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EARTHRISE OBSERVATORY

Commentary on energy & environmental technology industry developments

IS IT JUST ME OR IS IT HOT IN HERE?

The Investment Case for Thermal Management

In light of our recent investment in CoolChip Technologies, a company developing high-performance, high-efficiency cooling solutions for electronic equipment, we offer a brief overview of thermal management – what it is, why the need, and how it is done.

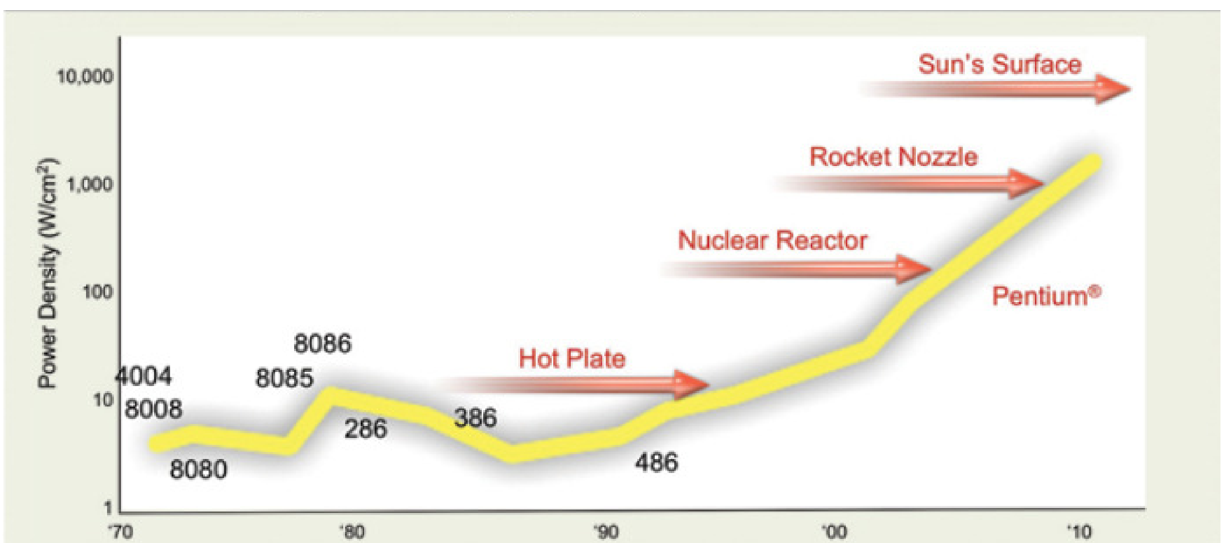
Thermal Management Summary

What it is: thermal management technologies reduce or remove the heat produced by computing and communications equipment and other devices.

Why the need: as microprocessors get faster and more powerful, they consume more electricity, and produce more heat.

How it is done: typically with fan, heatsink or both; other solutions are emerging.

Figure 1. Intel Processor Power Density (w/cm^2), 1970 – 2010E



Note: 4004, 8008, 8080, 8085, 8086, 286, 386,486 and Pentium are the names of successive generations of Intel processors.

Source: Intel Developer's Forum, 2004.

Moore, Better, Faster – Chip Speed and the Need for Power

Gordon Moore's 1965 prediction that computing power would roughly double every two years ("Moore's Law") has been remarkably accurate. These astonishing performance gains have been achieved primarily by shrinking the size of transistors, then cramming more and more of them into an integrated circuit. As the number of transistors per chip grew from the thousands in the 1970s to the billions today, the power required per chip has increased accordingly. And because electricity flows essentially always create heat (due to the resistance of the conductor), the rise in microchip power consumption has meant hotter and hotter equipment (see Figure 1 above).

A Chilling Effect – Thermal Management Solutions

To keep chips cools, the electronics industry has long relied on fans, heatsinks or both. A typical heatsink consists of a baseplate with fins, and is made from a thermally-conductive metal such as aluminum. Heat is drawn away from a hot spot (e.g., a microprocessor) by the baseplate, then spread out across the fins for dissipation by the cooler surrounding air. A fan is generally placed on or near the heatsink for faster cooling (see Figures 2 and 3 below).

