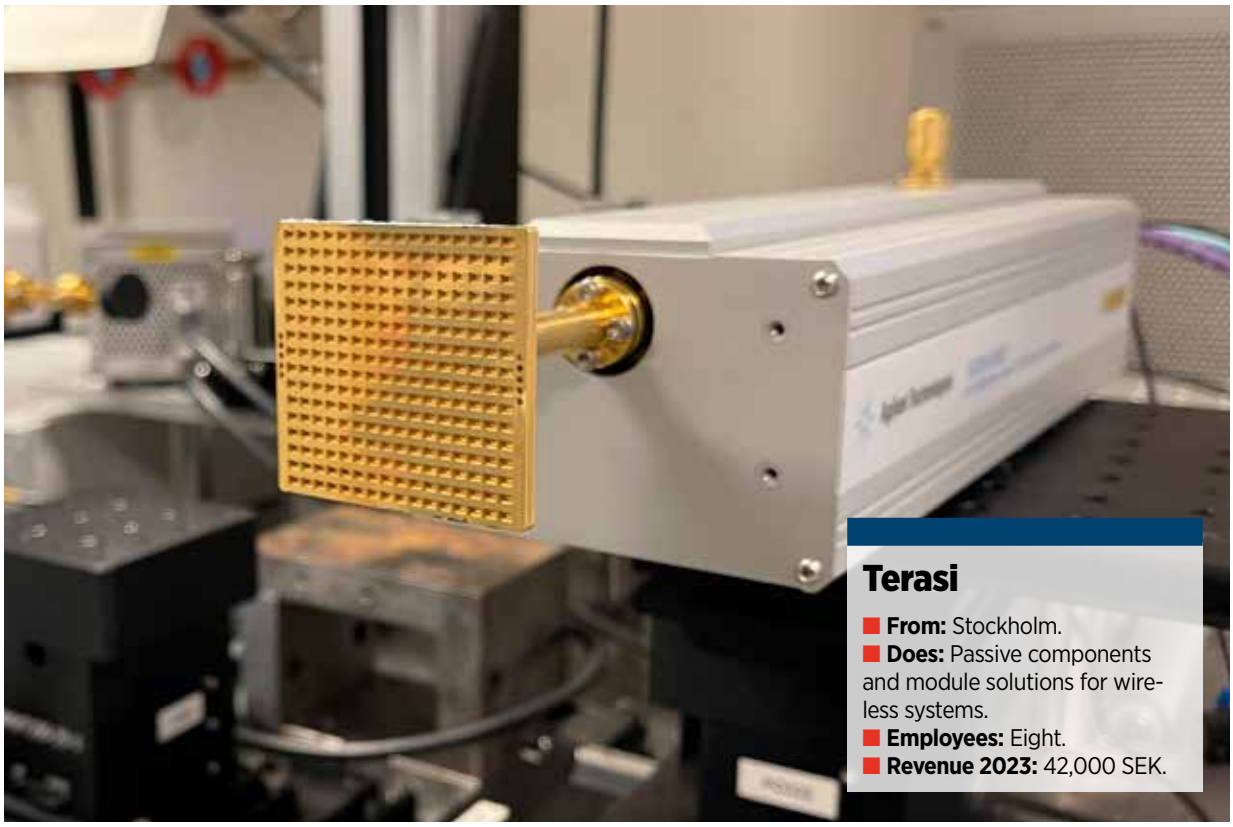
TERASI

Terasi
- **From:** Stockholm.
- **Does:** Passive components and module solutions for wireless systems.
- **Employees:** Eight.
- **Revenue 2023:** 42,000 SEK.

A prototype of Terasi's first antenna.

Swedish contender poised to fulfill the giants' 6g promises

The Swedish startup Terasi is set to help the telecom giants fulfill their 6g promises. Now the company has launched its first products – manufactured in Kista, Sweden.

Our appetite for data seems limitless. From a global data traffic of 26.7 exabytes per month in 2018 to 160 exabytes per month in 2023. According to an analysis by the telecom company Ericsson, this is projected to rise to 563 exabytes per month by 2029.

To manage the increasing data traffic, we need wider digital highways, or more bandwidth. Thus, 6g – the upcoming generation of mobile communications – will leverage higher frequencies to meet this demand. The journey is now extending into the terahertz spectrum, which can lead to data rates of over 1Tbit/second. But according to the Swedish deeptech company Terasi, there are several challenges to address.

