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World's first ultra-fast photonic computing processor using polarization

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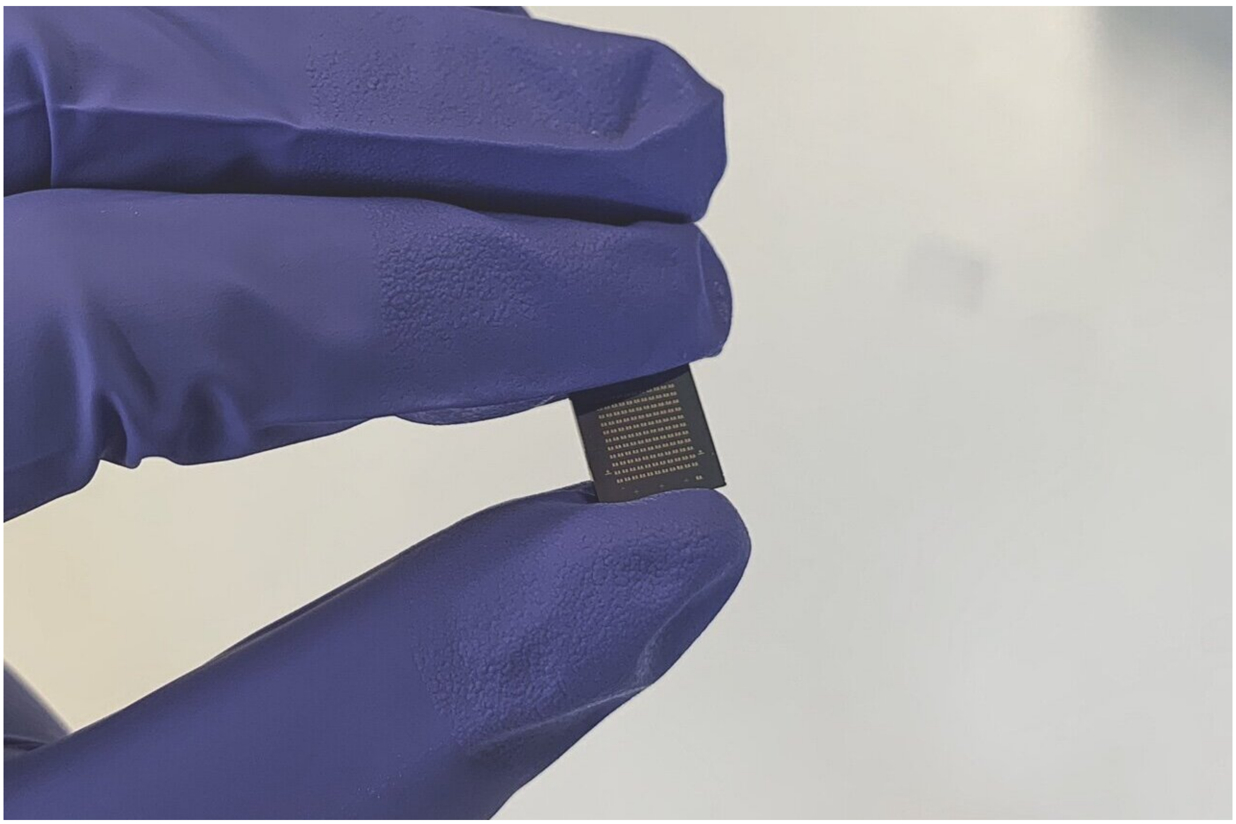


Credit: June Sang Lee, University of Oxford

In a paper published today in *Science Advances*, researchers at the University of Oxford have developed a method using the polarization of light to maximize information storage density and computing performance using nanowires.

