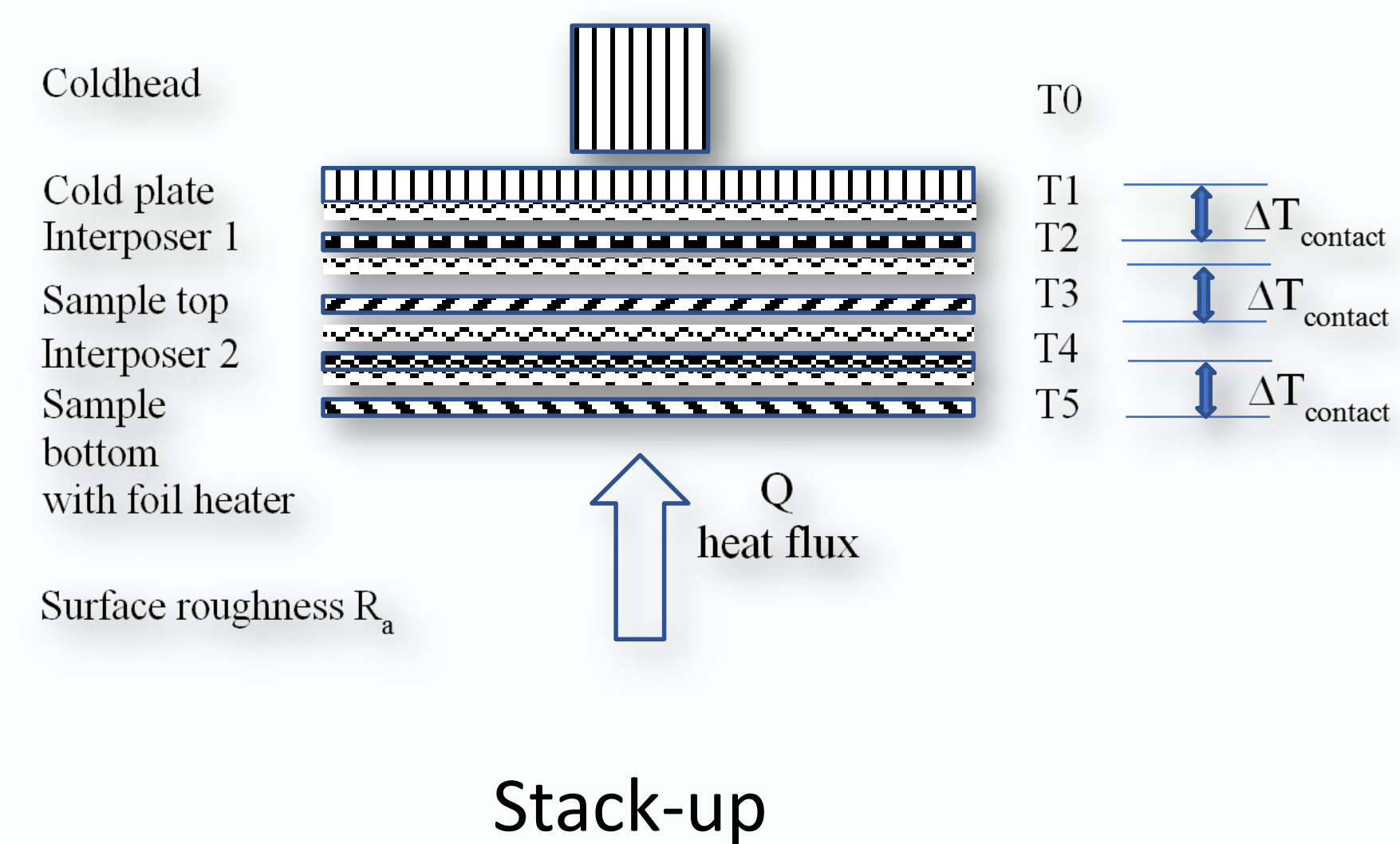




GE Research

Use of Galinstan as a Contact Agent for Additively Manufactured Components in Cryogenic Engineering



