PHONONIC

Ebook

The cooling technology that powers 5G transformation

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Cooled optics enable 5G networks to deliver unheard-of levels of performance and bandwidth

5G, the 5th generation mobile network and the new global wireless standard, is transforming the way the world communicates and connects, offering faster data, wider coverage and more stable connections – and enabling the design of a network that connects everyone and everything. 5G growth is explosive, and it's coming up faster than anyone could have anticipated given the exponential increase in data demands in the time of COVID. Broadband outages are spiking around the world as network providers scramble to implement measures to manage the exploding traffic. While global data center traffic had already been increasingly rapidly pre-COVID – over 3x between 2015 and 2020, driving a $6 billion in annual transceiver sales by the end of 2020 and over $12B by the end of 2024 – this latest emergent expansion of connectivity has generated an additional 25-30% increase in traffic due to increased working-from-home, learning from home and video streaming. And that explosion in network usage is resulting in billions of dollars in accelerated global infrastructure spending. Yet this increase is not just a short-term acceleration in response to the global pandemic. 5G networks are driving global economic growth and innovation.

"By 2035, 5G will enable $12.3 trillion of global economic output and support 22 million jobs worldwide. Much of that growth will come from the digitization of transportation, agriculture, manufacturing and other physical industries."

Ronan Dunne, Executive Vice President and Group CEO, Verizon Consumer Group

Speeding global economic growth through 5G deployment

By supporting millions of devices at ultrafast speeds, 5G is an indispensable technology, creating growth and spurring innovation on a truly global scale as its adoption accelerates throughout the world.

The country that leads in the deployment of 5G will gain an edge in rolling out future technologies. This is particularly true in places like South Korea, currently leading the globe in 5G deployments, with 85 of over 100 cities already connected. Not far behind South Korea is China, who is accelerating its deployment plans in order to provide superior connectivity to their citizens and to leverage 5G capabilities as an economic growth engine. 5G is now available to consumers in 50 Chinese cities, including Beijing and Shanghai, with more than 130,000 5G base stations to be activated by the end of 2020, making it the world's largest 5G deployment.

And just as the U.S. benefited from the range of services and businesses that emerged from 4G – like Facebook livestreams or ride-sharing services like Uber – 5G will spark a similar renaissance of new industry and ways of life. Although the U.S. is not at South Korean or Chinese levels of 5G network deployment, it is pushing forward aggressively in this space. In fact, telecommunications and government experts predict that half of the U.S. will have access to 5G by the end of 2020. In light of the COVID-19 pandemic, U.S. service providers are committing to increasing their capital spend on network infrastructure to hasten deployment. The effect that 5G will have on the optics market simply can't be overstated. Industry analyst, LightCounting, predicts the wireless front haul and backhaul optics market growing to almost $1.4B by 2022, driven almost entirely by 5G network deployments.

5G acceleration transforming how we live now and in the future

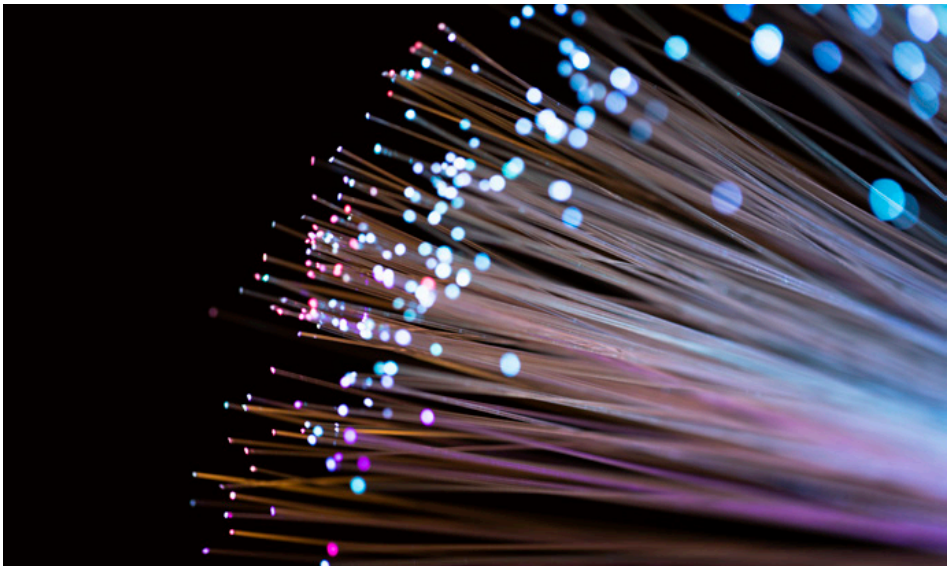
As our actions convert to digital in the time of COVID-19, 5G broadband technology is not only making life easier but also opening up new options for what's possible with mobile networks and the things connected to them. From supporting increased video streaming capability to online school and work, the possibilities are virtually limitless. 5G's ultrafast speeds and unprecedented response times deliver data analysis and essentially instantaneous response.

