

PASSIVE THERMAL TECHNOLOGY, LLC

Loop Heat Pipe White Paper

The applications requiring efficient cooling solutions span industries, continents and processes limited only by one's imagination. Not a day goes by when you don't find virtually every electronic industry technical publication featuring an article on the problem of efficiently cooling CPUs, GPUs, workstations, servers, data centers, etc.

Passive Thermal Technology (referred to as PTT) is not your typical start-up looking to develop technology for a future market. Our technology exists, both the product and the manufacturing process.

PTT's technology is based on **Loop Heat Pipes (LHP)**. LHP's are the most efficient heat transfer devices ever invented. The PTT team includes leaders in this field.

LHP's key differentiating features are 4x higher capacity of heat removal, being able to transport the removed heat 10x longer distances, and using zero electrical energy to operate – giving 10x higher efficiency. The energy cost savings can be staggering.

Computers are the market entry target for the PTT technology as they are both high value and high volume. Both CPU makers and GPU makers have escalated the heat per chip from 10s of watts 10 years ago to 100 Watts and more. This has created a dire situation for them. They can't continue to increase performance, until they find ways of both curing the local hot spot issues created by their chips and resolving the issue of getting the heat out of the computer. Value is also created in lowering the operating temperature of the chip – both for long term reliability and potentially higher yield and higher performance.

Presently, computers are cooled with a multitude of fans and heat sinks. Some of the heat sinks are enhanced with linear heat pipes, helping cure the local hot spot issue. But all of these fail at removing heat from the computer box. A typical multi-processor server with 100 Watt quad-core CPUs has up to 16 fans, each drawing 10 Watts. This additional 160 watts needs to be removed from the computer case as well. Some newer systems use liquids to capture local heat and remove it, employing pumps to move the fluid. Our proprietary documentation available under NDA describes the > 10x relative efficiency of the PTT LHP.

In heat transfer, a single-phase system works with either a gas (air) or a liquid, while a two-phase system works with both a liquid and a gas. Two properties of water are that heating or cooling ONE gram of water ONE degree C extracts ONE calorie of heat from the local environment, but boiling the same ONE gram of water extracts 540 calories of heat. By controlling the gas pressure, the boiling point of the liquid can be controlled to extract heat from the processor to cool it to the target operating temperature.

PTT's Loop Heat Pipe is a two-phase passive device. It employs an evaporator, condenser and pipes. The evaporator contains a wick that transfers the heat rejected by the processor to the working fluid inside the LHP. The wick also provides the capillary pressure that drives the working fluid around a cooling loop whose length can be measured in meters. The loop includes a device called the condenser, which is cooled by water or air. The function of the condenser is to return the vapor to a liquid, thereby completing the cycle, while rejecting the heat to the air or water used to cool the condenser.

A major part of this new technology lies in the manufacturing process. Equipment has already been developed by members of the Company's technical team to make and test LHP devices, providing PTT with the opportunity to develop custom prototypes and manufacture LHP's in small numbers. These methods are part of PTT's trade secrets, patents and patents pending.

Given the LHP's high heat removal capacity, high efficiency, long heat removal distance, and relatively low cost to build and operate, we are seeking Technology Partners to enable us to transition the technology to production.

To gain further knowledge of PTT's Loop Heat Pipe technology please contact Gerry Stanley at Passive Thermal Technology. (geraldwstanley@passivethermal.com)