Development of a Graphene Field Effect Transistor for GHz/THz Sensing

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A small forbidden gap matched to low energy photons (meV) and a quasi-Dirac electron system are both definitive characteristics of bilayer graphene (BGR) that has gained it considerable interest in realizing a broadly tunable sensor for application in the microwave (GHz) to terahertz (THz) regimes. For these reasons, graphene field effect transistors (GR-FETs) have the potential to exceed the detection limit of most existing semiconductor quantum point contacts (QPCs). This is due to the unique phase coherent length of open quantum-dot structures formed in bilayer graphene when exposed to GHz/THz radiation. Existing GR-FETs have been fabricated by micromechanical exfoliation of highly oriented pyrolytic graphite (HOPG-SG2) contacted with submicron-scale metal electrodes (Ti/Au or Pd/Au). The microwave transconductance characteristics show excellent photoresponse around the X band (~10 GHz) and are predicted to have continued sensitivity in the THz range after the measurement setup is optimized. Herein, improvements to the wiring setup, sample box architecture, graphite source, and bolometric heating of the GR-FET sensor were made in order to extend microwave photoresponse to 40 GHz and further improve THz detection. Future studies will include THz irradiation experiments (300-3000 GHz) using the same optimized experimental setup. THz photoresponse in this range will be important for future developments in medical imaging, spectroscopy, and communication which all exploit the unique linear non-ionizing benefits of THz radiation.