– Modern wireless systems, especially those using higher frequencies, have significant issues with energy dissipating into nothing. And they have very low efficiency. It will only get worse as we move towards even higher frequencies, says Terasi co-founder James Campion.

This is what Terasi aims to remedy.

In a wireless system, signals need to be processed, amplified, and converted. Therefore, the technology responsible for this – transistors, amplifiers, modulators, and so on – usually gets the most attention. These are the active components of wireless systems.


TERASI

James Campion.

But James Campion devotes all his attention to the system's passive parts, such as antennas, filters, and wires.

– We're developing hardware that is significantly more efficient, smaller, lighter, and cheaper.

After a funding round that raised 13 million SEK in the fall of 2023, Terasi launched its first products in mid-March. And several Ericsson vete-

Terans are now on its new board. But James Campion first shows a picture of a functioning prototype of a 6g radio system that doesn't come from Terasi. It's used in research. It almost looks like a steampunk museum piece, but he calls it "the million-dollar shoe box." Because it's as big as a shoebox and can cost a million dollars to manufacture.

– In a way, it looks kind of cool. But it's not so cool when you consider that with 6g, we'll need one of these on every street in the city, says James Campion, referring to the need for base stations, which, due to higher frequencies and shorter range, need to be more densely placed and installed closer to the user.

In another picture, only one component remains from the shoebox. Next to it lies a much smaller component. It's a waveguide filter developed by Terasi. Waveguide filters are used to filter which frequencies can pass through them.

– We can make components up to a hundred times smaller and lighter. But we can also improve performance because of the quality we have in manufacturing.

James Campion originally comes from Ireland, but we're conducting the interview in Swedish. He has been living in Sweden for over ten years. With a passion for wireless technology, he was looking for a suitable university and realized that "few are as good at such things"as Sweden. He was admitted to the master's program at Chalmers in Gothenburg and then continued his doctoral studies at KTH in Stockholm.

The inspiration behind Terasi can be traced back to Nasa in the 1990s. The American space agency was searching for components with high tolerance and high mechanical performance to meet the tough requirements for technology to be used in space. When NASA couldn't find what they were looking for, they started developing microelectromechanical systems (MEMS) themselves. MEMS enable the manufacturing of small components with high precision.

– They were among the first to link MEMS manufacturing to THz or sub-THz applications and were a major inspiration for what we did at KTH, says James Campion.

Four years ago, James Campion was contacted by an old colleague. The colleague, who worked in the measurement industry, had heard about researchers at KTH who were manufacturing calibration components more accurate than anything on the market. Such a component could be used to calibrate other components in, for example, measurement instruments or wireless systems.

Terasi can produce calibration components with a dimensional accuracy better than 1 micron. What the colleague didn't realize was that the researcher he wanted to contact was James Campion himself.

– They had read my research papers and asked if we could develop some products for them. That's how we got our first customer. My co-founders, Adrian Gomez-Torrent and Bernhard Beurle, and I had talked for a long time about doing something with our technology. This sparked a fire within us.

Prior to Terasi, when everything was purely in the research phase, James Campion hadn't focused much on costs, sizes, or scalability

– We basically had a basic technology and some ideas.

Yet, these were not ordinary ideas.

In the dawn of mobile telephony, with NMT, AMPS, and GSM (or what we now call 1g and 2g), lower frequencies were used. It was easy to create stronger signals. But as each mobile network generation replaced another, data traffic was redirected to higher and higher areas of the electromagnetic spectrum. Then problems that could previously be disregarded became apparent.

This concerns, for example, the printed circuit board (PCB) of wireless systems. One can think of a PCB as a green Lego baseplate on which active and passive components are built. The PCBs are traditionally made with a base layer of plastic or fiberglass that provides stability and isolates electronic circuits. Plastic and fiberglass have long been cost-effective materials, but as the signal loses strength at higher frequencies, their limitations become apparent.

– Much of what little signal you have goes into this material that is used. There is a big loss there, says James Campion.

Of course, one could attempt to build PCBs with other types of materials, but it would also be a fundamental shift that could make them incompatible with existing systems. Terasi's plan is to bypass the limitations of PCBs with its passive components. Partly by making the components themselves more efficient, but also by making them work well together with the system's active parts.

– You can make the best antenna possible, but if you can't connect it to the PCB in a radio system, you can't take advantage of it, says James Campion.

