Team develops method for creating 3D photonic crystals

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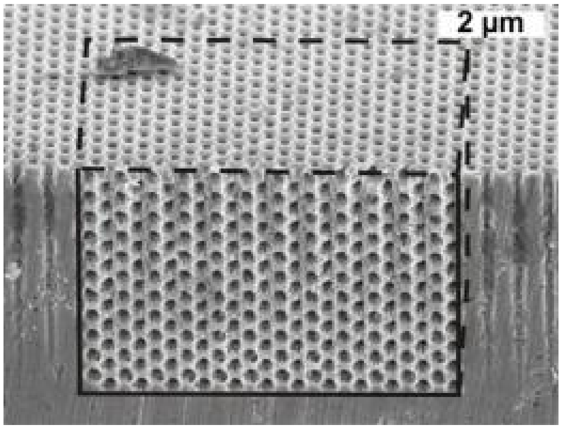
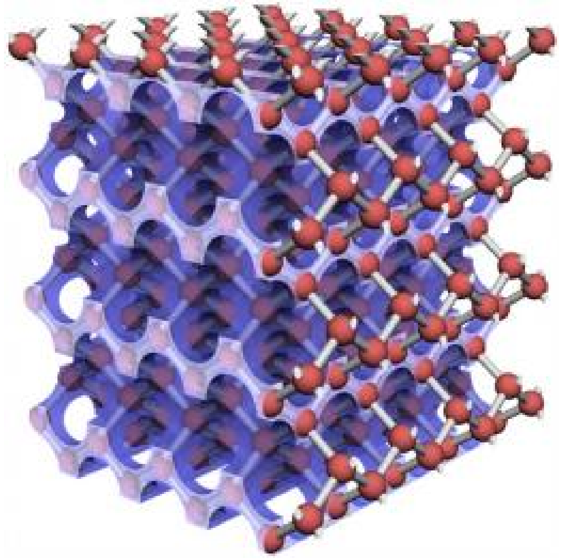


Electron micrograph of a three-dimensional diamond structure in silicon (outlined). The scale bar in the top right corner represents a distance of 2 micrometres, which is about one fiftieth the thickness of a human hair. The object on the upper left-hand side is a dust particle that settled onto the crystal after the etching procedure.

Dutch researchers at the University of Twente's MESA+ research institute, together with ASML, TNO (the Netherlands Organisation for Applied Scientific Research) and TU/e (Eindhoven University of Technology) have developed a method for etching 3D structures in silicon. These structures behave as photonic crystals (semiconductors for light), making it possible to manipulate light in all sorts of novel ways. For instance, you can use them to "trap" light, or to create zones that are impenetrable to light of specific wavelengths. This method brings the optical computer (a much faster type of computer that uses optical bits instead of electronic ones) one step closer. The researchers give details of their method in two articles that will soon be published in the scientific journals *Advanced Functional Materials* and the *Journal of Vacuum Science and Technology B*.

Moore's Law states that the number of transistors that can be mounted on a computer chip will double every two years. However, it is becoming increasingly difficult to reduce the size of transistors any further. So, given the limitations of current technology, Moore's Law will not be applicable for very much longer. One way around this problem is to stack the transistors in three dimensions (3D). Researchers at the University of Twente have developed a method for making 3D structures out of silicon. These structures behave as semiconductors for light, making it possible to manipulate light in all sorts of different ways. For instance, these structures make it possible to trap light, or to create zones that are impenetrable to light of specific wavelengths.

These structures are produced using standard equipment developed for the manufacture of computer chips. This has various practical benefits. For example, the structures are easier to produce and they can be integrated with electronic components on silicon chips.



Model of a diamond structure (red balls and grey bars) superimposed on the 3D silicon structure. The similarities between the diamond lattice and the artificial structure are clearly visible here.

The method consists of two steps. In the first step, millions of tiny holes are etched into the upper surface of a wafer of silicon. Just 300 nanometres in diameter and less than 8 micrometres deep, these holes are too small to see, even with the aid of an optical microscope. The second step involves the truly innovative aspect of this method, and is therefore the toughest. The wafer is tilted and millions of tiny holes are then etched into the side of the silicon, in the same way as before. In order to obtain the requisite structure, the second structure has to be aligned extremely accurately relative to the first structure. The maximum permissible deviation is just 30 nanometres and half a degree. The 3D structures created in this way have tiny pores that intersect at an angle of 90 degrees. The material has a structure resembling that of a diamond crystal, but larger by a factor of 2000.

The study was carried out in the department of Complex Photonic Systems (COPS), and at the University of Twente's MESA+ research institute. This involved close collaboration with researchers from ASML, Eindhoven University of Technology, and TNO. The study's sponsors included NanoNed/STW, the FOM Institute, and the Netherlands Organization for Scientific Research (NWO).

Provided by University of Twente

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