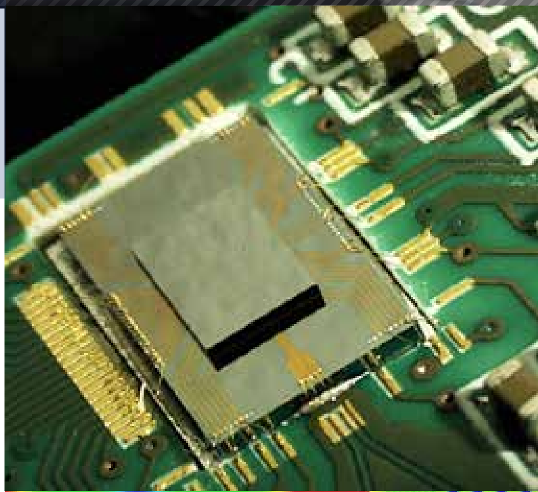
APPLICATION STORY

FLIR camera images next-generation silicon photonics optical network



At the Tyndall National Institute, a leading European research center based in Cork, Ireland, researchers are looking into ways to build the high-performance optoelectronic devices of tomorrow. A dedicated research group is using an advanced FLIR thermal imaging camera as part of a thermal microscope system to image the silicon photonic optical network unit (ONU) for next-generation passive optical networks.

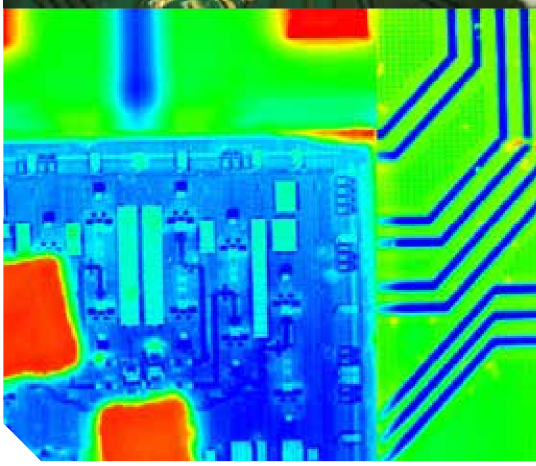
Consumer technology is changing very fast and our telecommunications networks are struggling to keep pace. Smartphones and tablets have become commonplace and the widespread wireless streaming of high-definition video and games is putting the current network architecture under immense strain. Equipment manufacturers are therefore looking into new ways to integrate devices and components in order to support our next generation's telecommunications needs.

But the level of integration required has severe implications for hardware design in general and even more considerable challenges in terms of thermal management. The thermal challenge grows with ever-increasing levels of integration, as more functionality needs to be built into less package space. Packing so much functionality into smaller package footprints will lead to substantially increased thermal densities.

Next-generation passive optical network (PON)

Dr. Lee Carroll, research manager at the Photonics Packaging Group at Tyndall comments: "The last decade has seen the emergence of silicon photonics as a vehicle for next-generation information communication technology applications. One practical solution for the efficient distribution of high-speed electrical modulation onto the photonic platform is the face-to-face stacking (3D-integration) of a driver electronic integrated circuit on top of a silicon photonic integrated circuit (Si-PIC)".

Researchers at Tyndall are now developing a next-generation passive optical network (PON) demonstration module for high-speed fibre-to-home internet connectivity. At the heart of the PON is a Si-PIC that receives information on an incoming optical signal (downloading), before reflecting the optical signal back, after encoding extra information (uploading). In this device, an electronic integrated circuit (EIC) is bonded to the top of the Si-PIC, to precisely distribute the electronic timing signals that are needed to drive the optical modulator in



Measurement of EIC and Si-PIC temperatures on a Si Photonic Chip (composite thermal image) the photonic chip. Joule heating from these high-frequency timing signals causes an increase in the temperature of the EIC and Si-PIC, which can have a significant impact on the performance and reliability of the photonic-chip.

Studying thermal behavior

"Silicon photonics are very sensitive to temperature changes," says Dr. Kamil Gradkowski, another researcher at the Packaging Group. "The thermal behavior of a packaged Si-PIC can impact the performance, stability, and lifetime of the device. We use a combination of thermal modelling and temperature measurements to characterize the thermal behavior of a packaged PIC."

Tyndall researchers are now using the FLIR X6540sc thermal imaging camera to simultaneously measure the EIC and Si-PIC temperatures in different operating conditions, so that they can determine the most efficient way to thermally stabilize the photonic chip.

Dr. Kamil Gradkowski: "Thermal imaging beats other sensor technologies by far. In the past, we have been using thermistors, a type of resistor whose resistance is dependent on temperature, to study thermal behavior on circuit electronics. But the drawback of this technology is that it only measures temperature for one given point, not for a whole surface. Another disadvantage is that by placing a thermistor on a circuit, you actually influence the temperature and the reading. With a thermal imaging camera on the other hand, you can measure an entire surface in a non-contact way."

FLIR X6540sc research camera

Dr. Cormac Eason, design engineer at the Tyndall Institute, comments: "We had already used an older FLIR model, which we liked very much, but with the new X6540sc the image quality and the software for processing these images has improved significantly. Being able to conduct high-resolution (640 x 512 pixel) thermal measurements at high frame rates (100 Hz) using the FLIR X6540sc camera has shown that thermal management of the photonic module accounts for approximately 30% of the overall power budget, and so is a significant factor in the overall operational cost. We aim to use the camera to evaluate future packaging designs that are better optimized for cooling".

The FLIR X6540sc provides ultra-fast frame rate acquisition for scientific and research applications involving dynamic thermal events. The device features a 640 × 512 digital InSb detector with spectral sensitivity from 1.5 to 5.5 µm and an f/3 aperture. It provides images up to 125 Hz in full frame and up to 4011 Hz in a 64 × 8 sub windowing mode.

Invaluable features for researchers

Features on this research grade camera include high thermal sensitivity, snapshot imagery, a motorized spectral filter wheel and a detachable touch screen LCD. The camera connects to the company's ResearchIR Max R&D software for thermal imaging data acquisition, analysis and reporting. The X6540sc can be temperature-calibrated up to 300°C, or up to 3000°C with spectral and/or neutral density filters, and it provides measurement accuracy of ±1°C for standard configurations.

Dr. Kamil Gradkowski commented: "We have to study very small surfaces in the size of millimeters, so we certainly value the camera's windowing option which allows us to look at a small subset of the image with high frame rates. Also the microscopic lens has served us quite well. Another valuable feature is the detachable LCD screen, which allows us to monitor our recordings in real time in a much more convenient way."

"With our research, we want to change the way people think about thermal management. It is important to know that the cost of photonics platforms does not only come from the packaging itself, but to a large degree from the operation, and the associated cooling and thermal management. We hope our research will contribute to that understanding and ultimately lead to more energy-efficient solutions."

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For more information about thermal imaging cameras or about this application, please visit:

www.flir.com/research

The images displayed may not be representative of the actual resolution of the camera shown. Images for illustrative purposes only.
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