Tessera Technologies, San Jose, CA, USA

Silent Air Cooling: A New Approach to Thermal Management

A multi-disciplinary team at Tessera Technologies has leveraged simulation to develop a completely new system for cooling Ultrabooks.

BY JENNIFER HAND

For Tolstoy on the train, debates at the dinner table and browsing in bed, thin and light tablets have become an essential tool for entertainment, clarification and communication. Serious data handling, however, calls for the power of a bigger device and when tablet users, accustomed to silent running, turn on a notebook, or an even thinner Ultrabook™, the first thing they notice is…noise.

A fundamental requirement for optimal performance, removing heat from electronic devices is an unavoidable necessity and for portable computers this has, up to now, been achieved by a small mechanical fan. The trend towards 'thin' Ultrabooks means that a typical fan unit is now squeezed into a height of less than 10 mm. With a couple of millimeters allowance top and bottom for air gaps and casing, the actual fan blade measures only a few millimeters and that is pushing the limit of effectiveness. Although some of the latest fans can operate in cavities of less than 5 mm, performance is markedly diminished because smaller blades move less air with each revolution and thus have to turn faster, creating even more noise. The truth is that engineers have nearly exhausted the potential for improving fan technology just as the consumer threshold for noise tolerance has fallen even further.

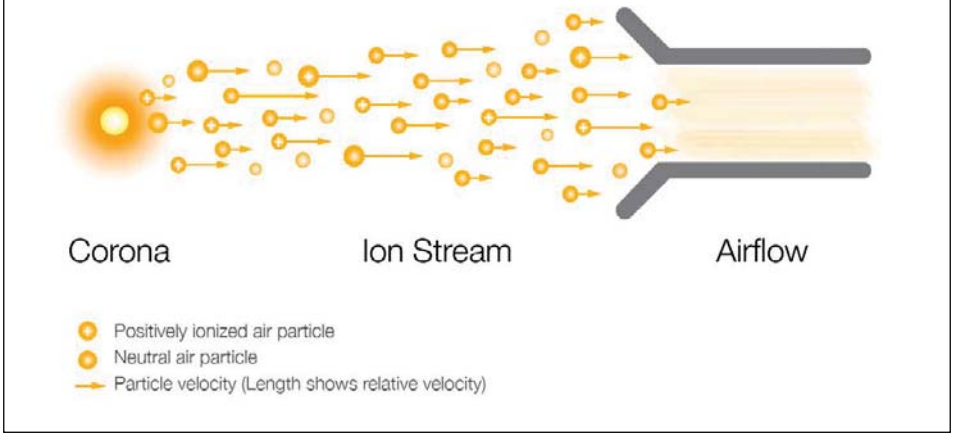

FIGURE 1: Working principle of Silent Air Cooling™.

As a University of Washington student in 2001, Nels Jewell-Larsen recognized the need for research in this area and began a development program. Developing a silent replacement for rotary fans has been the core of his work since then. For the past five years he has been Senior Program Manager heading up a specialist development effort within Tessera Technologies Inc. where Ken Honer is the division lead. "We've put together the best team in the world," says Jewell-Larsen. "We called on experts in areas such as material science, mechanical and electrical design, thermal management, and high-volume manufacturing. We have been able to turn my original idea into a real-life product that is leaps and bounds beyond the early university lab prototypes where it started." As a result, Tessera Technologies

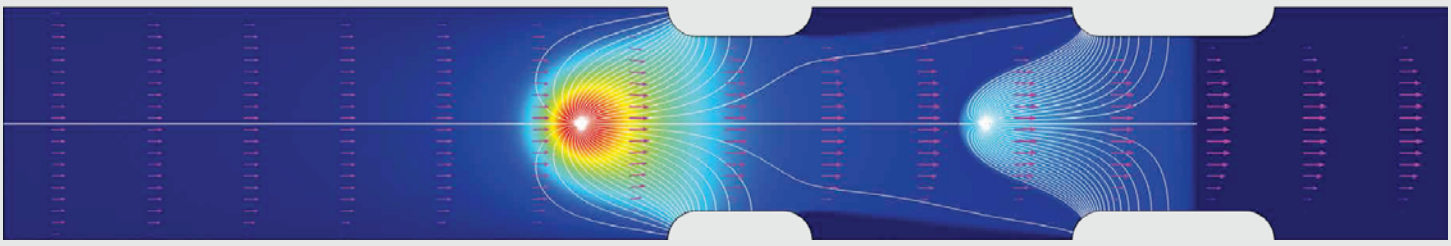

FIGURE 2: Multiphysics plot of a two stage Silent Air Cooling air mover. Space charge density as a surface map (red color indicates higher space charge density) with space charge flux lines shown by white lines. Air velocity displayed as arrows, with arrow length linearly scaled to velocity.