To support the overwhelming global need for this blazing fast speed, a monumental amount of fiber optics, lasers, detectors and optical components are needed to pull off the 5G application speeds that generate a massive amount of heat. Active cooling and temperature control is critical for the performance of many of the optical components that are particularly sensitive to temperature fluctuations. Mission-critical cooled optics provide the foundation needed to accelerate this quantum leap in telecommunications – and to facilitate the next-generation advancements built around 5G.

Source: Inphi "Bandwidth in the Age of COVID" - https://www.inphi.com/bandwidth-in-the-age-of-covid-19/

5G requires cooling innovation

As new 5G applications push forward and deployments continue to expand, there will be a much heavier technical demand on the optical networks that are used throughout the network. seeing broadband outages spiking around the globe. These applications will require extraordinary amounts of fiber optics – as well as the lasers, detectors and other optical components that transmit signals along all of that fiber – much of which will need to be actively cooled in order to work effectively and efficiently. Temperature fluctuations in the optical components negatively impact laser performance. Even small changes in temperature can result in channel overlap, leading to data loss.



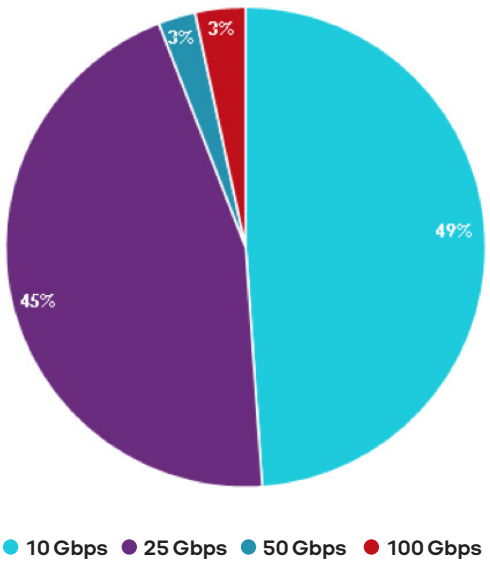
Precise, accurate and stable temperature control is a critical factor in maintaining laser light emission at very specific wavelengths. If the exact wavelength is not maintained across the wide operating temperature range that these components experience, the signal can bleed into neighboring wavelength channels – and the transmitted data can be lost or corrupted. The result? That 4K HDR Netflix stream you are watching starts stuttering and pixelating. Or the Teams call you are on for work cuts out and distorts the voices and webcam broadcasts. In the future, this issue could have even more dire consequences for critical applications like autonomous vehicles or remote medicine. To combat these temperature fluctuations, a growing number of wireless carriers are shifting from uncooled, "gray" optics to cooled, WDM (wavelength division multiplexing)-based solutions to more efficiently utilize already-deployed fiber and future proof the network for increased bandwidth. The cooling technology needed to leverage these WDM solutions is thermoelectric coolers (TECs), which are destined to play a critical role in the development and expansion of 5G.

Phononic TECS deliver cooled optics

WDM is a technique in cooled fiber optic transmission that enables the use of multiple light wavelengths (or colors) to send data over the same strand of fiber. As many as 96 wavelengths of light can travel on one fiber, which creates a huge multiple in the bandwidth and data transmission capability of that single fiber. This technique has long been the technology of choice for transporting large amounts of data between links in a network and serves to maximize the usefulness of existing fiber lines and reduces equipment needs at link points within the network.