Stack-up

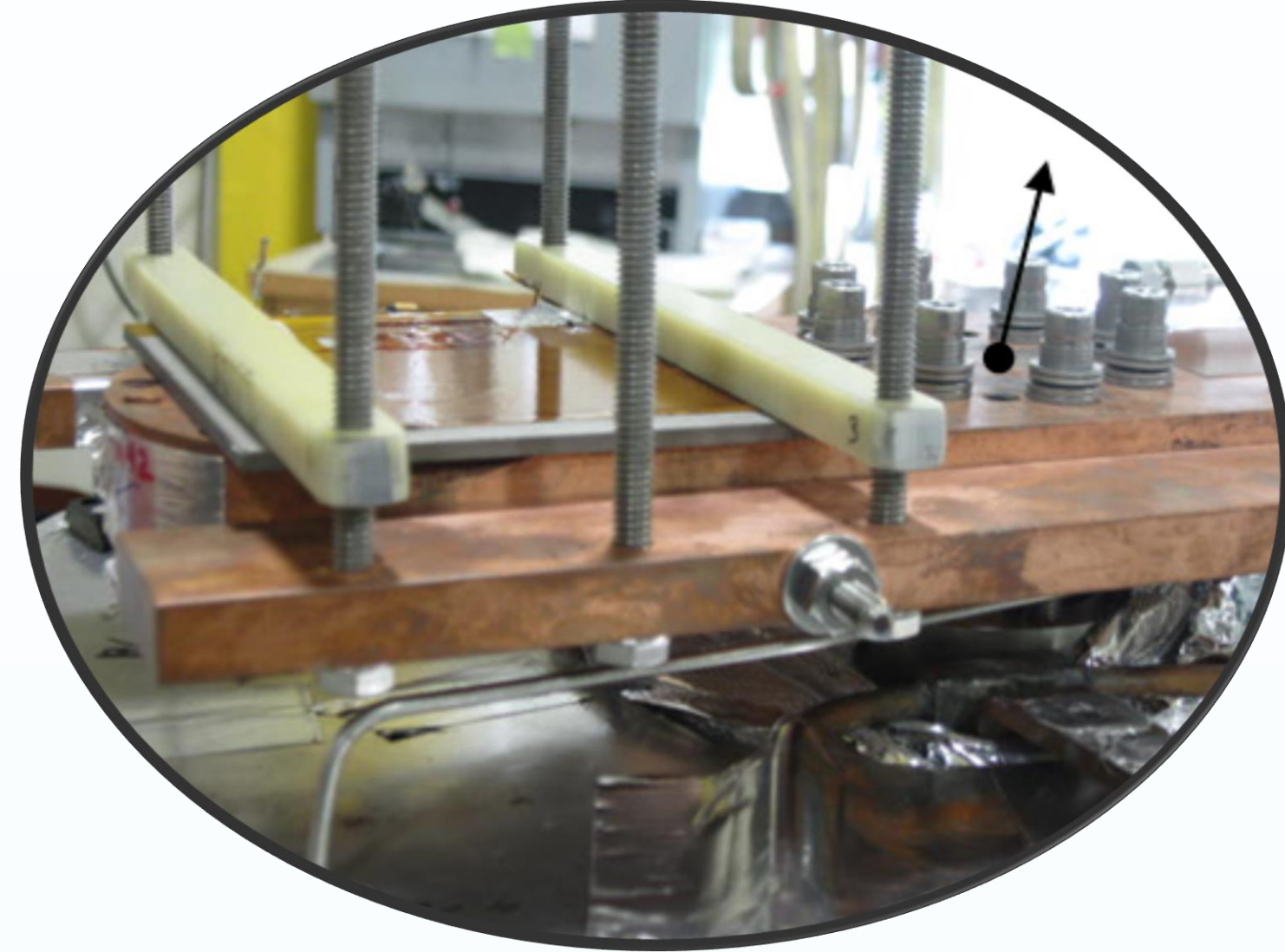


Figure 4: Direct mount to heat bus

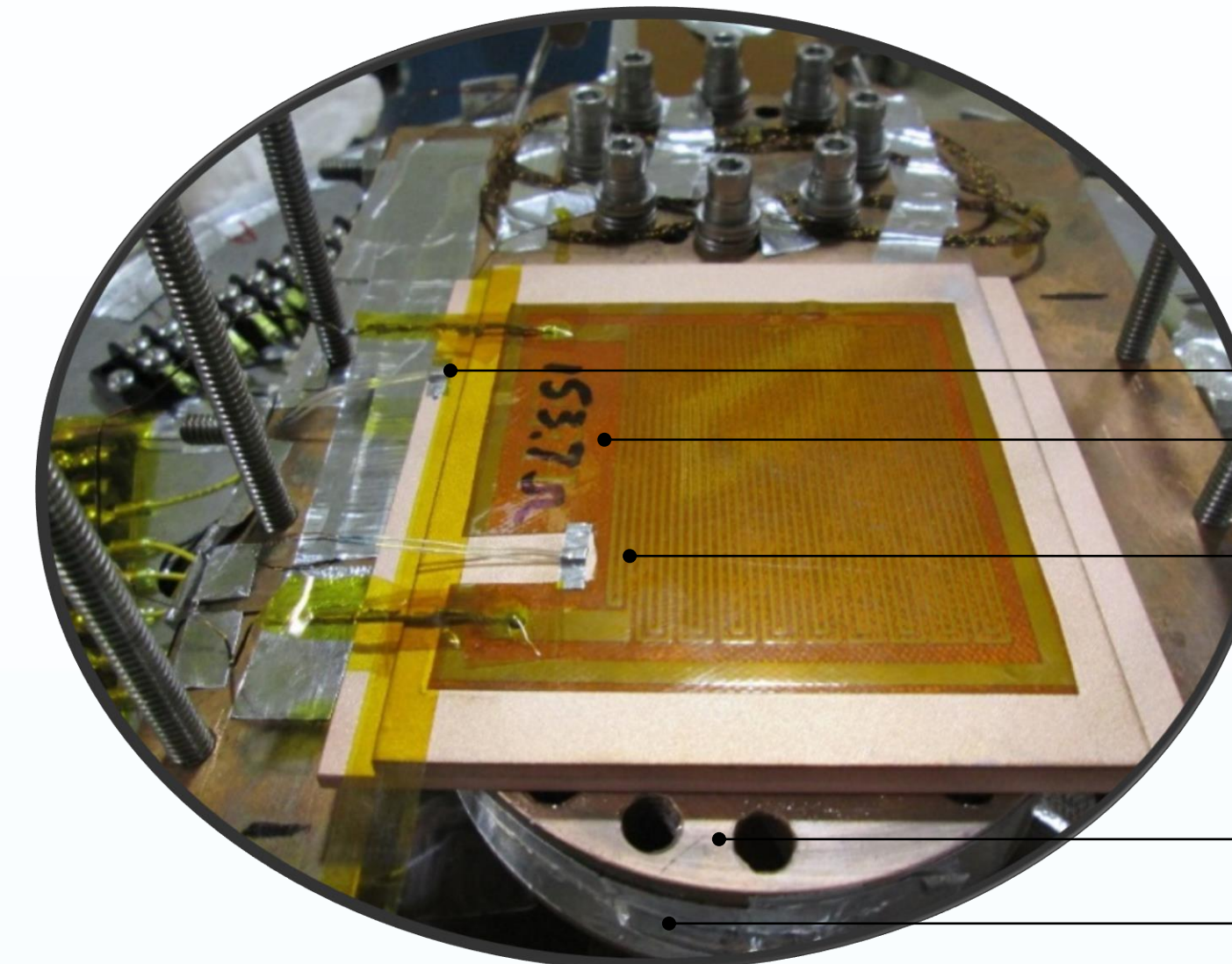


Figure 5: Two samples mounted to heat bus

Table 2: Test plate & cold bus details

Bus / cold plate:	
Contact area:	70 mm width, 150 mm length
Thickness:	25 mm Copper
Test plates:	
Contact area:	100 x 100 mm
Thickness:	3.175 mm
Surface R_a :	4.1 μm Cu-plated Ti grade 2 3.3 μm Cu-plated Inconel 718

