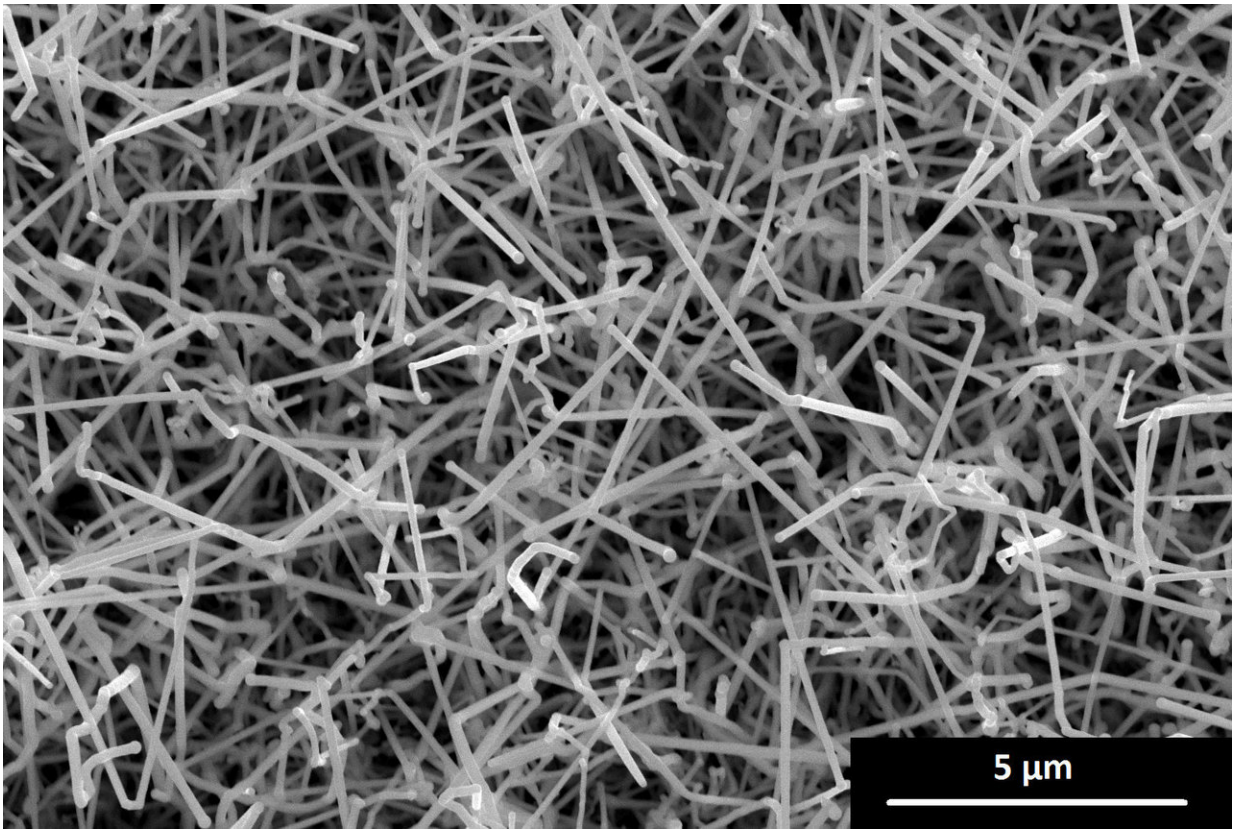


Nanostructures made of previously impossible material

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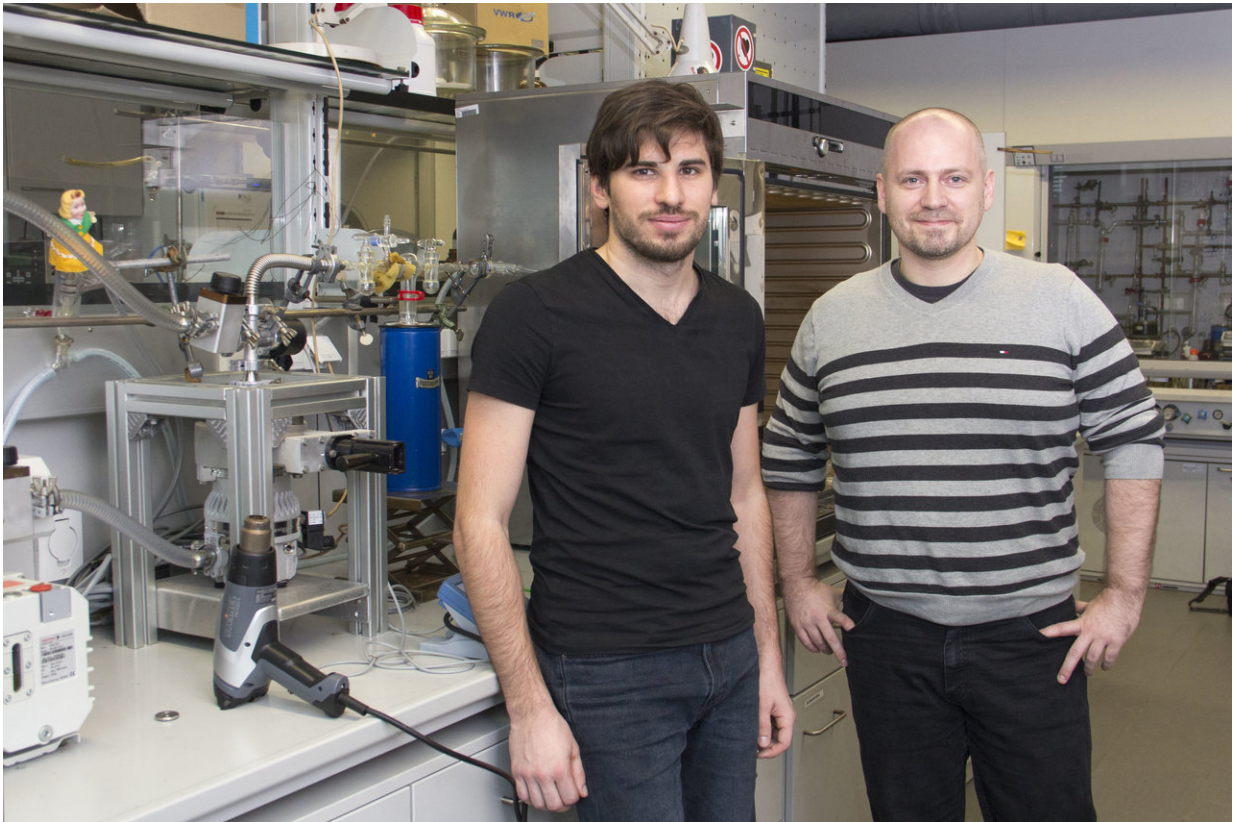
Nanostructures made of previously impossible material. Credit: TU Wien

Materials scientists often seek to change the physical properties of a material by adding a certain proportion of an additional element; however, it isn't always possible to incorporate the desired quantity into

the crystal structure of the material. At TU Wien, a new method has been developed to produce previously unattainable mixtures of germanium and other atoms. This results in new materials with significantly altered properties.

"Incorporating foreign [atoms](#) into a crystal in a targeted manner to improve its properties is actually a standard method," says Sven Barth from the Institute of Materials Chemistry at TU Wien. Modern electronics are based on semiconductors with certain additives. Silicon crystals incorporated with phosphorus or boron are one such example.

Researchers have encountered difficulty incorporating germanium with other atoms. Melting the two elements and thoroughly mixing them together in liquid form and then letting them solidify does not work in this case. "This simple thermodynamic method fails, because the added atoms do not efficiently blend into the lattice system of the crystal," explains Sven Barth. "The higher the temperature, the more the atoms move inside the material. This can result in these foreign atoms precipitating out of the crystal after they have been successfully incorporated, leaving behind a very low concentration of these atoms within the crystal."



