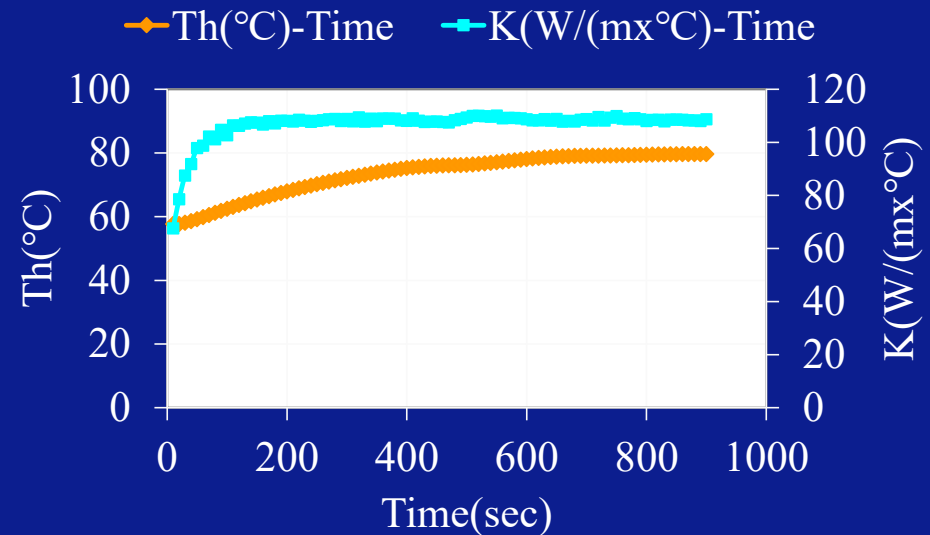
TestConX 2023

Thermal Burn-in: GT-50 to GT-100s

- Tested with Longwin ASTM D5470



300 μm



1,5 mm

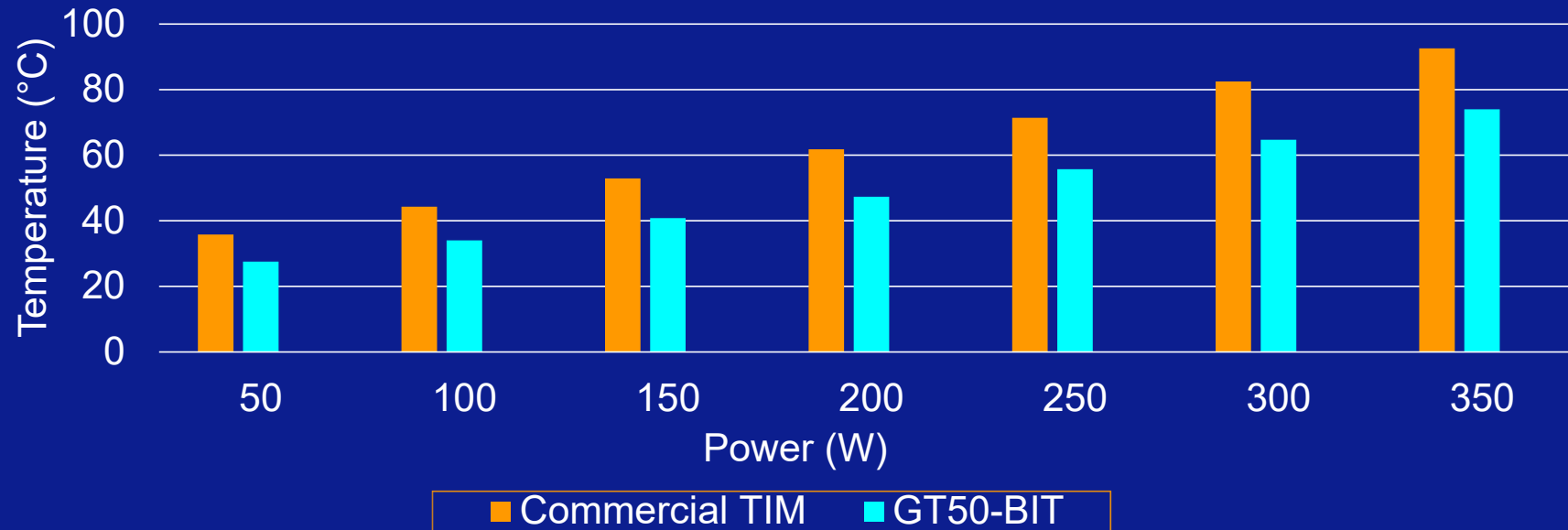


Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

8 **2023**

Thermal Burn-In: Test Report of GT-50

Commercial TIM vs GT-50 in terms of power dissipation performance



Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

9 **2023**

TestConX 2023

Thermal Burn-In: Test by Customer