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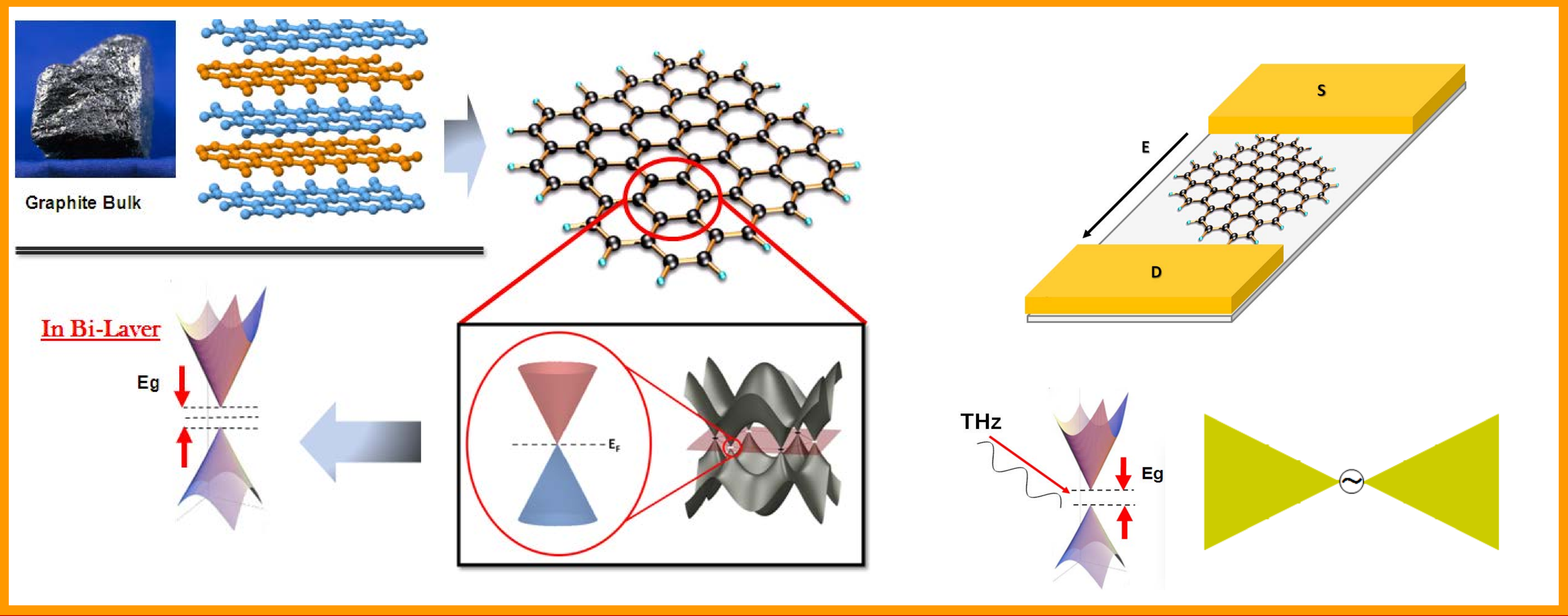
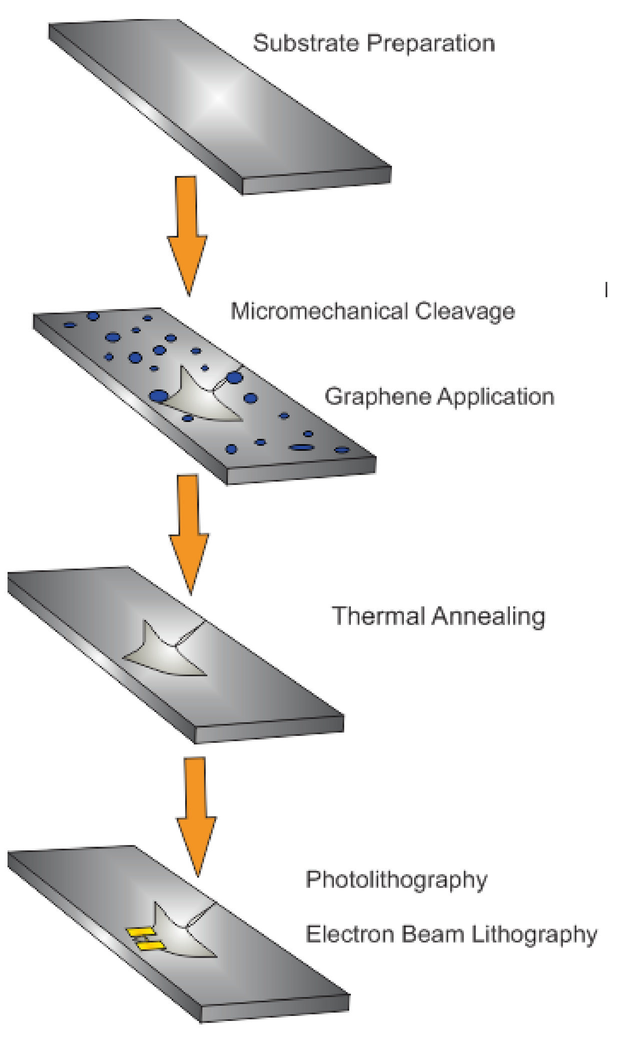
Chiba University 千葉大学