Thermoelectric coolers are needed to stabilize the temperatures used in the semiconductor laser diodes used in the Wavelength Division Multiplexing (WDM) that delivers 5G speeds. All matter expands with increasing temperature, including the diminutive, semiconductor laser diodes that light up the fiber network with data. The wavelength of light emitted by the laser changes with the size of the laser, shifting to longer wavelengths at higher temperatures and shorter wavelengths at reduced temperature. These changes can be incredibly small, but crucial for WDM applications where the spacing between channels can be less than 1 nanometer. Thermoelectric coolers work to either heat or cool the transmission lasers, thus stabilizing their temperature and preventing any wavelength drift. This combination of extremely compact size, heat density and precise control mean TECs are literally the only thermal management solution that can meet all of these exacting demands.

Cooled wireless modules by datarate



5G Fiber Optic: TEC cooled infrastructure

Many developers are already moving to create optics applications that are tailor-made for the intense needs of 5G optical networks. The following are some examples of how developers are reimagining solutions to match the growing bandwidth requirements of 5G technology:

• **25G 6-channel/8-channel LAN-WDM** – Tight wavelength spacing drives the need for precise temperature control.

• **I-Temp 10G, 25G and 50G transceiver solutions** - Industrial temperature range (-40°C to 85°C) will often require temperature control in both cooling and heating modes to ensure the laser experiences a narrow operating temperature range.

• **25G 12-channel M-WDM** - This is a very popular application in China, where China Mobile - the largest wireless carrier in the world - has specified this particular wavelength grid as a central part of its front-haul network. The solution specification explicitly calls out the use of TECs. All of the transmission lasers designed for this application utilize compact and low-cost TO-can laser packages.

• **100G and 200G Optical Transport Network (OTN), QSFP28 and QSFP56** – These solutions are often used in mid-haul and backhaul for longer links and en masse transmission of data into and across the core network.

• **Other non-optical applications for TECs in 5G networks** – The unique requirements of 5G radios have spurred innovation and a shift in how the optical and wireless parts of the network are connected together. TECs are also used as the cooling components in compact air conditioners for electronics cabinets at tower sites. Smaller TECs similar to those used in fiber optics can also be used for highly-localized cooling of temperature-sensitive components in embedded electronics systems.

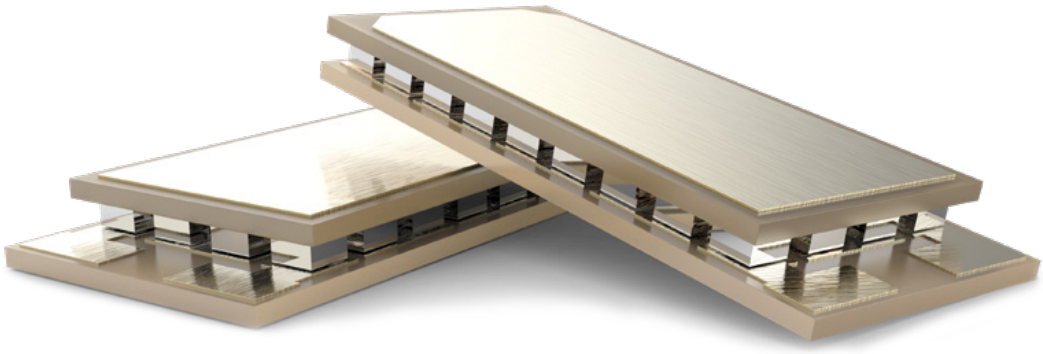
Phononic TEC Benefits

With innovative thermoelectric technology platforms created expressly for the unique needs of optical communications applications, Phononic leads the industry in TECs for cooled TO-can packaged lasers. Key benefits of Phononic TECs for 5G applications include:

Differentiated TO-can technology
As TO-cans have very compact footprint, they come with very stringent requirements for the TEC. To meet this need, Phononic has developed specialized technical and manufacturing processes specifically to produce cooling TECs for TO-can parts at unprecedented scale to support the voracious demand of cooled lasers for 5G and "Fiber to the x" (FTTx) access networks.

Low power consumption + high heat pumping density
When power budgets are tight and every milliwatt counts, Phononic delivers the best performance TEC for 5G optical communications. Optical communication application developers can count on TECs that offer lower power consumption, higher heat pumping density and the ability to reach higher temperature deltas in order to cool laser chips to even lower temperatures and increase laser performance, efficiency and yield.