35.6°C
Graphite

27.6°C
Competitor

25.1°C
GT-50



Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

10

2023

Graphene TIM in Computer

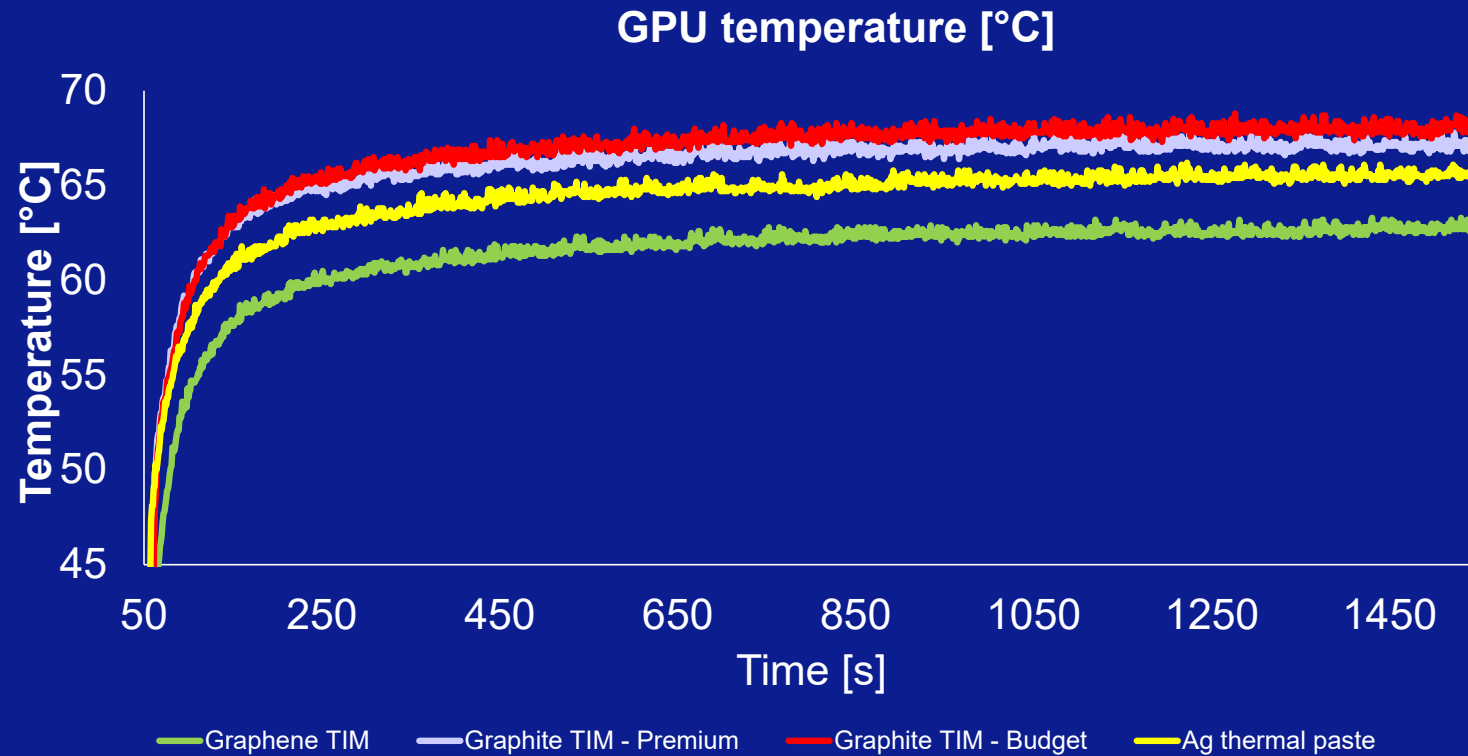
- Computer specification:
 - CPU: Intel i5-11600K 3,9 GHz 12 MB
 - Overclocked to 4,7 GHz for CPU tests
 - Program: Cinebench
 - GPU: ASUS RTX 3080 TUF Gaming OC 10GB
 - Overclocked from 1785 MHz to 1815 MHz
 - 100% fan speed
 - Program: Heaven Benchmark by UNIGINE Company



Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

11 **2023**

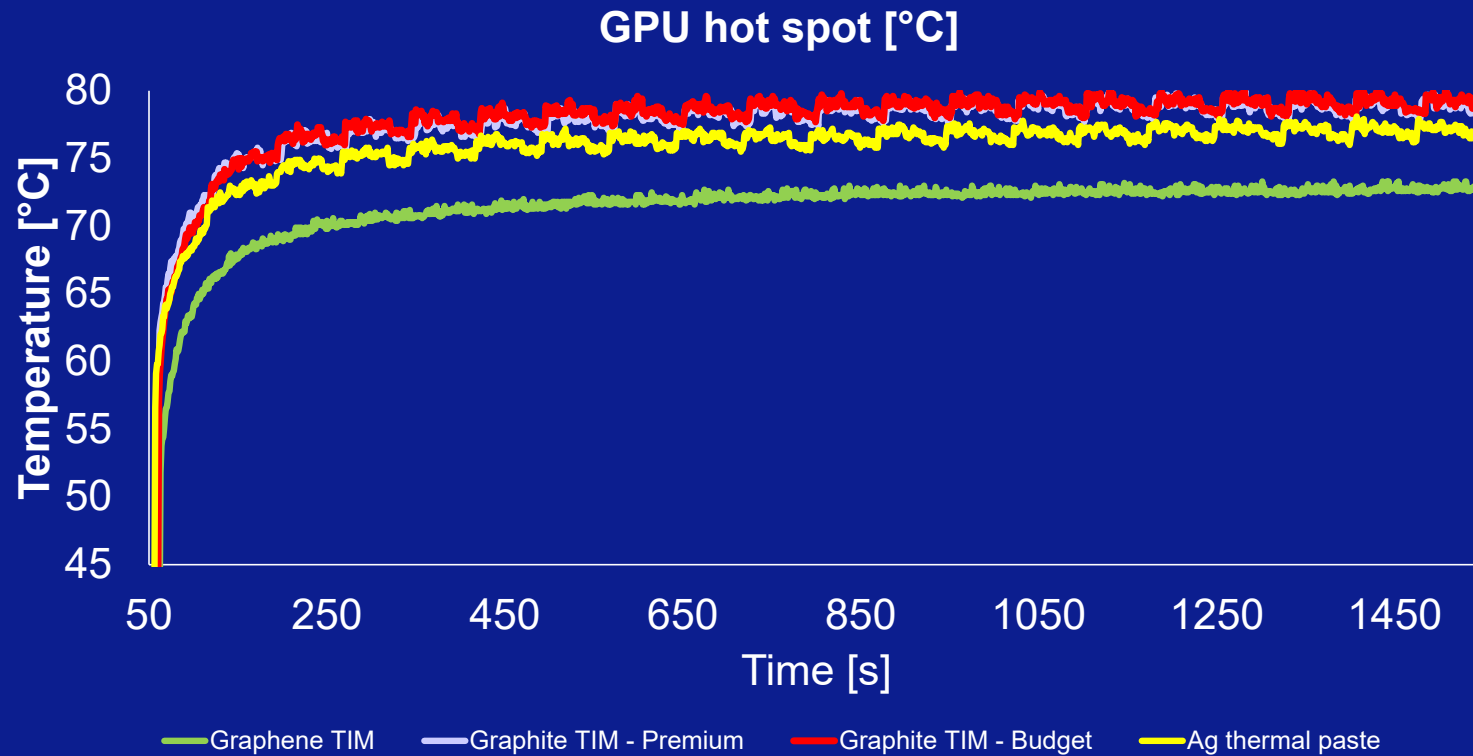
Performance on GPU: Temperature Throttling



Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

12 **2023**

Performance on GPU: Temperature Throttling

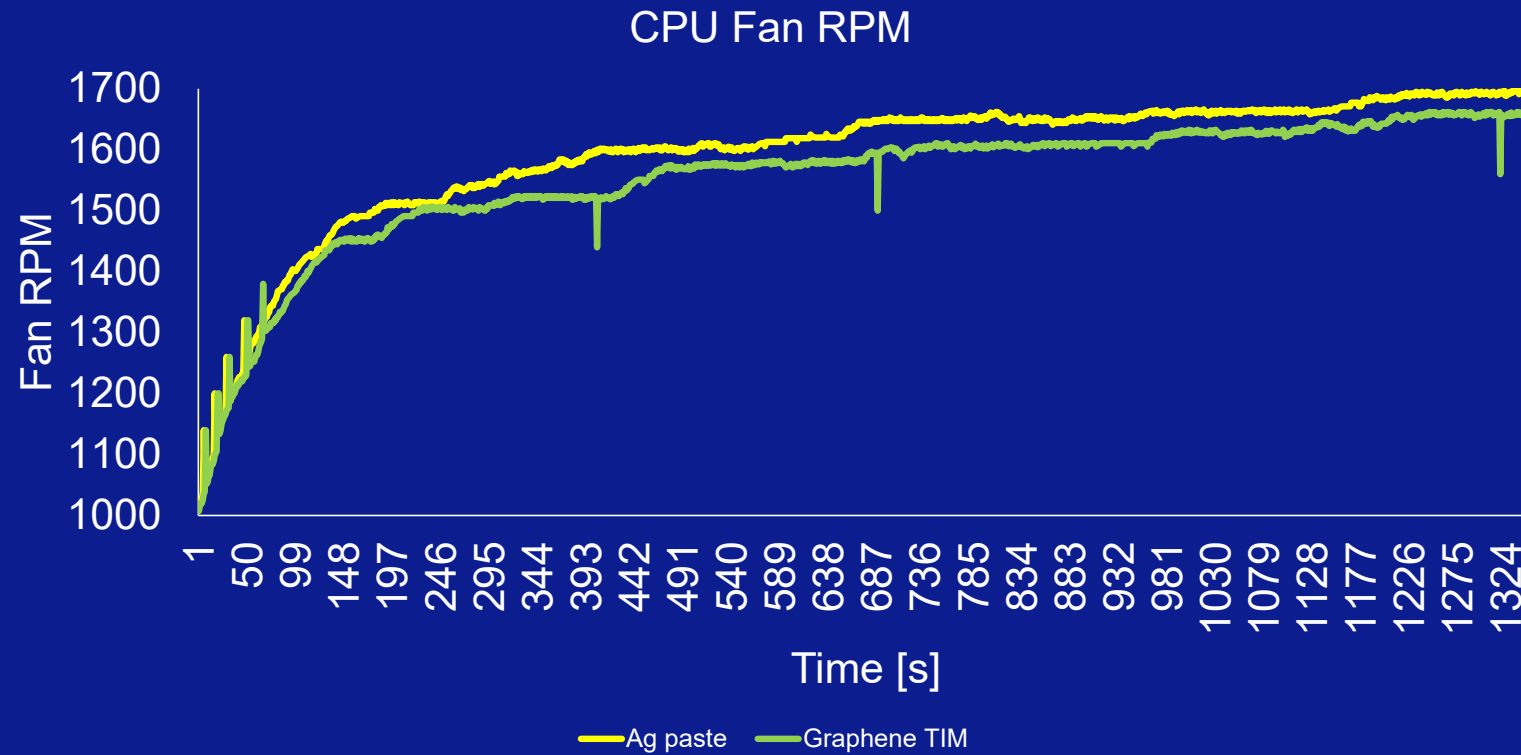


Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

13 **2023**

TestConX 2023

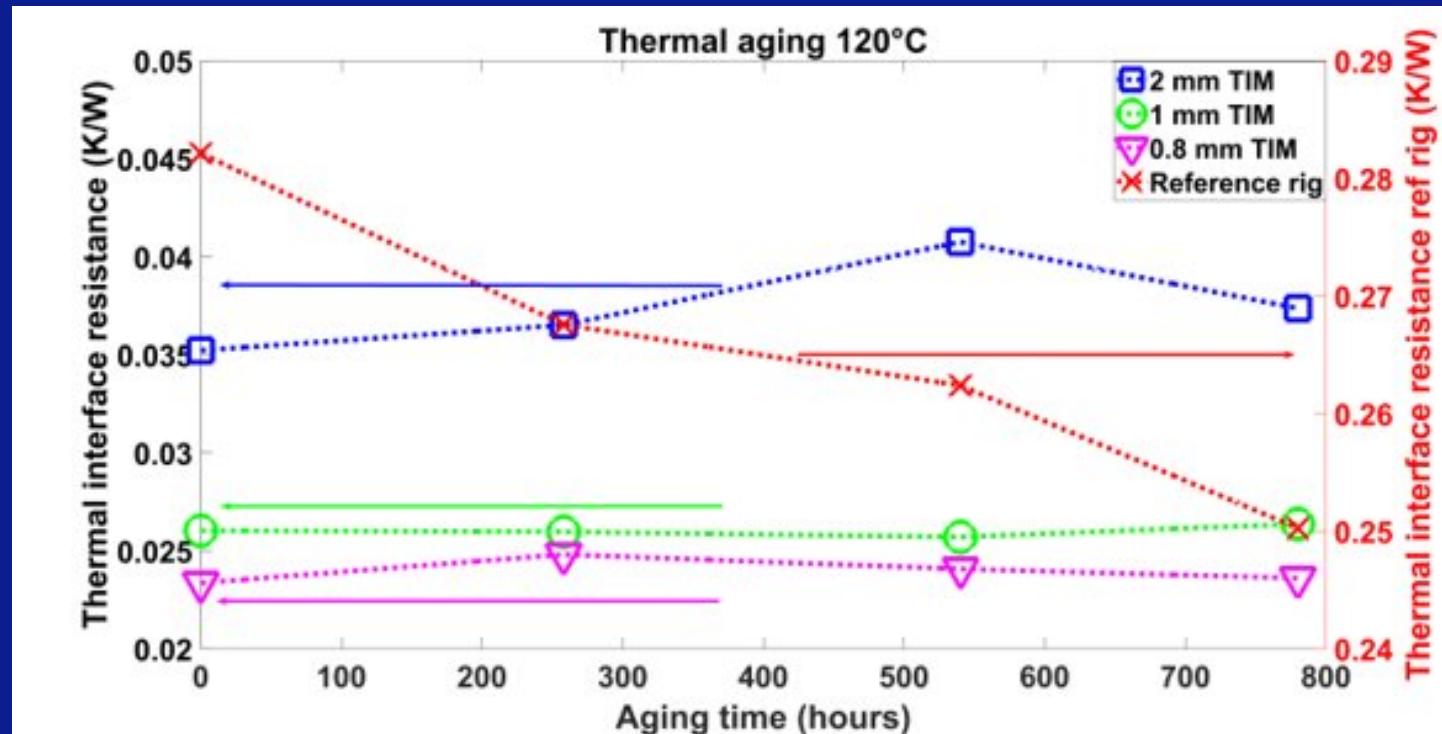
Performance on CPU: Fan Speed



Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

14 **2023**

Reliability Test: Aging