Graphene Field Effect Transistor (FET) Nanosensor

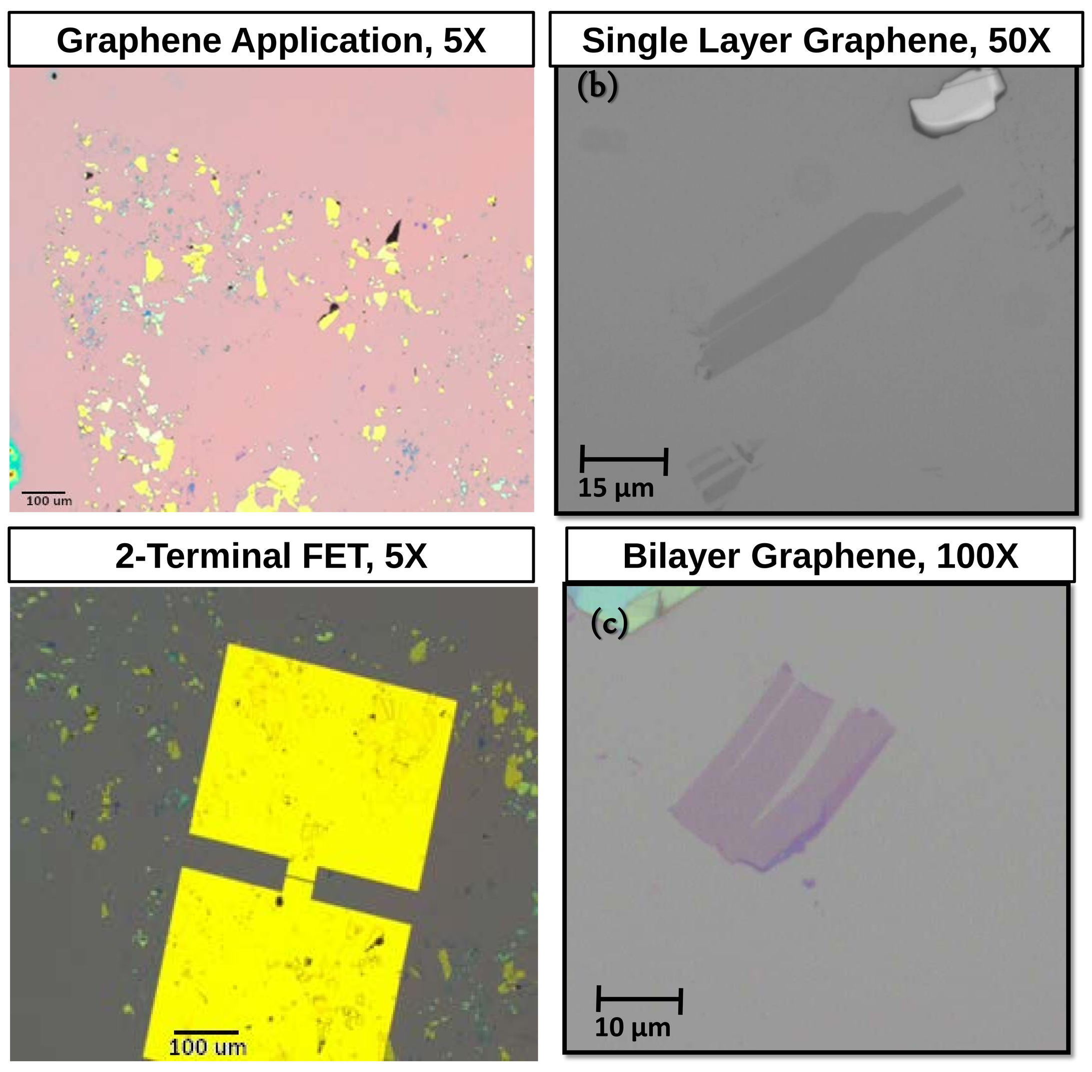


Fabrication of Graphene FET Device

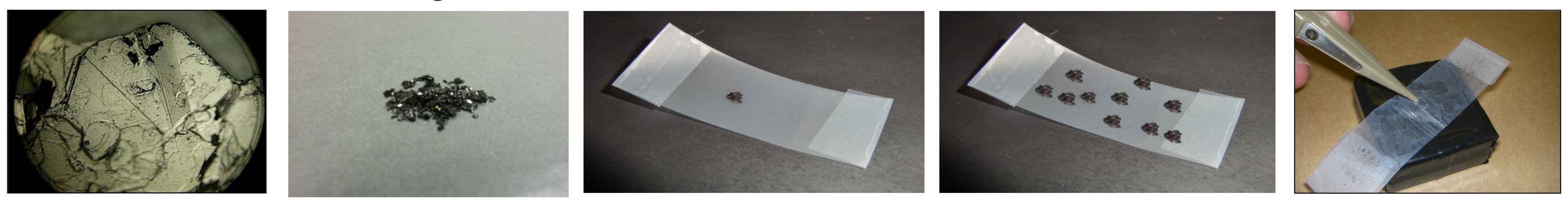
