Researchers develop novel process for structuring quantum materials

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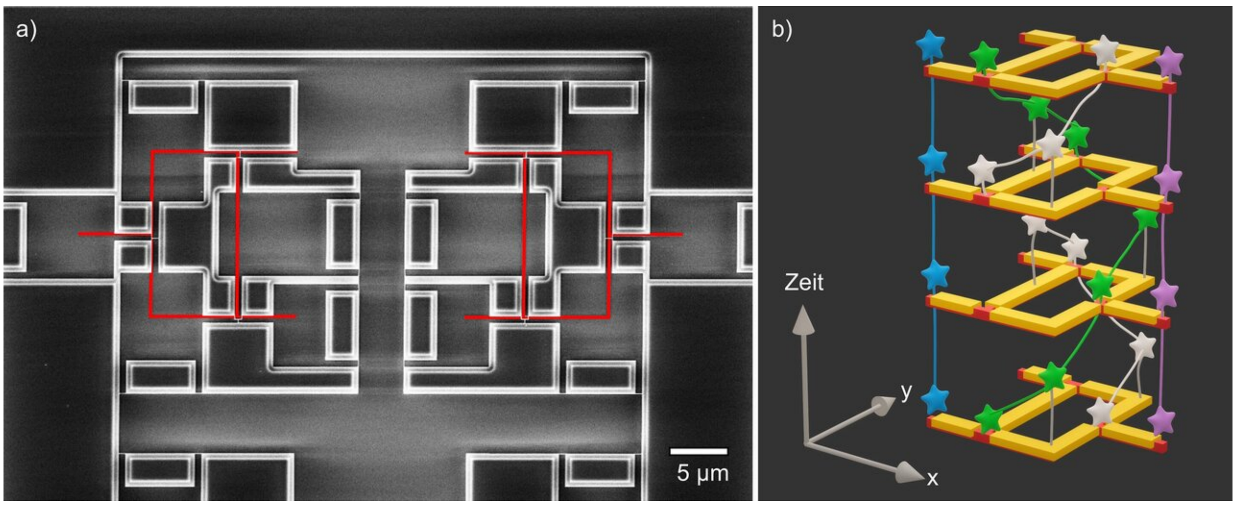

(a) Scanning electron micrograph taken during the Jülich process: Shown is a die during fabrication. The topological insulator (indicated in red) has already been deposited selectively. In a next fabrication step, the superconductor is deposited via shadow mask evaporation. In black and white various mask systems can be identified. These masks make it possible to manufacture the desired quantum devices completely under ultra-high vacuum conditions. (b) In such networks, researchers aim at shifting so-called Majorana modes (represented by stars) along the traces defined by the topological insulators in order to perform topologically protected quantum operations. While the blue and violet Majorana stay at the same position (x,y) in space, the green and white Majorana twist around each other during time, performing a knot in space-time. Credit: Forschungszentrum Jülich / Peter Schüffelgen

Implementing quantum materials in computer chips provides access to fundamentally new technologies. To build high-performance quantum computers, for example, topological insulators have to be combined with superconductors. This fabrication step is associated with a number of challenges that have now been solved by researchers from Jülich. Their results are presented in the current issue of the journal *Nature Nanotechnology*.

The Incas used knots in cords in their ancient writing "Quipu" to encode and store information. The advantage: Unlike ink on a sheet of paper, the information stored in the knots is robust against external destructive influences such as water. Novel quantum computers should also be able to store information robustly in the form of knots. For this, however, no cord is knotted, but quasiparticles are arranged in space and time.

What you need to build such a quantum-knot-machine are new materials, so-called quantum materials. Experts speak of topological insulators and superconductors. The processing of these materials into components for quantum computers is a challenge in itself, especially because topological insulators are very air-sensitive.

Scientists at the Forschungszentrum Jülich have now developed a novel process that makes it possible to structure quantum materials without exposing them to air during processing. The "Jülich process" makes it possible to combine superconductors and topological insulators in the ultra-high vacuum and thereby produce complex components.

First measurements in their devices show indications of Majorana states. "Majoranas" are precisely the promising quasiparticles that are to be knotted in the shown networks of topological insulators and superconductors in order to enable robust quantum computing. In a next step, the researchers at the Peter-Grünberg Institute, together with their colleagues from Aachen, the Netherlands and China, will equip their networks with read-out and control electronics in order to make the quantum materials accessible for application.

More information: Peter Schüffelgen et al. Selective area growth and stencil lithography for in situ fabricated quantum devices, *Nature Nanotechnology* (2019). DOI: 10.1038/s41565-019-0506-y

Provided by Forschungszentrum Juelich