Table 1: Test results for various thermal interface materials

Interface choice	Interposer / bond	dT (K) @ < 4 K	Fail T (K)	Sample geometry mm (pcs)* heat transfer area	Comment	No.
Copper / Copper	Bare / dry	1.5	12	111 x 108 x 3.175	Vacuum / – no grease	1
Copper / Copper	Galinstan	0	–	111 x 108 x 3.175	GalSn - wetted	2
Copper / Copper	Grease	0.1	7.3	111 x 108 x 3.175	Apiezon® N (both sides)	3
Copper / Copper	Indium + Grease	0.055	–	25 x 25 x 0.038 (6)	Apiezon® N (both sides) In 99.99 %, pure	4
Copper / Copper	Al ₂ O ₃ / Grease	0.145	9.5	25 x 25 x 0.045 (5)	Aluminum oxide tape (Apiezon® N on both surfaces)	5
Copper / Copper	Graphite + Grease	2.6	15	25 x 25 x 0.16 (5)	Farnell / Element 14	6
Copper / Copper	Aluminum + Grease	0	7	25 x 25 x 0.12 (5)	3M 425 Alu 99.6% foil + grease	7
Copper / bare Titanium	Indium / Grease	0.2	15	20 x 20 x 0.127 (6)	Grade 2 Titanium, In 99.99 %, oxidized	8
Copper / Titanium	Grease	–	35	108 x 95.3 x 3.175	Apiezon® N	9
Copper / Titanium	Galinstan	–	30/17	108 x 95.3 x 3.175	2 runs, no coating	10
Copper / Cu plated Inconel	Galinstan	1.0	16	108 x 95.3 x 3.175	Inconel 718	11
Copper / Cu plated Titanium	Galinstan	–	12	108 x 95.3 x 3.175	Sputtered Cu single side	12
Cu plated Inconel / Cu plated Inconel	Galinstan	0.03 ⁺	–	108 x 95.3 x 3.175	Each plate Cu sputtered (both)	13
Cu plated Titanium / Cu plated Titanium	Galinstan	0.40	–	108 x 95.3 x 3.175	Each plate Cu sputtered (both)	14
Cu plated Titanium / Cu plated Inconel ^o	Galinstan	0.61	–	108 x 95.3 x 3.175	Each plate Cu sputtered (both)	15

Designation in table

– experiment stopped before final dT was reached, dT too big, timeout

* 330 N of spring load on sample area

+ 2nd cooldown after warmup to RT^o bottom plate Inconel

6. Summary

For the given task, Galinstan was the obvious choice for matching materials with very low thermal resistance. However, only materials with the same CTE achieve good bond strength and high thermal conductance at 4 K.

Dissimilar materials even fail when copper coated due to the CTE mismatch.

So far, thermal and mechanical properties of Galinstan are still unknown.

Given the ease in which a repeatable thermal and mechanical contact can be made and maintained and removed at 16 °C for many applications, this is a suitable alternative to high purity indium, or other solders and greases that require high contact pressures.