Fabrication Scheme



Graphene Samples

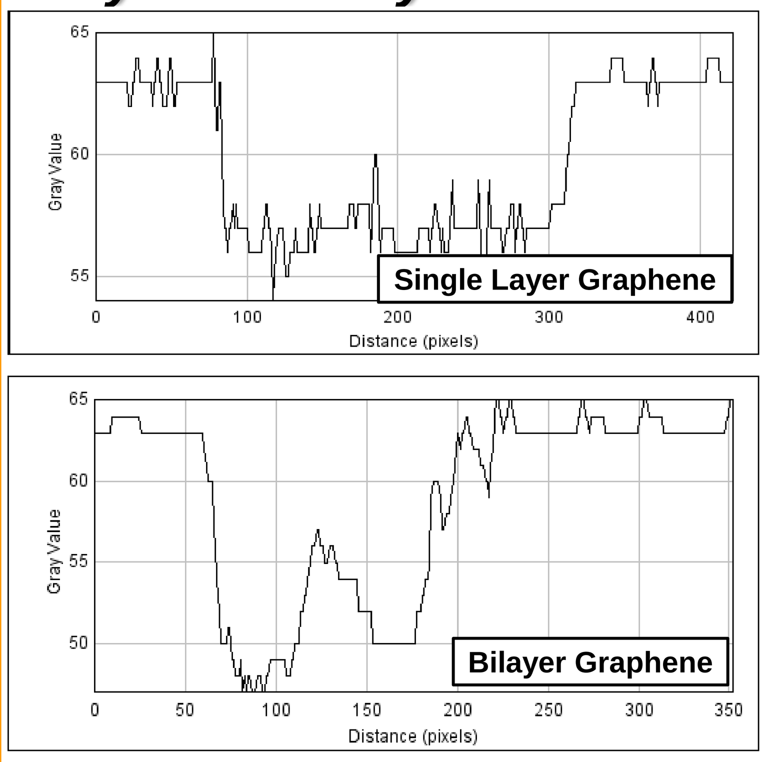


Micromechanical Cleavage

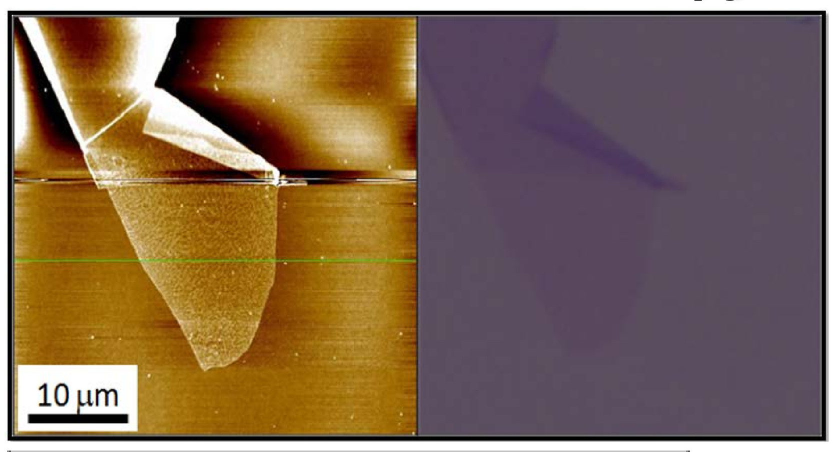


Characterization

