Wood-based electronics for sustainable 6G?

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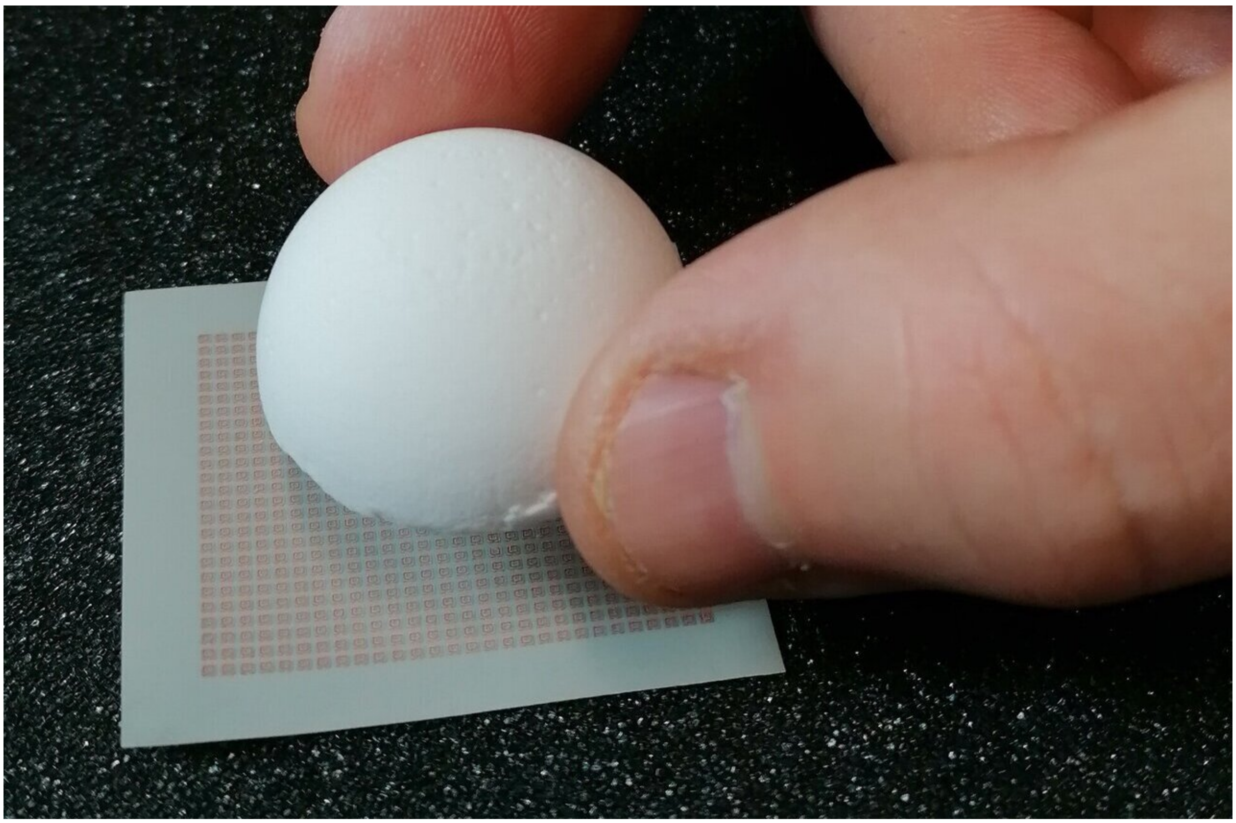

Composite lens made of nanocellulose for 6G frequency, about 800 antennas. Credit: University of Oulu

The amount of electronics in the world is growing. It is important to study how we could made electronics more sensibly and more sustainably in comparison with the current production method. What will new technology do and what it will be used for? These aspects determine how devices should be manufactured and what they could be made of.

The interfaces between communications technology and materials technology are interesting, and wood-based electronics are an important line of investigation, especially in a country like Finland where forest industry represents one fifth of the export of goods. Predictions of what kinds of applications wood-based electronics could be used for would be premature, but radio lenses that direct the signals of a radio transmitter have already been made of nanocellulose.

Key guiding factors in the manufacture of electronics are the temperature of manufacture and the use of energy. Temperatures are being brought down and in many situations production at room temperature is already possible. Different materials are optimized for the intended use of specific electronics: sustainability, recyclability, availability, environmental friendliness, and naturally also the price, which is affected by procurement, transport, and processing. The new manufacturing methods are significantly linked with printable electronics, which is going strong in the Oulu area. Production of wood-based electronics is one part of the development of printed electronics. Radio lens is a central part of the production of new technology at the intersection of radio technology and printed electronics.

"We are now making a 6G radio device for demonstrating data communications that is as fast as possible. In 6G the frequency of the signal is 300 gigahertz, and the wavelength is such that the size of the antenna need not exceed one millimeter," says postdoctoral researcher Sami Myllymäki of the Microelectronics Research Unit, University of Oulu, Finland.