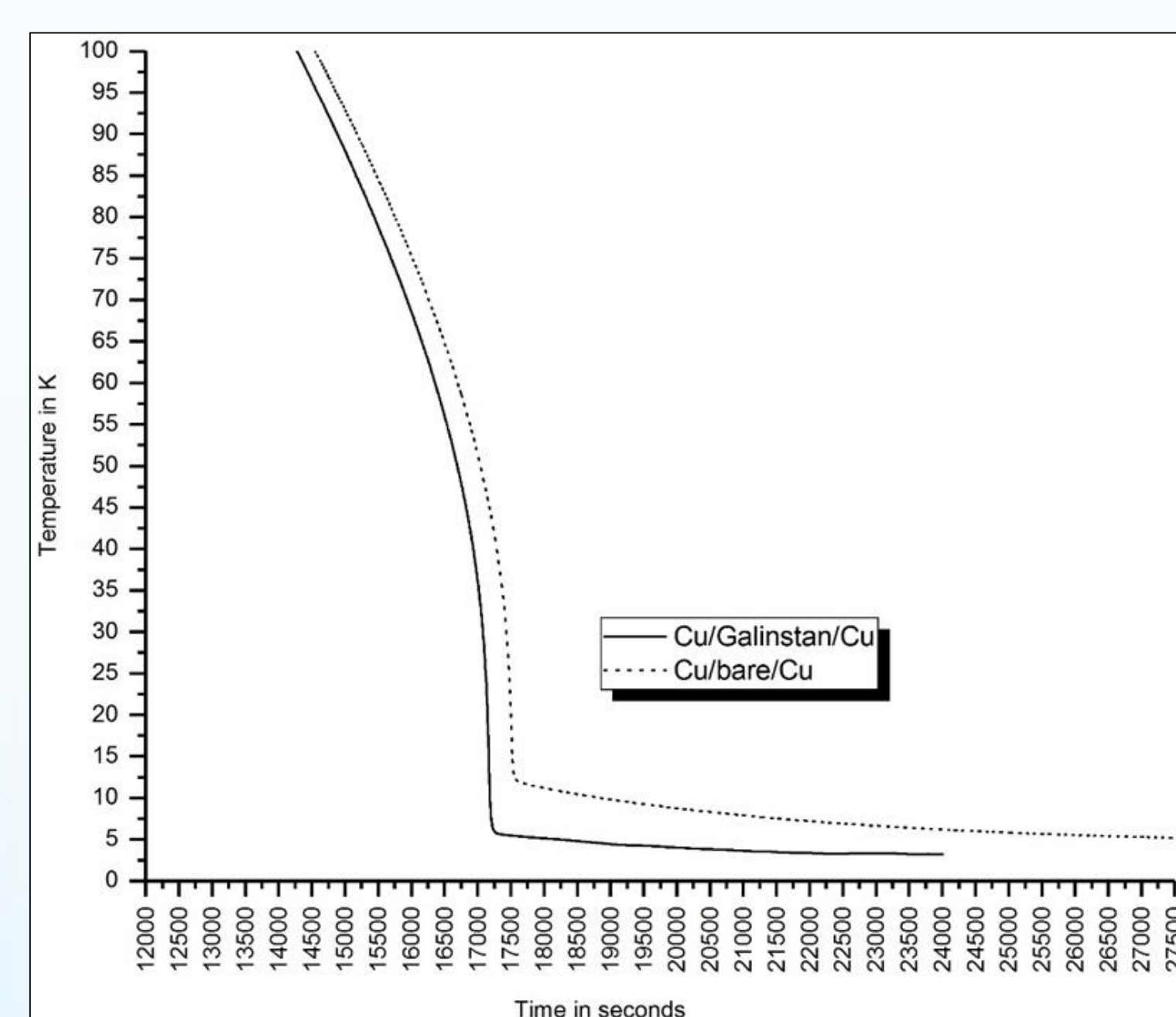


Figure 6: Copper plate sample cooldown with Galinstan compared to bare / dry surfaces