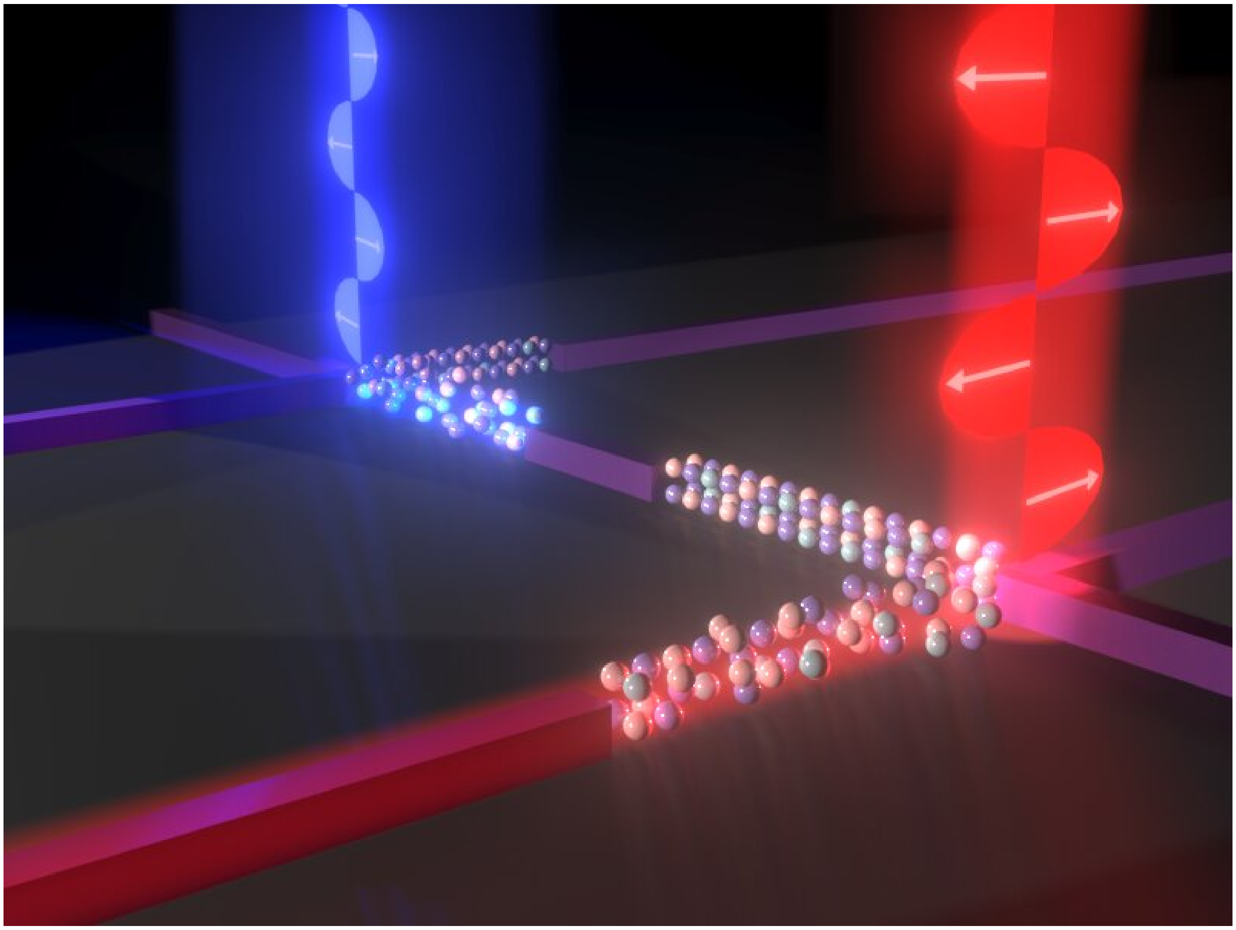
Light has an exploitable property—different wavelengths of light do not interact with each other—a characteristic used by fiberoptics to carry parallel streams of data. Similarly, different polarizations of light do not interact with each other either. Each polarization can be used as an independent information channel, enabling more information to be stored in multiple channels, hugely enhancing information density.

First author and DPhil student June Sang Lee, Department of Materials, University of Oxford said: "We all know that the advantage of photonics over electronics is that light is faster and more functional over large bandwidths. So, our aim was to fully harness such advantages of photonics combining with tunable material to realize faster and denser information processing."

In collaboration with Professor C. David Wright, University of Exeter, the research team developed a HAD (hybridized-active-dielectric) nanowire, using a hybrid glassy material which shows switchable material properties upon the illumination of optical pulses. Each nanowire shows selective responses to a specific polarization direction, so information can be simultaneously processed using multiple polarizations in different directions.

Using this concept, researchers have developed the first photonic computing processor to utilize polarizations of light.

