Applicative Study on The Advantages of Using Unconventional Materials to Increase Computer Performances

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Key words:

Thermal interface material-s (TIM-s), polymers, metal alloys, heat, cooling solutions, computers.

Introduction:

Due to increasingly intensive use of computing technology, especially of the self-optimizing capable kind, it is appropriate to exploit its work capacity to the maximum. Accessing superior levels of performance is conditioned by the robustness and the performance of the employed cooling solutions. Conventional polymer TIMs fail to accomplish the current needs, prompting the unconventional, metal alloy-based TIMs to intervene and outperform them. The hereby study shows an empirical take that proves the advantages of metal TIMs used in an optimal, ultra-performant system, compared to conventional TIMs used until now.

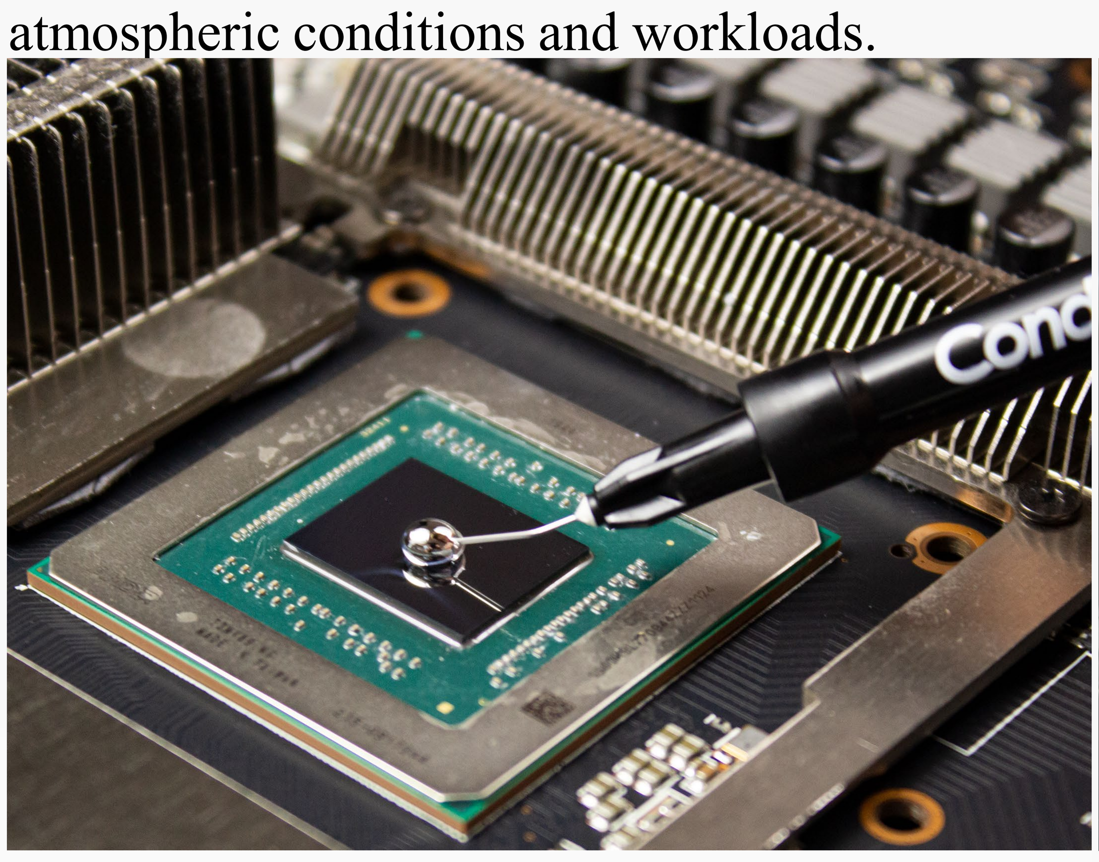
Analysis framework of TIMs:

The study was conducted on a traditionally-composed desktop PC, equipped with optimal and ultra-performant components. The studied elements are the work parameters of the Central Processing Unit (CPU) and the Graphics Processing Unit (GPU). The cooling solutions employed nowadays are performant, but dependent on TIM's qualities. Prior to changing the TIMs, the CPU had polymer-Ar based TIM and the GPU had OEM polymer TIM. The CPU managed to attain the maximum specified work frequency (4.4GHz) only sparsely, in short bursts, before the TIM succumbed to the thermal effort – very close to the manufacturer-enforced thermal limit. The GPU did not manage to reach maximum frequency and was surpassing the prescribed thermal limit.

These processors run power draw and computing power self-optimization algorithms [1], acting by thermal parameters. Above a certain thermal limit, current and voltage regulators intervene in what is called the Throttling phenomenon, where the computing power is severely diminished. Changing polymer TIM with metal TIM provides considerable impact in encouraging maximal operating states. Before and after changing TIMs, the system had undergone intense artificial workloads, to force the maximal operating state of both CPU and GPU, and to exploit every component of the cooling solutions to their limit.