Michael Seifner (l.) and Sven Barth (r.). Credit: TU Wien

Barth's team therefore developed a new approach that links particularly rapid crystal growth to very low process temperatures. In the process, the correct quantity of the foreign atoms is continuously incorporated as the crystal grows. The crystals grow in the form of nanoscale threads or rods at considerably lower temperatures than before, in the range of just 140 to 230 degrees C. "As a result, the incorporated atoms are less mobile, the diffusion processes are slow, and most atoms stay where you want them to be," explains Barth.

Using this method, it has been possible to incorporate up to 28 percent tin and 3.5 percent gallium into germanium. This is considerably more

than was previously possible by means of the conventional thermodynamic combination of these materials by a factor of 30 to 50.

This opens up new possibilities for microelectronics: "Germanium can be effectively combined with existing silicon technology, and also the addition of tin and/or gallium in such high concentrations offers extremely interesting potential applications in terms of optoelectronics," says Sven Barth. The materials would be used for infrared lasers, for photodetectors or for innovative LEDs in the infrared range, for example, since the [physical properties](#) of [germanium](#) are significantly changed by these additives.

More information: Michael S. Seifner et al, Direct Synthesis of Hyperdoped Germanium Nanowires, *ACS Nano* (2018). [DOI: 10.1021/acsnano.7b07248](#)

Provided by Vienna University of Technology

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