Can germanium replace silicon in mid-infrared group IV photonics?

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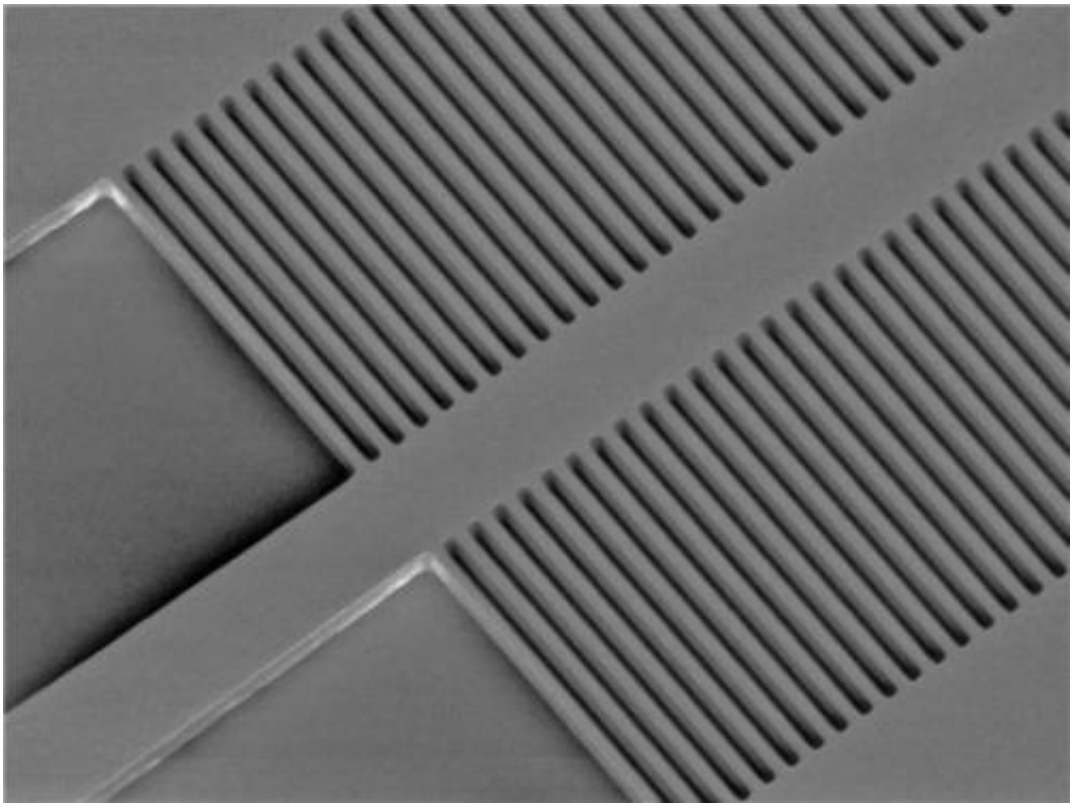

A novel mid-IR waveguide structure for sensing applications.

A new research project led by the University of Southampton is aiming to establish whether germanium, a group IV semiconductor, can be used as the material of choice in mid-infrared (mid-IR) photonics circuits and sensors.

Mid-IR group IV photonics has a number of important application areas, such as chemical and biological sensing, environmental and hazardous substance monitoring, medicine, telecommunications, astronomy, defence and security.

So far, research in mid-IR group IV photonics has focused on silicon-based devices for shorter wavelengths due to its availability, low cost, maturity of fabrication processes, possibility for photonics-electronics integration and a good transparency.

However, the transparency of silicon only extends up to eight micrometres (μm) and is therefore not very suitable as a core material for the mid-IR fingerprint band (8-14 μm). The Mid-Infrared GeRmAnium phoTonIcs fOr seNsing (MIGRATION) project will investigate germanium as an alternative platform to silicon with the aim to future proof emerging technologies in this field. Significantly, compared to silicon, germanium offers a number of other advantages in terms of device development such as higher nonlinear coefficients, better carrier mobility, and the potential to produce active devices based on germanium-based alloys.

Principal Investigator Dr Goran Mashanovich, Reader in Silicon Photonics and Royal Society Research Fellow in the Optoelectronics Research Centre (ORC), says: "This visionary programme of research provides us with a unique opportunity to create breakthroughs in the field of mid-infrared group IV photonics.

"The research will be performed in the world-leading facilities available at Southampton, which includes a £120 million cleanroom complex and 94 photonics laboratories. This will not only significantly reduce the fabrication and testing turnaround time, but will also give us much better control over the fabrication processes and offer possibilities to improve designs and generate new ideas."

One of the main outcomes of the project will be to identify high-quality germanium substrates that rival the performance of the well-established silicon-on-insulator wafers. This framework will then be used to demonstrate a library of devices such as waveguides, couplers, filters, amplifiers and modulators that will form the building blocks of integrated on-chip circuits, systems and sensors over an extended wavelength regime.

The interdisciplinary project, which is funded by the Engineering and Physical Sciences Research Council (EPSRC), will be led by Dr Mashanovich and his colleagues from ORC (Dr Frederic Gardes and Dr Anna Peacock) and Electronics and Computer Science (Dr Harold Chong) and will also involve other Southampton researchers from Biology, Chemistry, Engineering and Physics.

The main project adviser will be Dr Richard Soref from the University of Massachusetts, the pioneer of silicon photonics and mid-IR group IV photonics, with other partners including several universities, DSTL and IQE Silicon Compounds Ltd.

Dr Mashanovich adds: "Another huge advantage is that this programme will be closely connected with other very recently awarded research projects I am involved in, which investigate near-IR and mid-IR silicon photonics circuits. For example, we will be able to collaborate with researchers that work on integration of active and passive devices in silicon for telecommunication ('Silicon Photonics for Future Systems' EPSRC programme grant) or sensing applications ('Mid-IR silicon photonics sources, detectors and sensors' funded by the Royal Society) and that will certainly facilitate progress achieved in MIGRATION."

Provided by University of Southampton