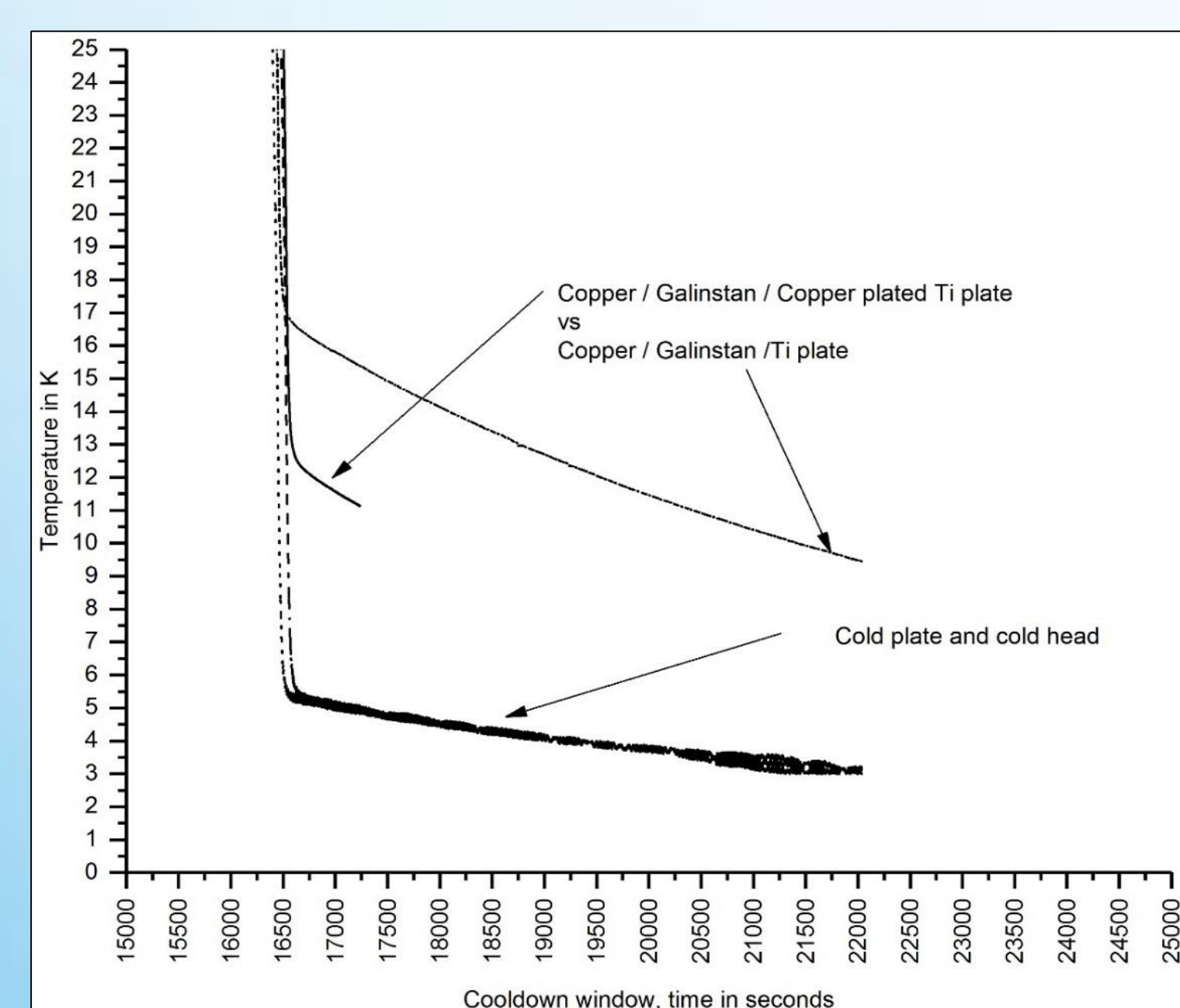


Figure 7: Graph of sample cooldown with dissimilar materials and Galinstan

5. Key findings

- Components can be bonded and separated at room temperature without applying any force on the mating surface using Galinstan
- Contact can be thermally cycled with repeatable performance
- For the 1 inch copper dumbbells we need a force of 6000 N to pull them apart at 100 K
- Galinstan can be used for many different cryogenic applications