Uses air

■ One method by which Terasi tries to increase the efficiency of wireless systems is by using air in transmission lines (which carry energy in the form of, for example, electromagnetic waves). Terasi takes advantage of the fact that air is an excellent dielectric medium for transmitting electromagnetic signals with minimal loss. The ambition is to abandon "all dielectric materials and substrates that cause losses." "Why fill your transmission lines with anything else when you don't need to?" notes the company on its website.

New Earth observations

■ Venturing into subterahertz frequencies unlocks more than just additional bandwidth. James Campion envisions a realm of entirely new applications. For example, you could use the properties of higher frequencies for a new type of Earth observation from space. They could be used for weather models and climate analysis. This is something Terasi is actively working on as part of a project led by the European Space Agency's (ESA) incubator.

To improve component efficiency, Terasi has scrapped the metals – such as copper, aluminum, and brass – that are usually used for waveguides and antennas. Instead, their manufacturing process has more in common with the semiconductor industry and specifically MEMS.

– We use some MEMS infrastructure and methods with silicon etching and so on, but also other materials and manufacturing methods. That's why we don't talk much about MEMS specifically.

Terasi has patented parts of its technology and currently manufactures the components in the Electrum Laboratory, KTH's cleanroom for nano- and microtechnology. KTH acknowledges that Terasi is one of the few users of the laboratory with commercial products.

– We have customers, and most of them involve pilot or development projects. We've actually secured a development project with a customer where we, together with them, are developing a 6g solution for beam steering. Many of our other customers are in the space, radar, and measurement industries, says James Campion.

In mid-March, Terasi launched its first three products on the market: an antenna, a waveguide filter, and the calibration component that gave them their very first customer. These are individual passive components for wireless applications above 60 GHz.

But the vision is bigger than that.

On the terminal side (mobile phones, tablets, and so on), system on chip (SOC) has long dominated the market. By integrating all (or at least most) components on a chip, manufacturers can optimize for energy efficiency and space. SOCs can also be used in radio systems, but they cannot accommodate all the components required. However, James Campion argues that packaging is of great importance – and Terasi is now focusing on what is called system in package (SiP). Several chips and components are mounted in the same package, where they are also interconnected.

– That's how systems were built before everything could be integrated into the same material and technology. It became outdated, but now it's starting to come back, but there's still a lack of good passive techniques that can be linked to the active ones in an efficient way.

James Campion shows a picture of a product that Terasi intends to launch in 2025. It's a 5g radio transceiver (which can both transmit and receive a signal).

– It's our first module. You can imagine it consisting of circuit boards and our antennas and filters. Then it can be installed in a radio system from, for example, Ericsson or Nokia.

Ultimately, Terasi hopes to offer a foundry model like the semiconductor manufacturers TSMC and Intel use. Terasi develops the technology that customers can then build their own solutions with.

– The advantages are many. You don't need to have hundreds of thousands of engineers to sit and modify products and components. And if you only design components individually and sell in small quantities, you don't take advantage of scalability, says James Campion.

– In the industries we operate in, security and intellectual property rights are important. Our customers want to own the design and IP. Smaller customers can also benefit from a foundry model where we can combine orders from many.

For James Campion, Terasi's technology is not just about meeting the data needs that will exist in the 2030s. During our interview, a strong passion for environmental issues also emerges.

– As we move towards 6g, we will have ten times more devices compared to now. We already use a lot of energy for today's infrastructure. Sustainability has finally become a key issue in the telecom sector. However, the push for change must come from demands placed on suppliers and operators. We can't have systems as inefficient as they are today.

PETER OTTSJÖ
peter.ottsjo@nyteknik.se

KTH

The Electrum Laboratory.

Terasi raised 13 million SEK – and more is coming

In the fall of 2023, Terasi raised 13 million SEK in a seed round. Among the investors are Navigare Ventures, Almi Invest, Onsight Ventures, and Deeptech Labs. The capital has been used, among other things, for the launch of the startup's first three products. At the same time, Terasi went from three to eight employees. "Since then, we've started investing in our own infrastructure in Kista and spending a lot of time and money on intellectual property", says James Campion. On March 6, Terasi got a new board led by Ingrid Nordmark, who previously served as head of research and development at Ericsson, chief technology officer at Charge Amps, and CEO of Rise Sics. Ulf Forssén, who has been a director at Ericsson for over 20 years, and Gustav Notander, investment manager at Almi Invest, have also joined the board.