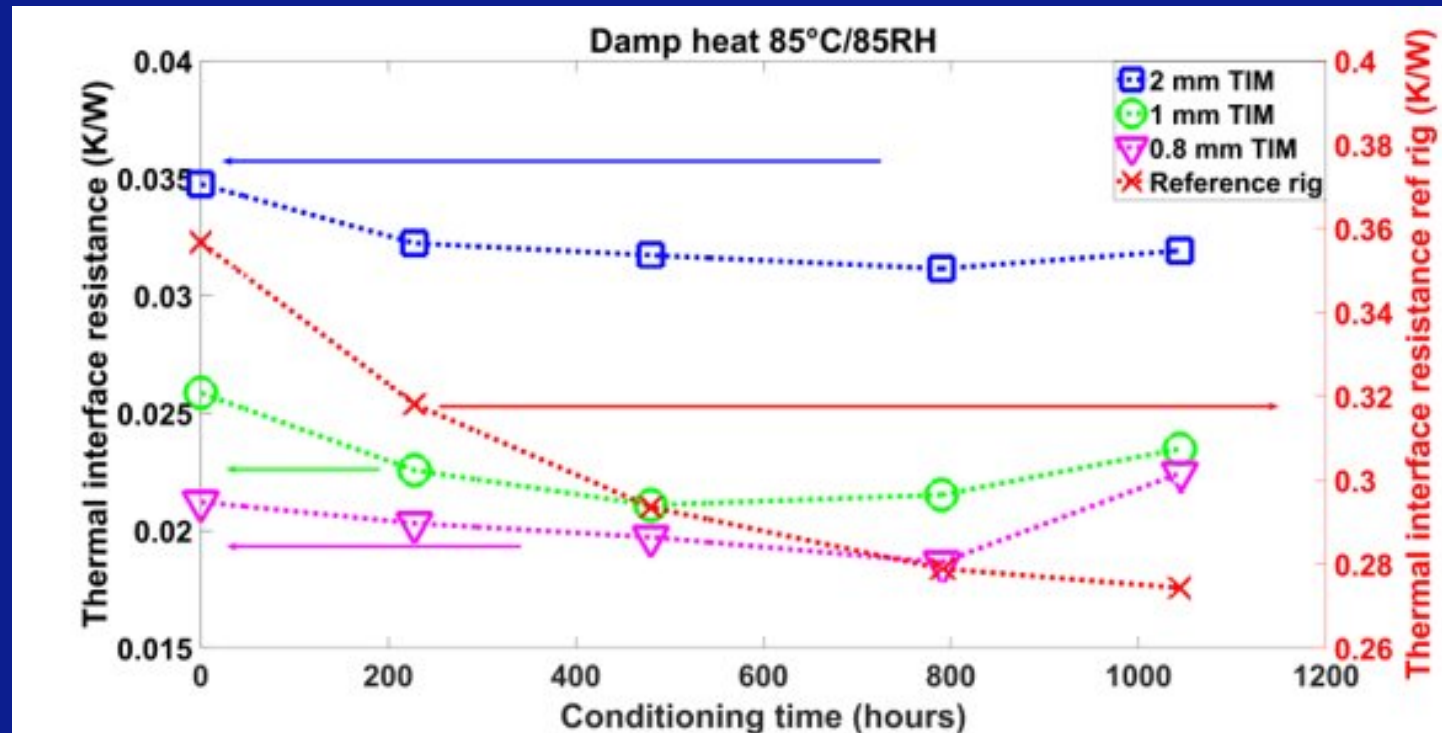


Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

15 **2023**

TestConX 2023

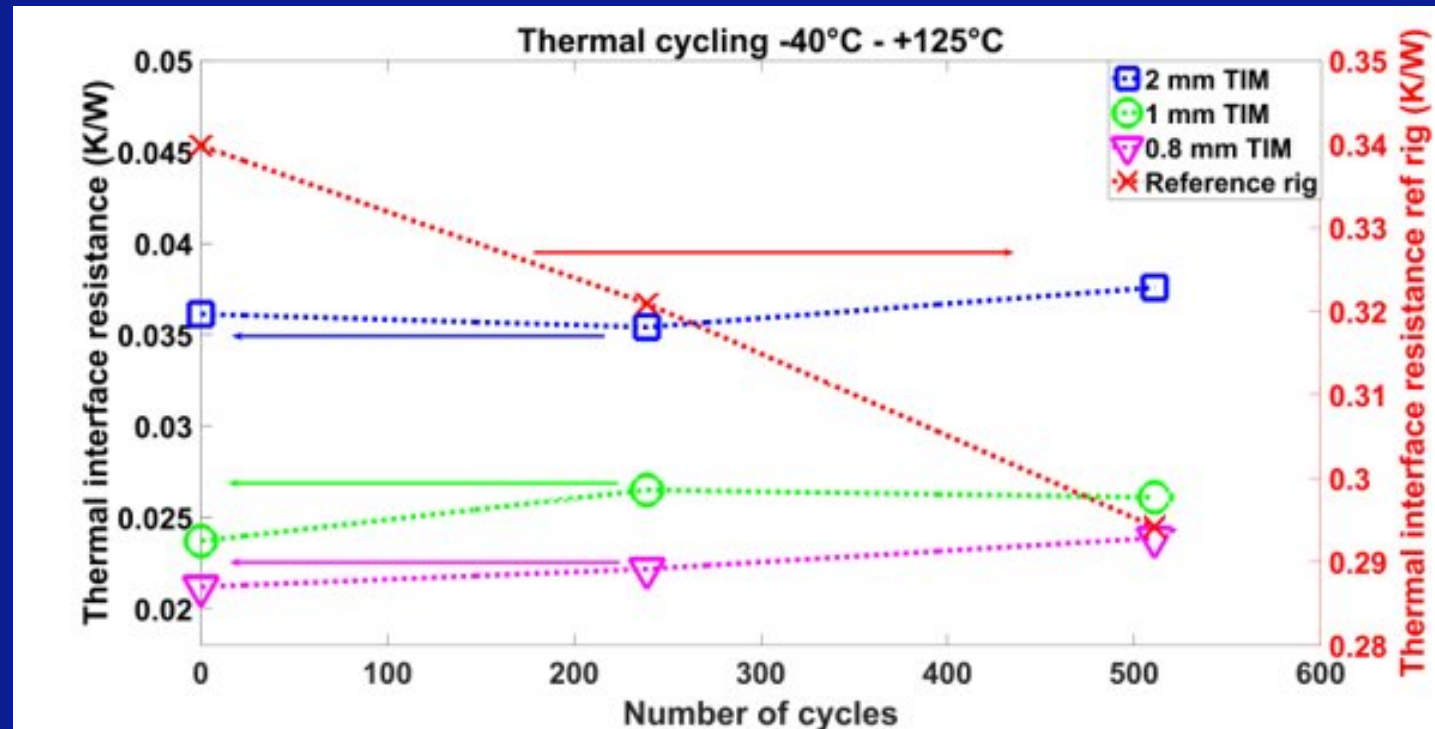
Reliability Test: Damp Heat



Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

TestConX 2023

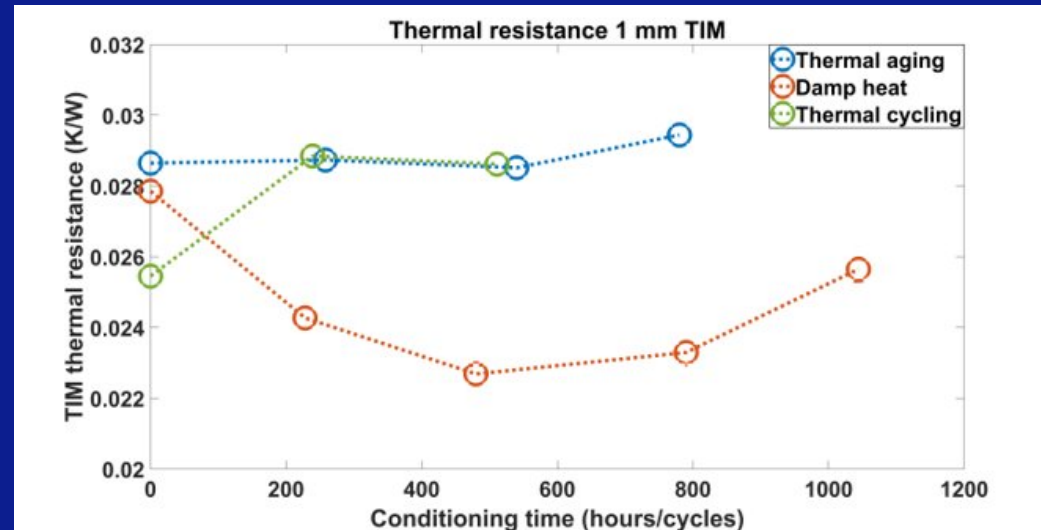
Reliability Test: Thermal Cycling



Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

17 **2023**