FIGURE 3: Silent Air Cooling's size compared to a pencil.

has just launched a new product based on this breakthrough technology called Tessera® Silent Air Cooling™.

Rotating Blades Not Required

"Probably the first thing to note is that Silent Air Cooling is not a fan, since it does not use a rotating blade to move air," says Jewell-Larsen. "It uses an electric field and charged air to create airflow, a totally different concept. Electronics cooling has never been done this way before." The technology relies on an electric field that charges and pushes nitrogen molecules in ambient air; these collide with other molecules in the air, transferring momentum and producing a continuous stream of laminar airflow. It involves the application of a voltage between two electrodes, generating a very high electric field near one of them that creates positively charged nitrogen ions. The ions created are pushed towards the second electrode generating a constant pressure source (see Figure 1). "Because the electric field does not change with time there are no pressure waves, so there is virtually no sound." In addition to being noise-free, Silent Air Cooling (SAC) fits in a very thin cavity, 4 mm and below, since it doesn't need rotating fan blades and doesn't need an air plenum above or below it.

"Simulation has been at the core of our product development because the team needed to take in account electrostatics, charge generation and transport, fluid dynamics and heat transfer (see Figure 2). We are in a niche field and there was no dedicated simulation software for this when we started, so we looked at several offers," comments Jewell-Larsen.

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"We even considered a custom-made software at one point. We then began using COMSOL Multiphysics because of its in-built flexibility."

Gustavo Joseph, Head Thermal Engineer, expands on this. "Many software packages can easily simulate the movement of fluid or electrostatic forces independently. What is very difficult to simulate is the generation of ions, their transport in an electric field and the force generated on air molecules resulting in the needed cooling flow. COMSOL Multiphysics is the only commercial off-the-shelf (COTS) available software that would allow us to build all our own equations and couple them into the already available fluid dynamics and electrostatics capabilities."

Joseph and Jewell-Larsen used COMSOL Multiphysics to design the core engine of the new technology, termed 'the blower' by the team. "As the main objective was to maximize pressure and airflow for cooling, we simulated different geometry and materials to optimize these parameters. After we designed the key aspects of the blower in COMSOL Multiphysics we ported that over to a CAD software to design the rest of the system."

The end result is a reliable, compact unit that operates at less than 15 dBA, which is below the average threshold for hearing (see Figure 3). Additional features include a self-cleaning system and, as there are no bearings, the system is easy to maintain. Tessera has over 140 patents in this area and initiated pre-production manufacturing late in 2012. The target market includes suppliers of portable computer devices and Tessera has been working with companies wishing to license the technology.

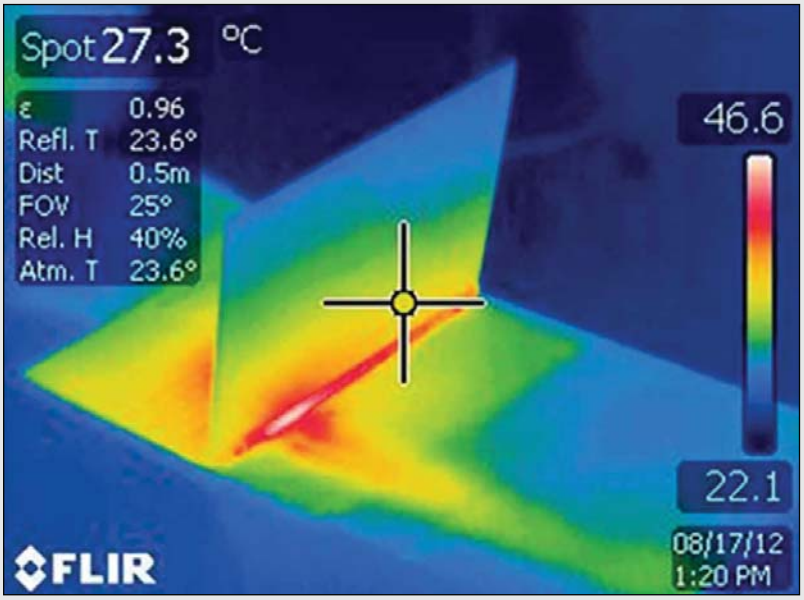

FIGURE 4: Thermogram of an Ultrabook being cooled by a Silent Air Cooling air mover.

Silent and Powerful

"Tablets are both portable and silent. Ultrabooks are powerful, capable, and thin, but noisy. There has not, so far, been a device that combines power with complete portability and silence. Now there is," concludes Jewell-Larsen. "We have demonstrated that the technology works in Ultrabooks (see Figure 4) and our objective is to have this technology in as many devices as possible, with designers free to build form factors that are thinner and thinner. This technology is going to have a really positive impact for users." ■