Faster large-scale production of app-specific TEC designs
Phononic not only produces an extensive offering of off-the-shelf products that support Box TOSA and TO-can laser packages, they also support and can quickly scale application-specific designs. The designs for these application-specific products are based on meticulously developed and thoroughly tested technology platforms that are proven to exceed Telcordia GR-468 CORE standards.



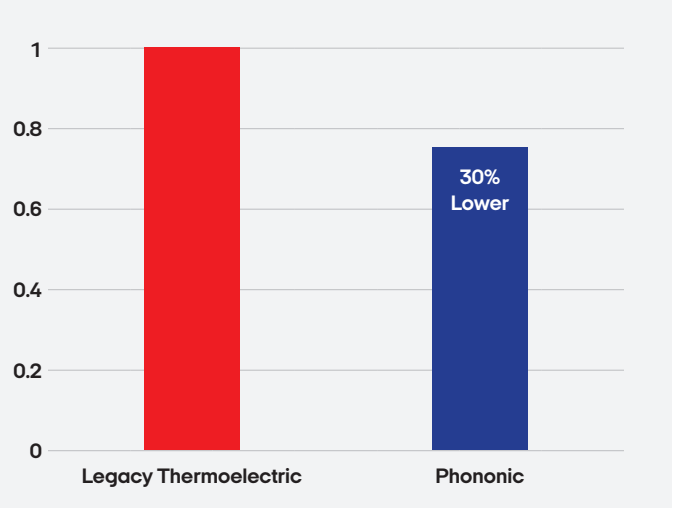
As 5G transforms the world, Phononic TECs drive mission-critical cooling needs

5G isn't just another iteration of wireless innovation. It has the potential to join a handful of technologies throughout history that transform industries across every sector of the economy. It can redefine work, elevate living standards and have a profound and sustained impact on our global economic growth – by extending mobile broadband reach, enabling the Internet of Things and delivering mission-critical services. And just as the opportunities that 5G enables are limitless, so are the possibilities for technology that supports the delivery of 5G. Cooled optics technology is a critical part of this paradigm shift – and will continue to grow in importance as 5G expands and transforms the world.

Low Power Consumption Drives Market Adoption

3rd Party Benchmark Testing Against Thermoelectric Incumbents

Realize > 30% Lower Power Consumption

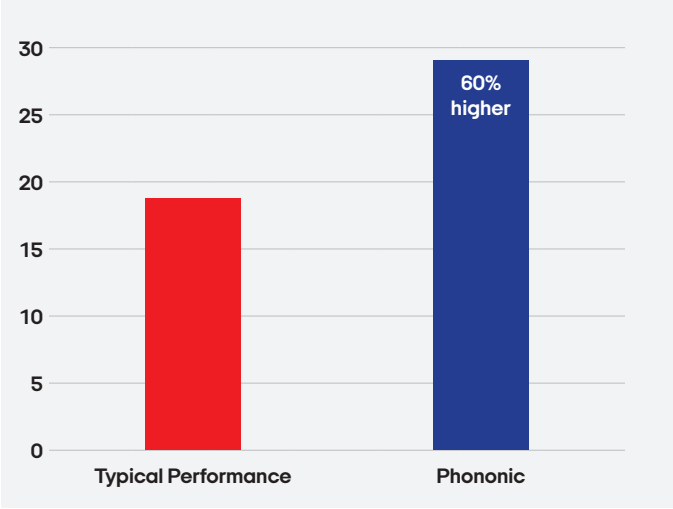


* Average TEC power savings based on customer benchmark testing

Heat Pumping Density Drives Form Factor

3rd Party Benchmark Testing Against Thermoelectric Incumbents

Achieve > 60% Better Heat Pumping Density



* Heat pumping density capability comparison based on comparison of Phononic designs to other commercially available TECs used for laser cooling

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About: Phononic is reimagining cooling and heating in ways never thought possible. Its breakthrough solid-state technology is transforming industries and creating new markets with innovative solutions that disrupt antiquated business models and incumbent technologies. Phononic is the critical element of innovation needed to radically change what it means to be efficient, effective and sustainable. The company has been named to the 2016, 2017 and 2019 CNBC Disruptor 50 lists, received the US EPA's 2017 Emerging Tech Award, R&D 100 Award and more.

Learn more at **www.phononic.com/solid-state-products/optoelectronics/**

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