# A Versatile Common Platform for Quantum Transport Measurements in Fluidic, Cryogenic, and *In Situ* Electron Microscopy Environments

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*In Situ* Transmission Electron Microscope (TEM) fabrication has made many advances recently, ranging from nanopore fabrication[1], to modification of 2D materials[2], to atomically precise manipulation[3], providing exciting opportunities for novel quantum architectures to be realized. However, to exploit the potential of these devices, measurements and characterization should ideally be possible *in situ* and also in the environment of the application, which can range from cryogenic temperatures for quantum computing[4] to liquid devices for quantum biosensors[5]. Here we present wafer-scale fabrication and validation of a common multi-functional low-noise chip platform capable of *in situ* TEM characterization and fabrication, microfluidic experiments, and cryogenic and scanning probe measurements.

A key aspect to the success of the platform is the modular design allowing the platform to be interchangeable between applications as diverse as DNA sequencing devices, nanoscale heat transport experiments, and *in situ* fabrication of devices via TEM. We will briefly cover some of these projects and their results to date. With a particular focus on TEM fabricated quantum biosensors based on graphene quantum dots.

Additionally, we will briefly cover the associated platforms enabling the various measurements, including *in situ* biasing holders and associated electronics, a biasing fluidic cell capable of simultaneously flowing fluid through the chips while measuring nanoampere-scale currents on the plane of the chip, and biasing devices for applications ranging from scanning probe measurements to cryogenic experiments. Finally, progress towards a new photonic architecture integrating on-chip wave guides will briefly be discussed.

1. Ivanov, A. P., et al. DNA tunneling detector embedded in a nanopore. Nano Lett 11.1, (2010).
2. Heerema, S. J., et al. Probing DNA translocations with inplane current signals in a graphene nanoribbon with a nanopore. ACS Nano 12.3, (2018).
3. Dyck, O. E., et al. Building structures atom by atom via electron beam manipulation. Small, 14.28 (2018)
4. Puczkarski, P., et al. Graphene nanoelectrodes for biomolecular sensing. J. Mater. Res. 32, (2017).
5. Gehring, P., et al. Quantum interference in graphene nanoconstrictions. Nano Lett, 16.7, (2016).

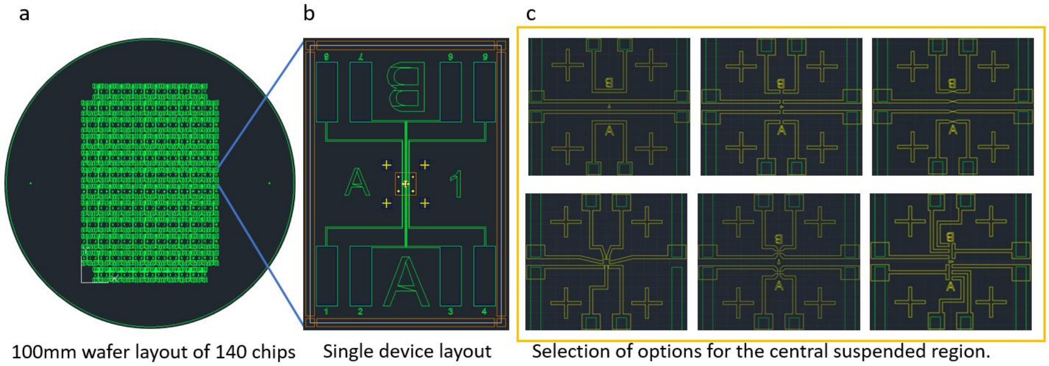

*Figure 1: CAD renderings of a) the layout of a single 100mm wafer, b) a single chip showing the various layers, and c) a selection of some of the interchangeable central regions six different applications.*

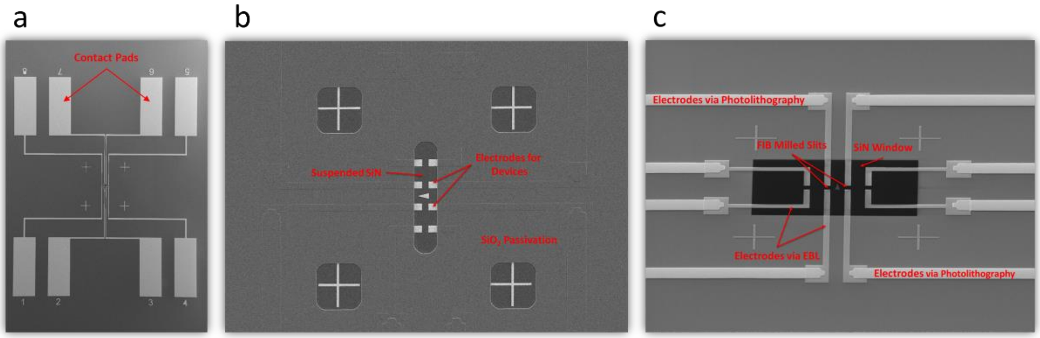

*Figure 2: Scanning electron micrographs of a) a single chip, b) the central electron-transparent region of a chip with dielectric passivation, and c) the central electron transparent region of a chip without passivation showing the different layers*

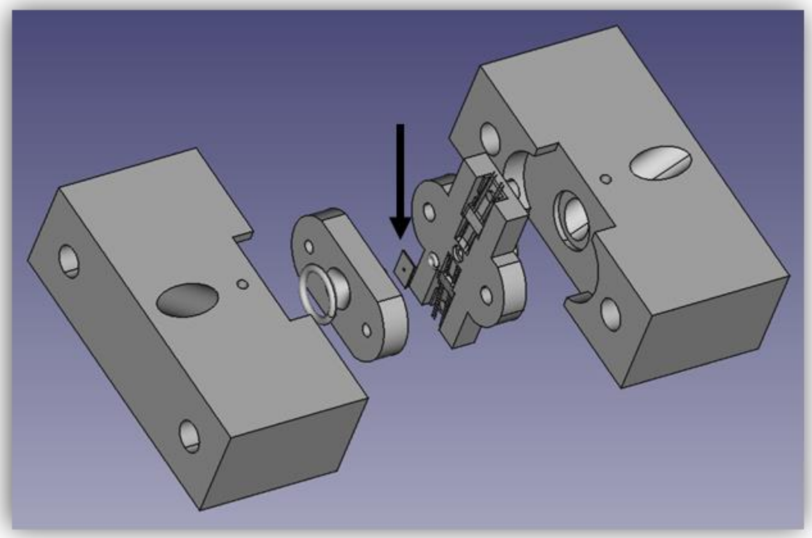

*Figure 3: A biasing fluidic cell capable of simultaneous transmembrane conductance and transverse biasing of devices. The black arrow indicates the chip.*