Remote infrared radiation technology measures thickness of ice on prawns

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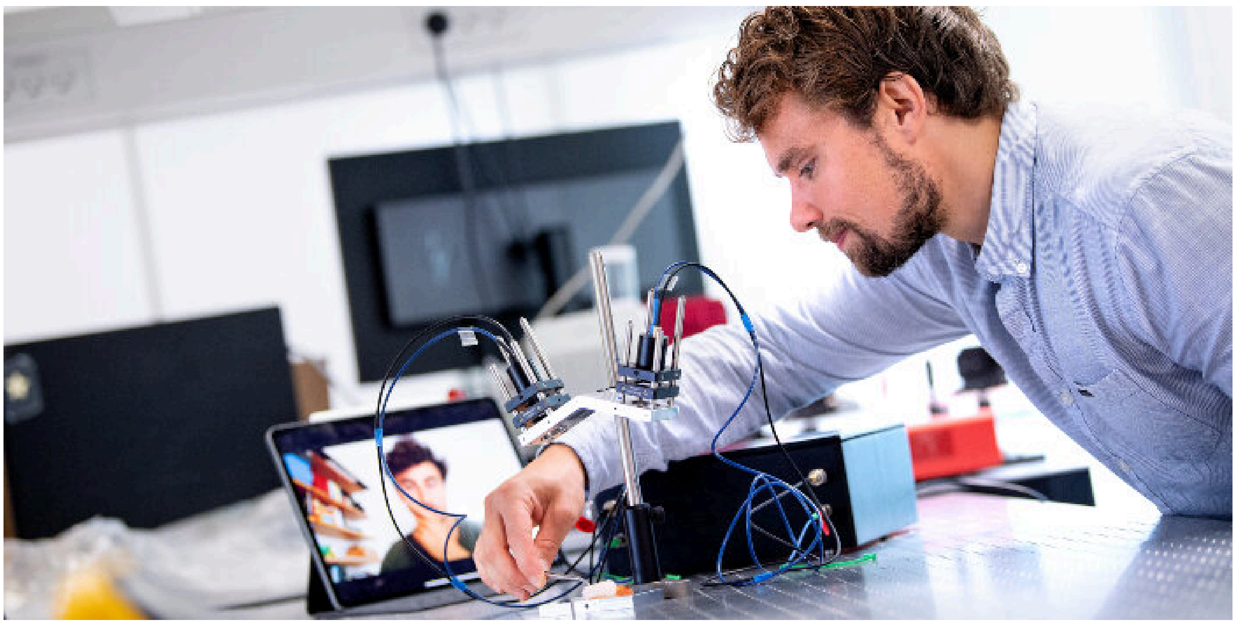

Credit: Bax Lindhardt

DTU and Royal Greenland have collaborated on a new technology that can measure the thickness of the ice glaze on frozen prawns. This is important to know so that the prawns stay fresh and consumers get the right quantity of prawns. The solution is based on terahertz waves, and the technology can be used to measure the thickness of innumerable materials.

How do you measure the thickness of an eggshell, a road stripe or the ice glaze on a prawn? Simon Lehnskov Lange—postdoc at DTU Fotonik—knows how. He heads a research team that is developing a compact and inexpensive device for quick and efficient measurement of the thickness of all kinds of materials.

The idea is to utilize a specific type of electromagnetic waves called terahertz radiation. This radiation can penetrate many different substances, and—at the transition between two different materials—part of the radiation is reflected and forms a small echo. By measuring the echo, the researchers can determine the thickness of the material with great precision.

In 2017, Simon Lehnskov Lange chatted with people from DTU Food, and they knew that Royal Greenland needed a quick and smart method for measuring the thickness of the ice layer on ice-glazed prawns.

At Royal Greenland, process developer Niels Bøknæs explains why it is important to ensure an even layer of ice on the frozen prawns:

"The glazing protects the prawns from rancidness, i.e. from drying out and unwanted chemical changes. As long as the prawns are frozen, it's not so much about food safety, but more about quality. The ice glazing prolongs the shelf life, because—without it—the prawns would dry out and not taste very good."

"We glaze by spraying water from nozzles on the deep-frozen prawns. We've found out that 10 to 12 percent water covers the prawns well. But in the industrial glazing process, the glazing is done with differences in process parameters. Maybe the water from the water nozzles is slightly too hot or cold, and the size of the prawns may vary a little. This means that the glazing thickness is not completely constant, and it's really a challenge to control the glazing content in the practical production," says

Niels Bøknæs.

Ice weight must not be included

Ice-glazed food products are typically sold by weight, and here the ice weight must not be included. When a consumer buys a bag of 200 grams of frozen prawns, there must be at least 200 grams of defrosted prawns when the ice glaze has melted. As the prawns are only weighed after the glazing for technical reasons, it is, however, important for the manufacturer to know exactly the quantity of ice used. Otherwise, consumers will get too many or too few prawns.