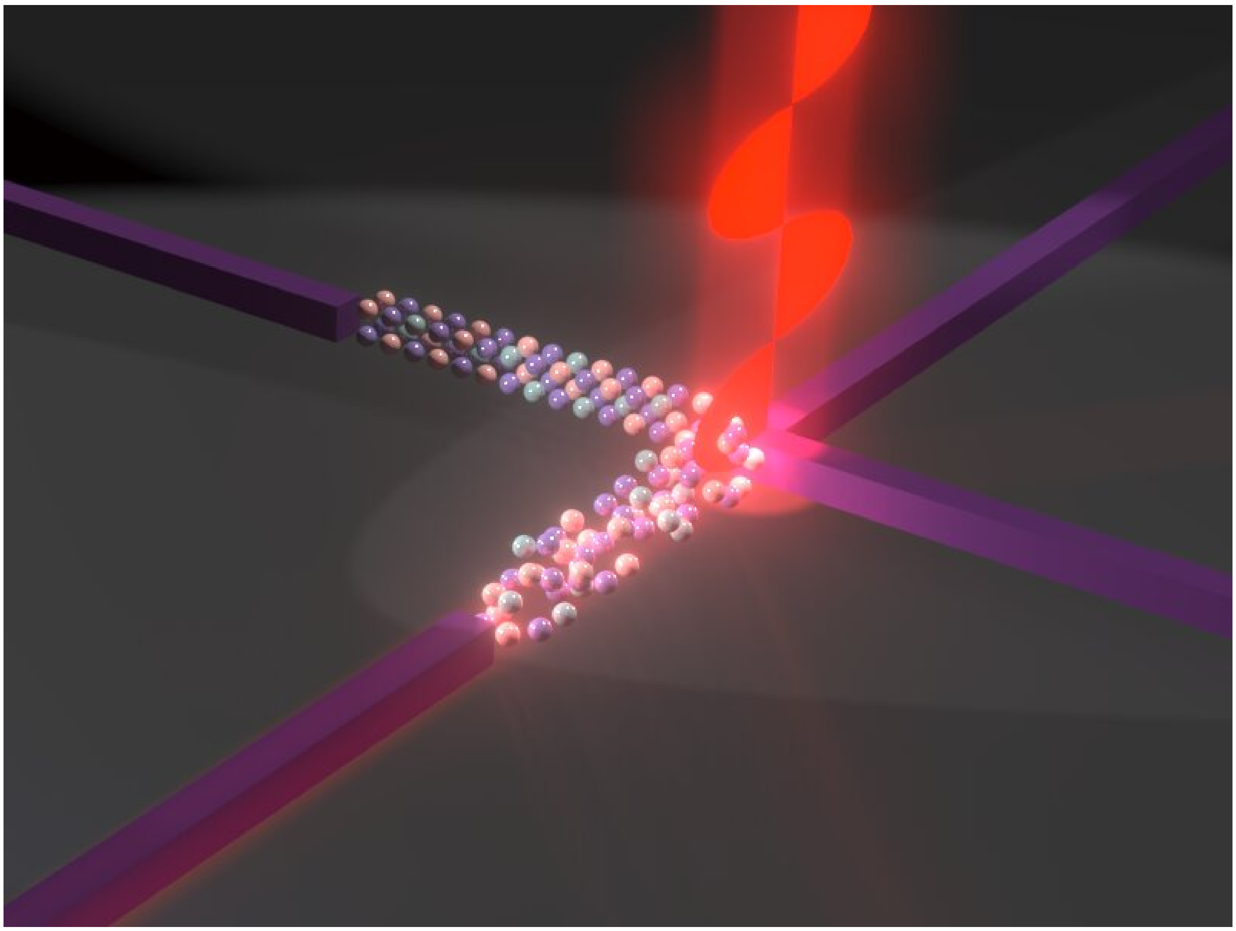
Photonic computing is carried out through multiple polarization channels, leading to an enhancement in computing density by several orders compared to that of conventional electronic chips. The computing speeds are faster because these nanowires are modulated by nanosecond optical pulses.



Hybrid nanowires that can selectively switch the devices depending on polarization. Credit: June Sang Lee, Department of Materials, University of Oxford

Since the invention of the first integrated circuit in 1958, packing more transistors into a given size of an electronic chip has been the go-to means of maximizing computing density—the so-called "Moore's Law." However, with Artificial Intelligence and Machine Learning requiring specialized hardware that is beginning to push the boundaries of established computing, the dominant question in this area of electronic engineering has been "How do we pack more functionalities into a single transistor?"

For over a decade, researchers in Professor Harish Bhaskaran's lab in the Department of Materials, University of Oxford have been looking into using light as a means to compute.



Hybridized-active-dielectric (HAD) nanowire is polarization-selectively switched and parallel photonic computing is realized. Credit: June Sang Lee, Department of Materials, University of Oxford

Professor Bhaskaran, who led the work, said: "This is just the beginning of what we would like to see in future, which is the exploitation of all degrees of freedoms that light offers, including polarization to dramatically parallelize information processing. Definitely early-stage work, but super exciting ideas that combine electronics, non-linear materials and computing. Lots of exciting prospects to work on which is always a great place to be in."

More information: June Sang Lee et al, Polarization-selective reconfigurability in hybridized-active-dielectric nanowires, *Science Advances* (2022). DOI: 10.1126/sciadv.abn9459. www.science.org/doi/10.1126/sciadv.abn9459

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