Equipment and employed methods:

CPU: AMD Ryzen 3700X 8c-16t 3,6-4,4GHz 7nm 65W-TDP;
GPU: Sapphire NITRO 5700XT 1,77GHz-2,01Ghz 7nm 265W-TDP;
Polymer TIM: CPU–Arctic Silver 5 8,9W/m*K [2]; GPU–OEM, ~4W/m*K;
Metal TIM: CPU+GPU ThermalGrizzly Conductonaut InSnGa73W/m*K [3];
Software: AIDA64 Engineer Edition [4];
Sensors: multiple and individual specialized sensors, in different areas of the CPU and GPU groups.
CPU cooling: CoolerMaster ML360R + 3 fans 56CFM @1700rot-1;
GPU cooling: OEM (Saphhire NITRO) + 3 fans 50CFM @3000rot-1;
Methods: Overall stress-testing before and after TIM swap, 5 minute intervals, extracting of maximal values only after stabilization. Identical atmospheric conditions and workloads.



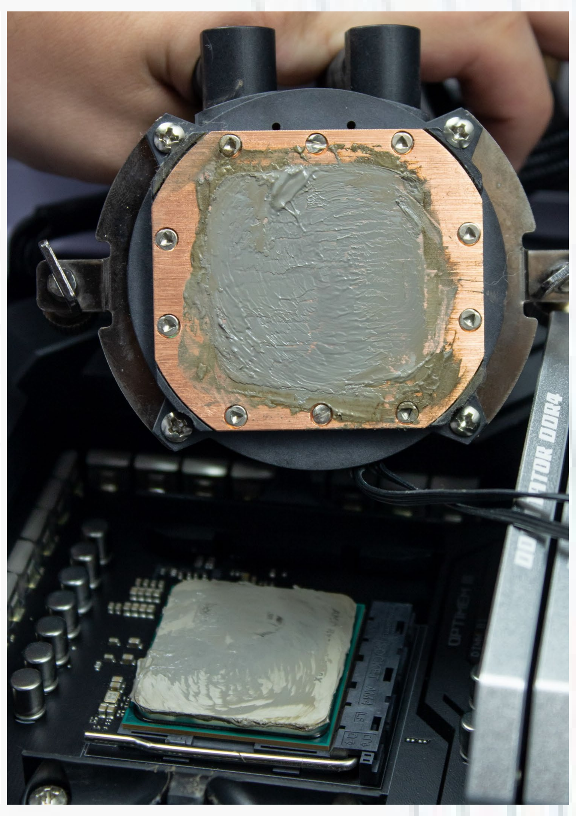


Figure1: Applying metal TIM on GPU. Figure2: Polymer TIM on CPU and coldplate.

The metal TIM used in Figure 1 is fluid above 8℃. It must be applied with a special syringe and evenly distributed on all active surfaces with a cotton swab. SMD capacitor fields around the silicon chip were preemptively coated with electrically inert lacquer. The cleaning of all surfaces is done with 99% isopropyl alcohol.

The polymer TIM in Figure 2 has one full year in use and already began to lose its performance, due to normal drying caused by extreme and frequent cycles.