Today, Royal Greenland manually checks the glazing percentage using a time-consuming and impractical method. The company would rather have a system in which the glazing thickness is measured continuously, allowing the glazing to be adjusted automatically in real time. If too much ice is used, the water nozzles can be turned down slightly—and vice versa. Royal Greenland has five large prawn factories in Greenland and Canada, and each of them can receive 80 tons of raw prawns a day and turn them into 27 tons of frozen, shelled prawns. There is consequently a lot of money to be saved by being able to measure accurately.

Here, the researchers from DTU Fotonik might be able to help Royal Greenland.

"We ran a small pilot project in which we glazed some prawns, and we discovered that we were able to measure the ice thickness, which is typically between half a millimeter and one millimeter," says Simon Lehnskov Lange and continues:

"So we agreed to try it out on a slightly larger scale. We brought a system to Royal Greenland's factory in Aalborg, where we validated the technology and demonstrated that we can measure prawns of all sizes and types—also under the prevailing conditions in such a factory, where, for example, it's quite cold. We're now patenting the method for measuring ice glazing thicknesses on foods," says Simon Lehnskov Lange about the results from the research project, which is named GLAZE.

Primary focus on foods

Measuring the thickness of ice on prawns is just one possible application of the technology. Terahertz radiation is stopped by metals, liquid water, and water vapor, but it can otherwise penetrate and measure the thickness of a large variety of materials. Therefore, the technology is also useable in many different industries, for example for continuous control of the quality of surface treatments. But first, the technology must be developed so that it is affordable for companies.

If they succeed in developing a price-friendly system that can measure—several times per second—the ice thickness of prawns passing by on a conveyor belt, Royal Greenland is a sure customer. And other producers will then follow suit, Simon Lehnskov Lange hopes:

"We're initially looking at food inspection, where we've now started to study other uses, for example measuring the thickness of eggshells."

A thick eggshell means a solid egg that can withstand the journey all the way to the consumer or that can protect the fetus until the chicken is hatched. Many eggs are lost because the shell is too thin.

Traditionally, egg producers have measured the thickness of eggshells by cracking the egg and using a micrometer screw. There are also methods where you do not have to waste the egg, but where the shell thickness is measured using acoustic methods. You can get a measure of the shell thickness by striking the egg and measuring its resonant frequency, or you can use ultrasound for a more direct measurement.

However, these measuring methods require direct contact with the egg, and they take time, and are cumbersome. With terahertz radiation, you get a quicker, high-tech solution that works without direct contact between the measuring instrument and the egg.

Price must come down

But it will be a while before the technology from DTU is ready for the market, says Simon Lehnskov Lange.

"We started with a system that cost 1.5 million Danish kroner. If we're to use the technology in the food industry, the price of our terahertz system must come down a lot. So we looked at whether we could produce a more inexpensive version by replacing the most expensive components with cheaper versions based on well-known semiconductor technology," says Simon Lehnskov Lange, who elaborates:

"We're now working on a demonstration model that is much smaller and designed to make it profitable for companies if we can get the technology mass-produced. We hope to have such a model ready for testing by the end of 2021."

In the work towards a less expensive and more compact version, the researchers receive help from FORCE Technology, where the role of the Center for Applied Photonics includes ensuring commercialization of Danish, photonics-based technology.

Simon Lehnskov Lange still remembers the first meeting at FORCE Technology, which—after hearing about the idea for the terahertz measurements—gave him a challenge, namely to measure the thickness of a road stripe:

"I went home with a piece of road, complete with asphalt and road stripe! In the laboratory, I ran it under our laser and found out that we could measure the thickness of the road stripe—the terahertz radiation could penetrate the material. In fact, we could measure both the thickness of the stripe and the asphalt below."

System on a chip

This convinced FORCE Technology that the DTU researchers were on to something.

"We saw a technology with a huge potential which can be used to the benefit of the industry, not just in Denmark, but worldwide," says Henrik Mertz, who heads the center at FORCE Technology.

"We have the experience and knowledge needed to develop prototypes. We're not optical specialists like the extremely competent university researchers, but we understand the world and the issues to be dealt with. And we can transform the researchers' knowledge and ideas into something that is operational and application-oriented," he continues.

The engineers at FORCE Technology dissect the DTU system and identify the components that can be optimized in relation to making it more compact and, especially, less expensive. The DTU researchers receive help with business development and good advice on how a final product must be composed and documented to be approved for sale, including CE marked. In addition, FORCE Technology has a wide network of companies that may be able to use the technology to create new applications.

Although a fully functional demonstration model may be ready as early as this year, there is still a fair way to go before the high-tech measuring instrument is ready for mass production. But Simon Lehnskov Lange is optimistic, and his ambition is that the solution will end up being a 'system on a chip':

"We hope that—in the long term—we can get the price down below 1,000 euros. And we will continue to develop the system to make it so compact that it is no bigger than a fingernail, with all the technology integrated in a single chip."

Provided by Technical University of Denmark

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