Selective-area epitaxy and electronic transport in in-plane InAs one-dimensional channels

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One-dimensional (1D) semiconductor nanowire proximitized by a superconductor could exhibit topological superconducting phases, which host Majorana zero modes at the ends of the proximitized region. Based on the hybrid superconductor/1D nanowire systems, scalable designs for topological quantum computing processes by braiding of Majorana zero modes have been proposed [1]. Experimental efforts have been made to realize the complex nanostructures consisting of multiple Majorana zero modes: bottom-up synthesis of self-assembled nanowire networks with predefined superconducting islands has been recently reported [2], and top-down processing of the large-scale nanostructures has been suggested on a two-dimensional material platform of epitaxial superconductor/semiconductor heterostructures [3].

In this work, we study a new bottom-up approach of selective-area growth of semiconductor 1D channel networks. This approach is advantageous for scalability and for minimizing damages from further fabrication processes. We employ chemical beam epitaxy to selectively grow in-plane InAs 1D channels on pre-patterned SiO_2/InP(001) substrates. For electronic transport, InAs Hall bars with channel width of 50-500 nm and length of 500–2000 nm are selectively grown and measured with a perpendicular magnetic field at cryogenic temperatures. In order to achieve optimal transport properties, we vary 1) substrate preparation process, 2) growth conditions, such as substrate temperature, growth rate, and V/III ratio, 3) 1D channel dimensions of width and height, 4) crystallographic orientations, 5) buffer layers, and 6) capping layers. The resulting electron mobility is observed up to a few thousand cm^2/Vs with electron density of low 10^{12} cm^{-2}. Magnetoresistance also reveals universal conductance fluctuations and weak antilocalization. Further transport studies of electrostatic gating and Aharonov-Bohm oscillations will be discussed.

[1] T. Karzig *et al.*, Phys. Rev. B **95**, 235305 (2017).
[2] S. Gazibegovic *et al.*, Nature **548**, 434 (2017).
[3] J. Shabani *et al.*, Phys. Rev. B **93**, 155402 (2016).

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