Epitaxial Graphene Devices for Quantum Electrical Metrology

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Quantum electrical metrology is an important application area of collective states of matter. One prominent example is the quantum Hall condensate for the realization of the resistance unit, the ohm. Compared with two-dimensional electrons with finite effective masses at the interface of semiconducting heterostructures, the linear energy-momentum dispersion of quasiparticles in graphene allows for a practical realization of the quantum Hall resistance standard under easily accessible experimental conditions of temperature and magnetic field. The metrology community has focused on epitaxial graphene, which was observed at least five decades ago [1], as a scalable platform to develop a practically accessible quantum resistance standard for more than a decade and a half. Technology has become mature enough that epitaxial graphene is now gradually deployed at national metrology institutes. Epitaxial graphene devices are formally accepted by the metrology community as an attractive alternative to the traditional semiconducting devices along with a formal guideline [2], which was approved by the Consultative Committee for Electricity and Magnetism. Here, we present the latest advances of graphene-based electrical metrology [3]. These include advancements in device fabrication, the long-term stability, the practical realization of graphene-based resistance quantum standards, graphene-based impedance quantum standards, and graphene-based current metrology at direct and alternating currents.

References:

[1] A.J.J. Van Bommel, J.E. Crombeen and A. Van Tooren Surf. Sci. 48 (1975) 463.

[2] *Companion Guide to the Revised Technical Guidelines for Reliable dc Measurements of the Quantized Hall Resistance for Graphene-Based Devices* (to be published)

[3] D.-H. Chae, H. He and M. Kruskopf, Meas. Sci. Technol. (2026) https://doi.org/10.1088/1361-6501/ae57c8

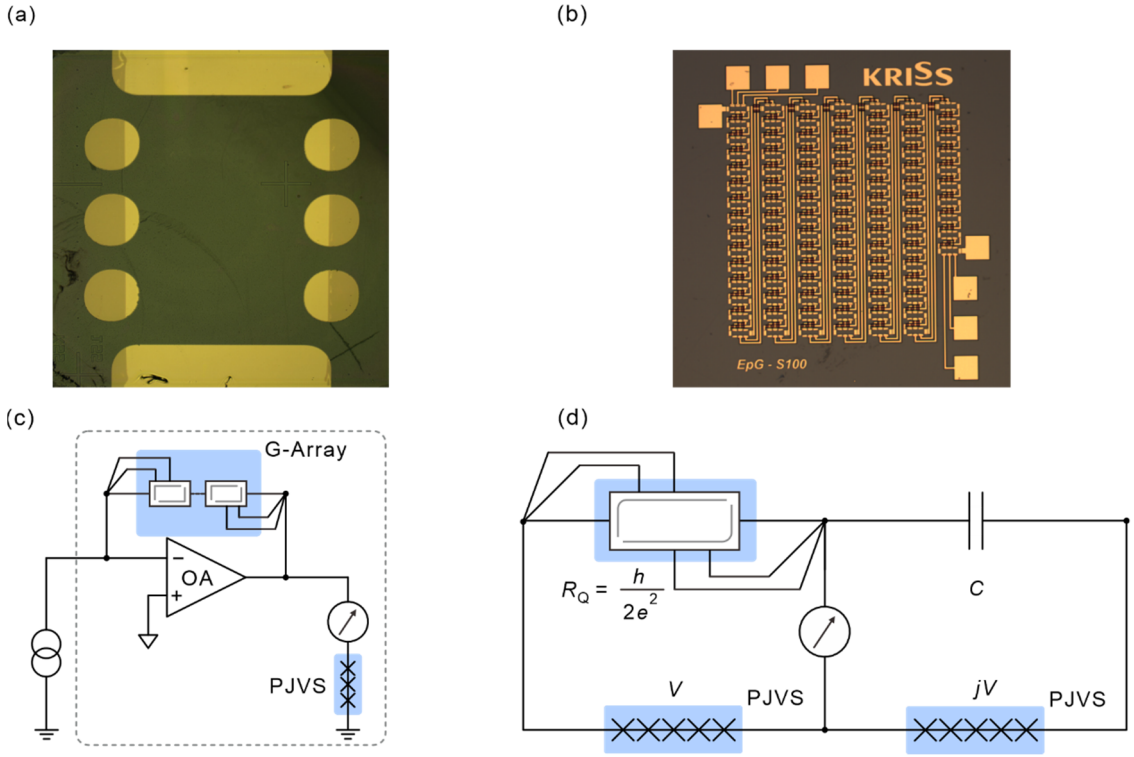

Fig. 1: (a) Centimeter scale graphene device for quantum resistance metrology. (b) Graphene-based array. (c) Graphene-based quantum mechanical ammeter. (d) Graphene-based impedance quantum standard.