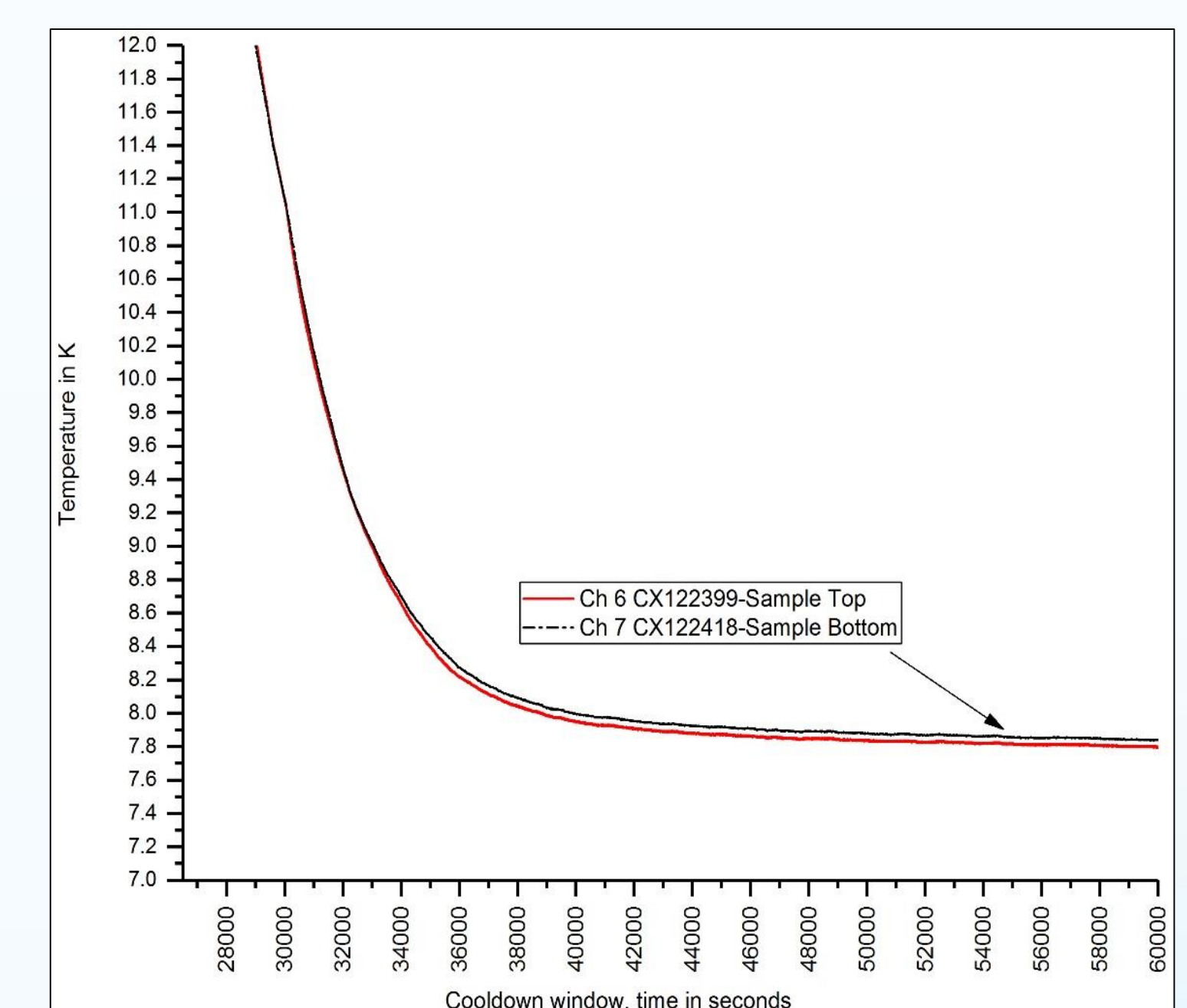


Figure 8: Cooldown curve of copper coated Inconel 718 samples

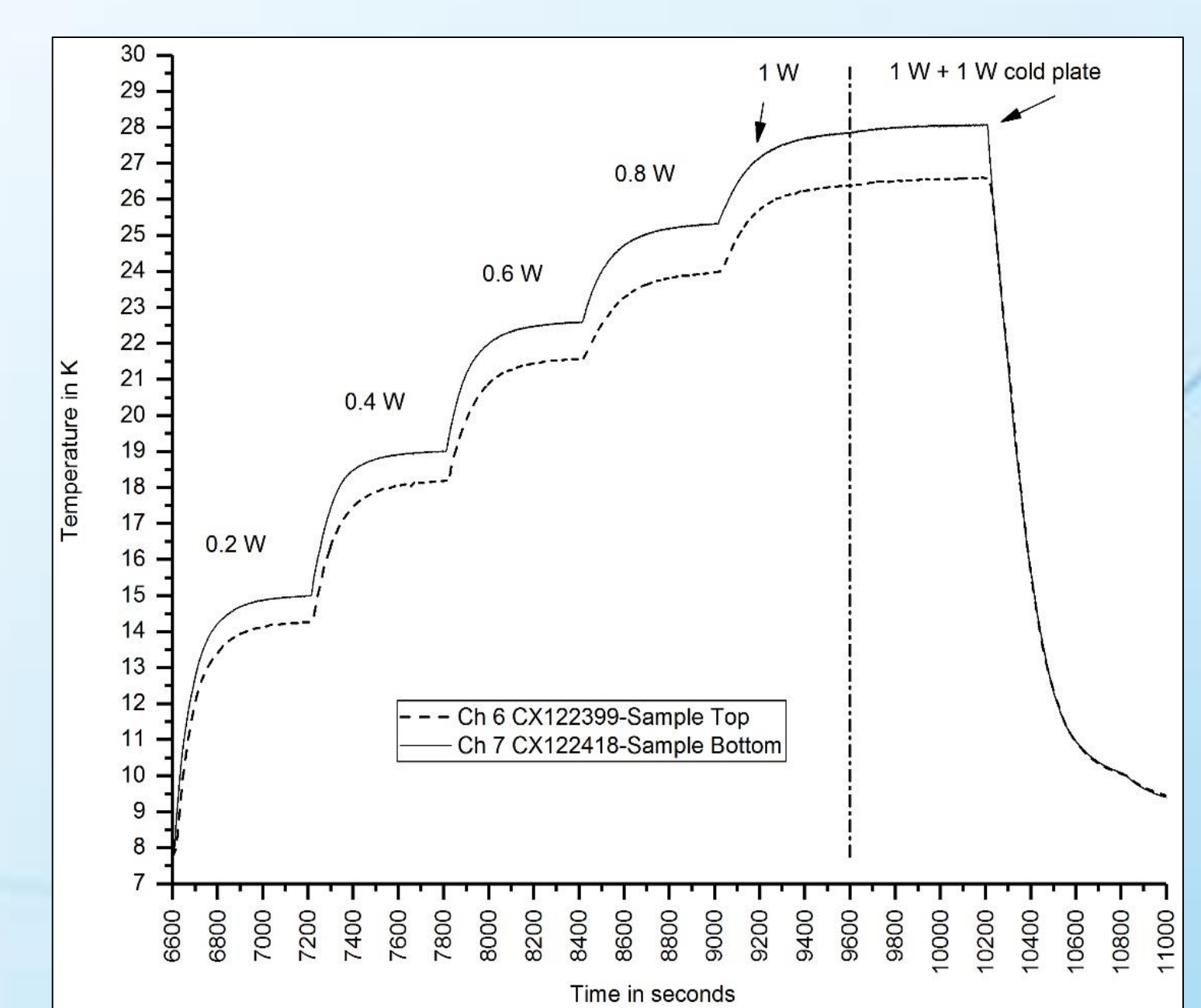


