High-throughput Approaches for Engineering Semiconductor Nanowire Devices for Terahertz Photonics and Beyond

H. J. Joyce[1], J. A. Alexander-Webber[1]

[1]*Department of Engineering, University of Cambridge, Cambridge CB3 0FA, United Kingdom*

hannah.joyce@eng.cam.ac.uk

Single semiconductor nanowires offer a route towards novel device functionalities, with examples including nanowire-based polarisation-resolving terahertz photoconductive receivers [1] and nanowire quantum electronic devices exhibiting proximity-induced superconductivity [2]. However, the processing of such devices is laborious and the yield is typically low, with published data limited to a handful of “hero” devices. To address this problem, we are developing high-throughput approaches that expedite nanomaterials characterisation and nanodevice processing. Using a quantum multiplexer, we have addressed arrays of transfer-printed single InAs nanowires from room temperature down to 4.2 K [3]. We have developed an alternative approach suitable for randomly distributed nanowires that obviates the need for pick-and-place positioning of nanowires. This approach involves automated microscopy assisted by machine-readable and lithographically compatible alignment markers, and automates the process of electrode design [4]. Scanning electron micrographs of example field-effect transistor devices are shown in Fig. 1. The alignment markers also facilitate the automation of other measurements including cathodoluminescence and photoluminescence. These high-throughput approaches yield large numbers of functional nanowire devices and permit the acquisition of large datasets, which in turn allows correlations between complementary measurement techniques (e.g. photoluminescence [5] and terahertz spectroscopy [6]) to be examined.

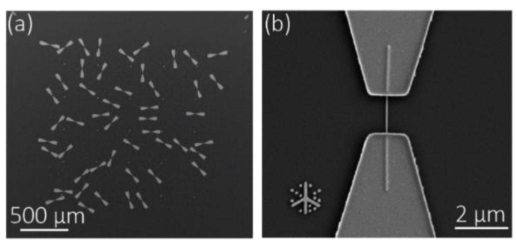

Fig. 1. Scanning electron micrographs of InAs nanowire field-effect transistors with electrical contacts designed via an automated imaging and alignment process. Reproduced with permission from [4].

References

[1] K. Peng *et al.*, Science **368**, 510-513 (2020)
[2] O. Gül *et al.*, Nature Nano. **13**, 192–197 (2018)
[3] L.W. Smith, ACS Nano **14**, 15293-15305 (2020)
[4] T. Potočnik *et al.*, ACS Nano **16**, 18009-18017 (2022)
[5] N. Jiang *et al.*, Front. Chem. **8**, 607481 (2020)
[6] L.L. Chen *et al*. Nano Lett. **22**, 3433-3439 (2022)