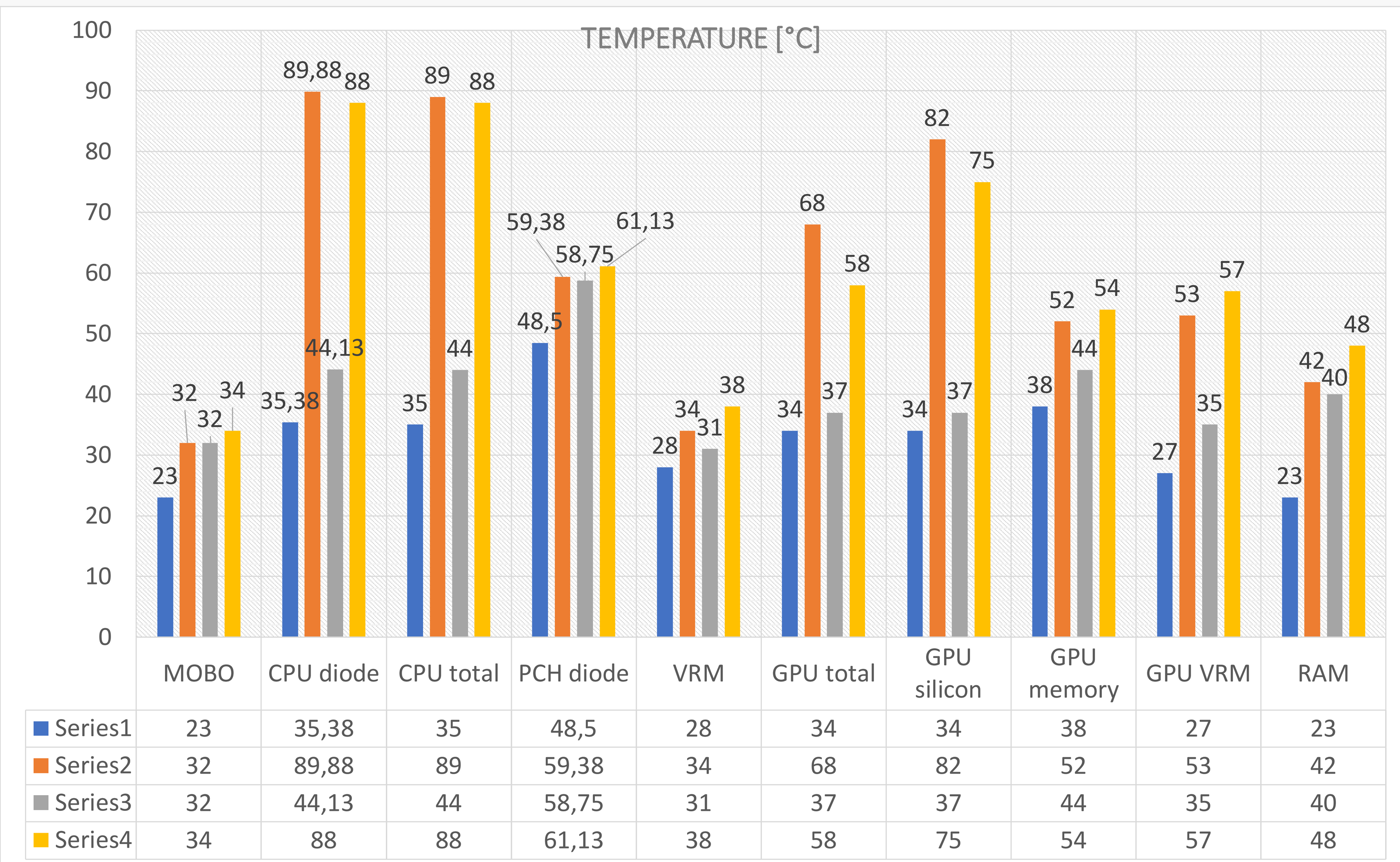
Polymer TIM acts as an electrical insulator, but has a setting time and a limited validity term, so its performance is constantly decreasing. However, it can be applied on any material [2].

Metal TIM conducts electricity, but it does not require set time and does not need to be repasted in time, while its performance remains unchanged. It is recommended to be applied only on copper or nickel surfaces, and never on aluminium, due to the adverse chemical reaction in its crystalline network caused by the inherent gallium component [3]. Adjacent electrical contacts must be isolated.

Results after testing:

3700X / 5700XT	Crt Nr.	SENSOR/ OBJECT	BEFORE (Polymer)		AFTER (Metal alloy)		U.M.
			START	STABLE MAXIMUM	START	STABLE MAXIMUM	
VOLTAGE	1	CPU core	0,968	1,496	0,968	1,48	[V]
	2	CPU socket	1,088	1,104	1,096	1,104	
	3	GPU core	0,725	1,2	0,725	1,2	
	4	GPU memory	0,85	0,85	0,85	0,85	
	5	GPU SoC	0,818	0,825	0,818	0.825	
CURRENT	6	CPU VDD	5	76.9	5	78.98	[A]
	7	CPU VDDNB	10.46	15.15	10.46	15.87	
POWER DRAW	8	CPU core	23.54	103.51	25.04	104.63	[W]
	9	CPU VDD	5	102.38	5	107.12	
	10	CPU VDDNB	11.38	16.48	11.38	17,26	
	11	GPU	30	229	30	231	
FREQUENCY	12	CPU	3480	4400	3460	4400	[Hz]

Table 1. Centralizing of resulting values using both studied TIMs.



Graph 1: Comparative study of temperatures (respecting Table 1).

Series 1 and 2 represent the minimum and respectively the stabilized maximum, using polymer TIM. Series 3 and 4 manifest after swapping to metal TIM.

The results indicate a noticeable drop in temperature and an increase in power draw. Throttling had never occurred, because fundamental limits were achieved prior to overheating. These facts confirm the prior hypothesis, that in better cooling scenarios, capable processors enter maximal states more often and for longer periods of time. If we would set lower, and thus more stable performance bars, we would witness dramatic drops in temperature and power draw, especially for the CPU. There were no electrical, chemical or runaway issues for the metal TIM, because the application standard was duly satisfied.

Conclusions:

Following our theoretical and practical studies, it is confirmed that replacing polymer TIMs [2] with InSnGa metal alloy TIM [3] does lead to increases in performance of concerned systems, even though the price point is higher and the manual labour is relatively difficult. If we ever want to manufacture InSnGa metal TIM in our own administration, we can model the conductivity coefficient based on necessity, along with its physical and chemical properties, for a reduced production cost compared to the market price.

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