Figure 2. Typical aluminum heatsink

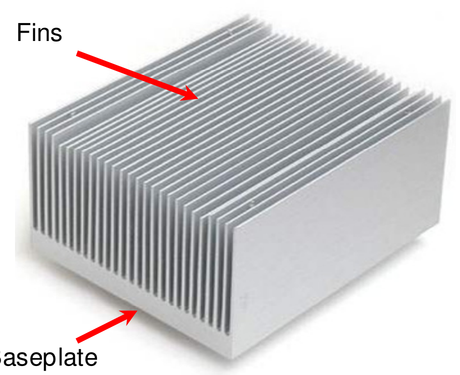
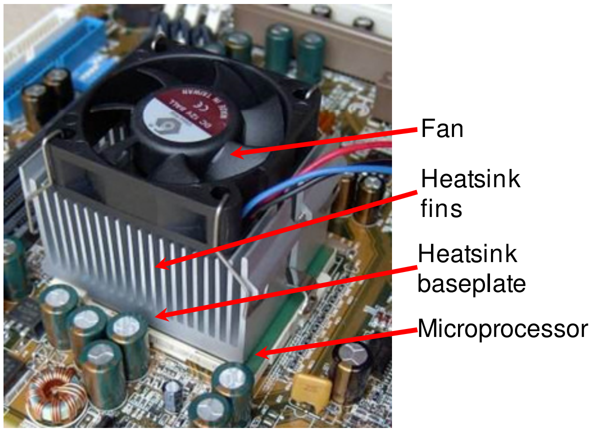


Figure 3. Heatsink and fan mounted on microprocessor



The fan-plus-heatsink combination is widely used. It is cheap, simple and generally effective. However, there are many instances when a different solution is needed – when vertical space is limited (as in an ultrathin notebook); when there are lots of smaller hot spots distributed around the circuit board (as in telecom equipment), rather than one or two large heat sources; when noise from the fan begins to impinge on the user experience (as in gaming devices like X-Boxes); or when there is simply too much heat to remove (as in high-performance computers).

Alternatives to fans and heatsinks range from the highly engineered to the exotic and experimental, and include passive heatpipes, pumped liquid cooling, and microfluidics. In general, they are costly to produce and install; entail considerable customization; and/or require added maintenance. In a recent example of the search for better cooling solutions, Intel placed data servers into vats of circulating mineral oil, and ran them for a year. Intel declared the experiment a success, but noted that it would not be bathing its own corporate data servers in oil anytime soon.

CoolChip Technologies, Earthrise Capital's newest portfolio company, is commercializing new thermal management technologies designed to offer high performance, high efficiency and high reliability at a competitive price. CoolChip's first product is essentially a spinning heatsink – a thermally-conductive aluminum fan rotating thousands of times per minute just microns above a metal baseplate. The idea is simple, but making it work requires a great deal of intellectual property, some licensed from Sandia and MIT, some developed internally. The interview with CoolChip's CEO that follows provides more details.

EARTHRISE CAPITAL PORTFOLIO OBSERVER

In our "Earthrise Capital Portfolio Observer," we hope to provide a deeper understanding of our portfolio companies through management interviews, technology summaries and real-world examples of products at work.

Earthrise recently completed an investment in CoolChip Technologies, Inc. (CoolChip). CoolChip is commercializing advanced kinetic cooling technologies for removing heat from electronic devices. Here we present an interview with William R. Sanchez, the co-founder, President and CEO of CoolChip Technologies, where he is responsible for overseeing sales, marketing, business development and overall strategy. He began his career as an entrepreneur focusing on clean energy ventures. From 2009-2011, he served as the President of vecarius, Inc., a startup company commercializing energy-harvesting power converters. Mr. Sanchez received his Ph.D. in electrical engineering and computer science from MIT, where his doctoral efforts focused on developing novel, high-efficiency power and energy management architectures. He has over seven years of semiconductor industry experience, and his expertise includes power electronics, high-speed communications, feedback and digital systems.

