S4-1: Epitaxial Graphene QHR standards: Beyond GaAs

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Abstract: Quantum standards in the new SI promise to provide “access for all” to primary units based on internationally recognized physical realizations. The laser, for example, has made standards of length inexpensive and accurate in terms of another easily accessed quantum standard, the GPS broadcast. Electrical standards based on the quantum Hall effect, on the other hand, have succeeded in yielding unprecedented consistency and accuracy, but have failed at reaching the broad user level of benchtop metrology. Thus, major NMIs are focused on creating graphene based quantized Hall resistance (QHR) standards that operate above 2.5 K, below 5 T, at a factor of 10 larger current than today’s typical GaAs QHR standards. This project addresses basic needs of the metrology community and will also provide aid to those studying graphene for other uses, by developing techniques to ensure long-term stability of graphene’s electronic characteristics. In high-quality EG standards produced at NIST, we have observed fully quantized magnetotransport in devices of millimeter-size, where the precise quantized Hall resistance of \(R_{xy} = \frac{h}{2e^2}\) is maintained up to record levels of critical current (0.72 mA). These results exceed the highest critical currents reported for the QHR in graphene and allow resistance traceability based on commercial non-cryogenic bridge measurement techniques. Room temperature bridges are much less difficult to operate than cryogenic current comparators developed and used at many NMIs, and are also compatible with the higher vibration levels produced in cryogen-free superconducting magnet cryostats. The growth techniques, device architecture, and characterization methods used to develop suitable EG QHR standards will be described.