Figure 9: Heat load measurements with Inconel

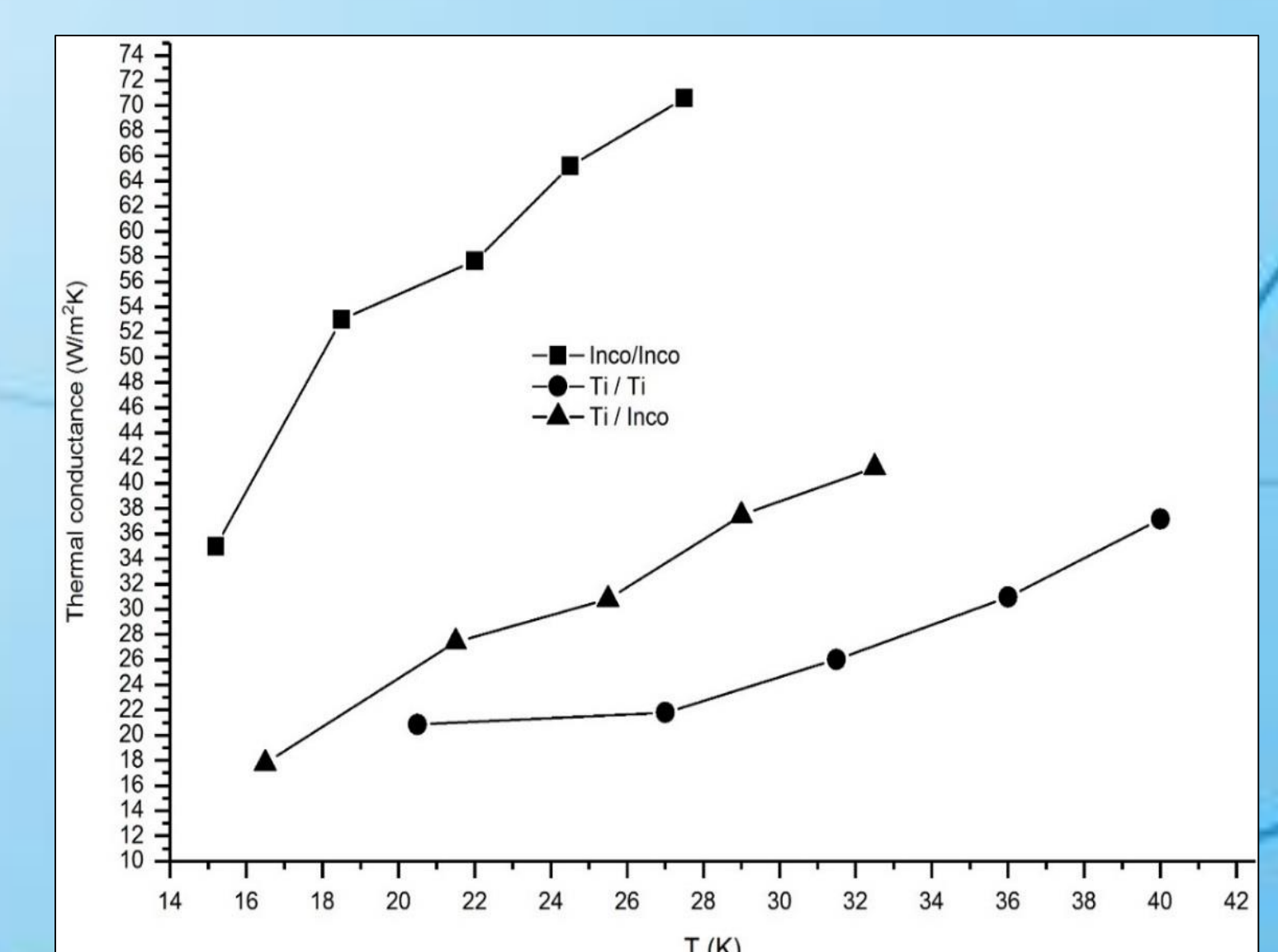


Figure 10: Thermal conductance measurements with Galinstan as interposer and different materials