Reliability Test: Summary for 1 mm TIM



	Thermal aging 780 h	Damp heat 1044 h	Thermal cycling 511 cycles
0,8 mm TIM	+1%	+6%	+13%
1 mm TIM	+1%	-9%	+10%
2 mm TIM	+6%	-8%	+4%



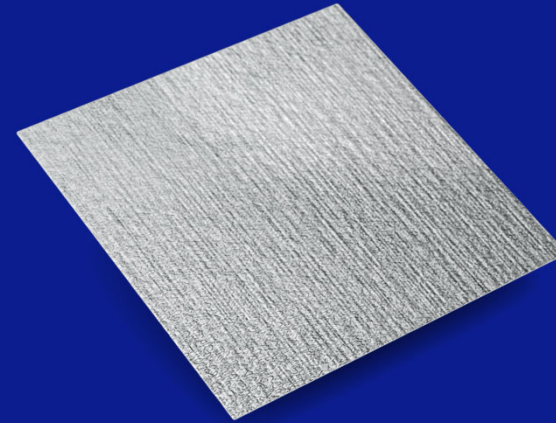
Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

18 **2023**

TestConX 2023

Conclusion

- Significant market potential
 - Thermal tests
 - Data centers
 - Electronic devices
- Reliability
 - Chemical stability
 - Thermal stability
 - Moisture effect



Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

19 **2023**

Acknowledgement

- Markus Enmark, “Reliability testing of graphene enhanced thermal interface materials”, IMAPS Nordpac June 12-14, 2022, Gothenburg, Sweden



Novel Graphene Enhanced Thermal Interface Materials for Testing and Thermal Burn-in Applications

20 **2023**