Aiming the signal toward the antenna of the receiver is a crucial point where radio lenses are needed. A lens focuses the radiation and increases the distance between the transmitter and receiver, thereby extending the range.

"For example, cameras also have lenses because they give a sharp picture. Similarly, in a radio the goal is high-quality signal transmission, which requires an accurate radio environment image. Radio lens is a central part of producing new technology," explains Myllymäki, who is specialized in radio technology and new materials.

One aim of 6G is to bring much greater speed to radio devices. A hope for the future is to transfer volumes of data that massively exceed what was previously possible almost without delay and, of course, very reliably. This will be made possible by raising the frequency. Consequently, the requirements for the computational capacity of the data to be transmitted will also vastly increase.

"The computational power and high frequency steer equipment solutions in a direction that imposes high demands on a silicon-based microprocessor, and the speed of a transistor in the amplifiers is pushed to the extreme. On the other hand, it is not feasible to replace silicon with a more expensive material, which should be considered when innovating something new," Myllymäki ponders.

The semiconductor industry uses plastics, ceramics, and metals. With respect to materials, consideration is given to what is used now, and what new materials might replace them. Silicon is the key material, and any new materials will be compared to it. A new material must naturally be better than the current ones in performance, but also in other respects.

"Traditionally in electronics the aim has been to fit things into a small space, which means that they are tightly integrated. This has been done by utilizing materials with high permittivity. In 6G, it is not essential to squeeze things into a smaller space. For purposes of integration, small size in the new materials has largely reached its sensible limit," Myllymäki points out.

Radio lenses out of nanocellulose

If we calculate the share of electronics in the overall consumption of plastic in the world, it is quite small. Therefore, wood-based electronics alone will not bring us a new way to utilize the forest industry, but it is definitely one of the possibilities for the future.

"The search is on for raw materials that replace plastic. Environmental friendliness is an important, perhaps even the most important reason. Nanocellulose is a natural, interesting substitute material. In addition, the recycling is easier when the material is water soluble," Sami Myllymäki says, adding that the material is also brittle, but nevertheless a potential option.

"Nanocellulose has many benefits: it is a light, mechanically strong material, with a low loss structure for electricity, and the material is easy available. Lightness and low loss are important. Loss of signal in the material needs to be made low. The best of materials can be 99% air and then the proportion of loss is infinitesimal. We can already print a material that is similar to air for research purposes—which means that it is extremely light. However, it is also brittle," Myllymäki notes.

Nanocellulose is used in different ways in the production of components: mold casting technology, printing technology, and 3D printing. It is a great bonding agent in materials and it forms a printable surface. When we go to materials with low permittivity, they start to be so porous that they do not have a contiguous surface for an electrical conductor. Cellulose makes these suitable for printing and gives a necessary support structure. They are formed out of nanotube structures, which means that much air is mixed in. Sami Myllymäki explains the matter enthusiastically, even though a water soluble and brittle electronic component sounds like a strange starting point, to say the least.

"As researchers we are looking for positive possibilities. We must not get bogged down with problematic issues. I also believe that the market will decide, which means that a protective surface material can be developed for lenses, which means that they are durable enough, and water solubility is not an obstacle to use, but it is a significant advantage at the recycling stage.

The multidisciplinary character of the University of Oulu is showing its strength once again when developers of new electronics from the same place acquire tailor-made nanocellulose as a handicraft produce from northern Finland. The mass comes from the Fibre and Particle Engineering research unit, whose goal is to promote the implementation of circularity and bioeconomy with the help of materials research.

Reflecting surfaces and smart dust

Sami Myllymäki is specialized in radio technology and microelectronics which is a great combination for 6G research.

"I have an engineer's identity and I am a link person between different topic areas and their researchers."

Both 5G and 6G are taking us to a heavy radio infrastructure and powerful computational requirements.

"And then there are IoT devices that can link to the internet. A single, exceedingly small device is sufficient for producing certain information, for example, measuring temperature. Structural electronics are developing at the same time; devices and materials are functional on their own, electronics is integrated into them already in the manufacturing phase," Myllymäki says.

An interesting example are reflecting surfaces that are needed to help the propagation of signals as wireless data communications expands in the built environment. What could they be like? From this we can move to large-sized materials of printable electronics. The material needs to be electronically adjustable, or controllable. When radio devices are used to point a signal at a surface, it needs to be capable of directing it to the desired target. So, researching new materials and developing directing lenses are also centrally also linked with the large surfaces of the built environment and the highly promising area of intelligent reflecting surfaces.

The next interest for Myllymäki, in addition to reflective surfaces, is to consider extremely fine smart dust, or devices that might be made in the future that are so small that they are like tiny particles.

"We researchers offer alternatives. It is not possible to move to anything new if it has not first been developed. Experimental culture must be maintained. We can do that when we think about how 6G works. Researched knowledge beats guesswork every time," Myllymäki concludes.

Provided by University of Oulu

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