CoolChip was the grand prize winner of the 2011 MIT Clean Energy Prize.

Earthrise: What is your technology in brief?

Sanchez: CoolChip's technologies are cooling devices to keep electronics from overheating. For many years there has been little innovation in the way cooling is typically done. Now there is demand for smaller devices that perform more efficiently and are as cost effective as conventional solutions. Other new approaches being developed, such as liquid cooling, micro-channel techniques, heat pipes, etc., are cumbersome, difficult to scale, and costly.

COOLCHIP TECHNOLOGIES

CoolChip Technologies Kinetic Heat Sink

Earthrise: What is unique about CoolChip's approach?

Sanchez: We started from first scientific principles to create a smaller device that can remove heat more efficiently. A core concept featured in our devices was conceived by a scientist at Sandia National Labs in response to a solicitation from DARPA, the Defense Advanced Research Projects Agency. We are licensing that technology along with additional technology from MIT that is complementary. In addition we have now developed our own innovations and submitted three of our own patent applications.

Earthrise: Can you describe the difference between your first product and the traditional solution?

Sanchez: Typically there are two pieces to cooling, a spreader such as a metal plate to spread the heat from the electronics and a pump used to circulate cool fluid, e.g., a plastic fan that pushes air to move the heat away. A thermodynamic problem, however, prevents the movement of the air as efficiently as one would like. CoolChip's solution is to make the fan out of metal and couple it closely to the electronics to enable more air movement. Intuitively, more metal means more heat transfer surface area.

Earthrise: Why do you think that this approach has not been tried before?

Sanchez: The primary barrier has been the misconception that air is *always* a thermal insulator. The key is to create and maintain an effectively zero distance between the stationary and rotating parts so that there is very little thermal impedance in the thermal circuit. Combining something moving (the cooler impeller rotates at several thousand RPM) with something not moving is a critical issue that must be solved. It is not a trivial engineering challenge to achieve that coupling in a way that is scalable, inexpensive, and rugged enough to stand up to thousands of cycles from zero to a few thousand RPM and back, in any orientation.

Earthrise: The challenge, then, is primarily a mechanical engineering one?

Sanchez: That's right. My background is electrical engineering. Among other things, I was working on waste heat removal at MIT when I came across the DARPA challenge. I realized that the solutions proposed by Sandia and MIT in response to that challenge were both capable of addressing the huge needs of data centers and a variety of electronic devices for more efficient cooling techniques.

The members of our team include electrical, mechanical, chemical, thermal, and acoustical engineers.

Earthrise: What applications are you targeting first and which later?

Sanchez: The volume markets are for the equipment in data centers [enormous banks of computer servers which serve web-based businesses like Google, Facebook, financial institutions and retailers]. Keeping data centers cool requires tremendous amounts of energy. If the internal device cooling in those servers can be made smaller and more efficient, the servers will use less power, and will have more room for computation ability. We aim to slash cooling power dissipation of servers in half with CoolChip's more efficient cooler.

First, however, we are targeting niche applications for early adopters such as the gaming industry and avionics. Other applications include medical devices, vehicle infotainment systems, laptops and notebooks. Our technologies are versatile, and customers are eager for smaller and more energy-efficient cooling solutions.

Earthrise: Thank you William

EARTHRISE ACTIVITIES

- Ann Partlow and Jim LoGerfo were active participants in the 2012 **New Energy New York** (NENY) venture forum. In addition to screening and selecting companies to present at NENY, the Earthrise team served as members of the judges' panel at the forum.
- Similarly, Ann and Jim also took part in the company selection process for the **25th Annual National Renewable Energy Laboratory Industry Growth Forum**, a premiere event for emerging energy technology companies and investors. Jim will attend the NREL Growth Forum in Denver in October, and will participate on the judges' panels there.

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Earthrise Capital Fund is a venture capital fund which invests in resource efficient technologies, including energy efficiency, clean energy, power conversion, energy storage, alternative fuels, and green chemistry.