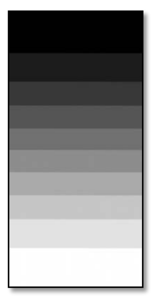
Greyscale Analysis



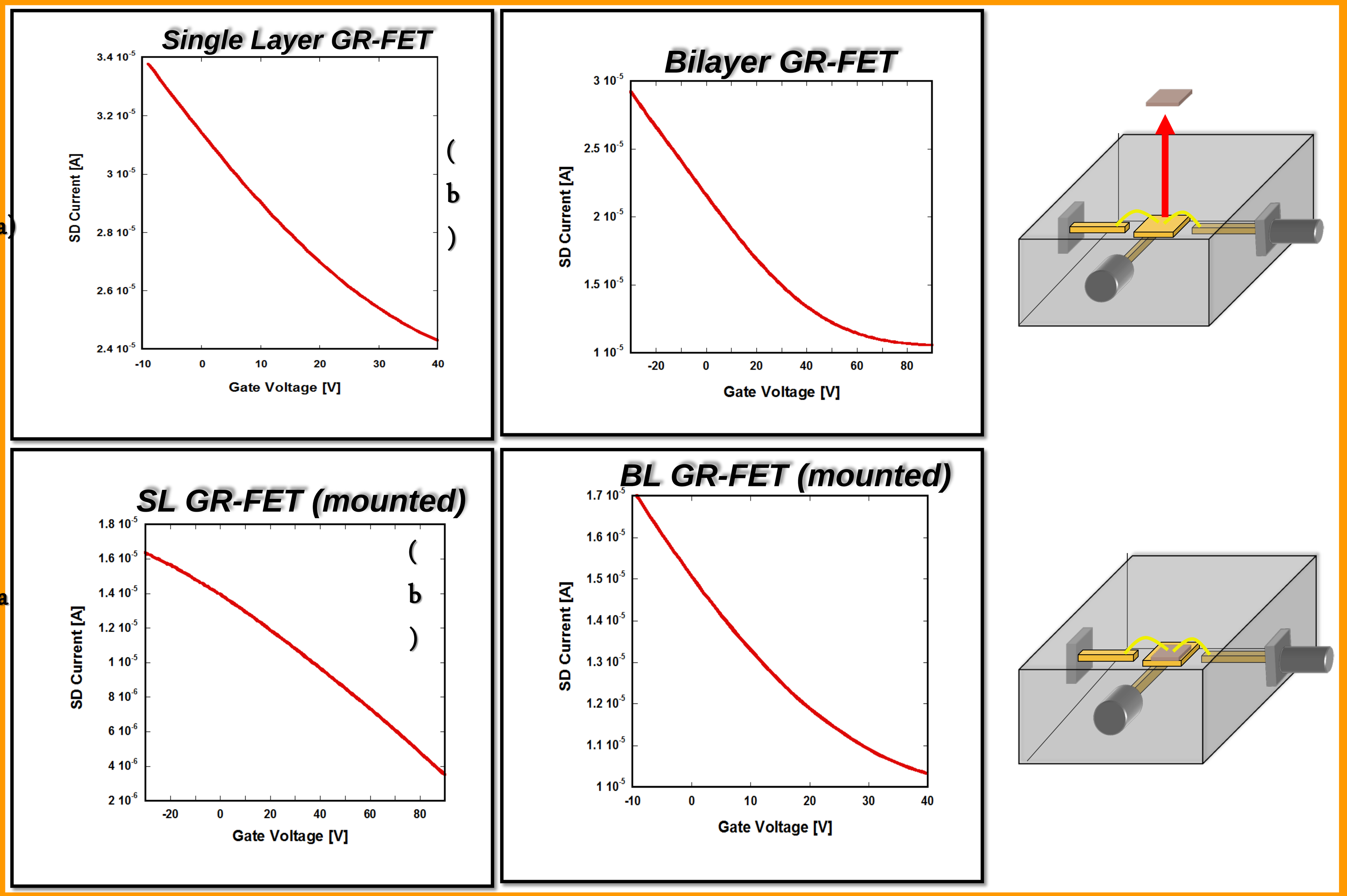
Atomic Force Microscopy



AFM Value	Gray Value
< 6 Å	< 10
6 – 8 Å	10 - 16
9 – 12 Å	17 - 24

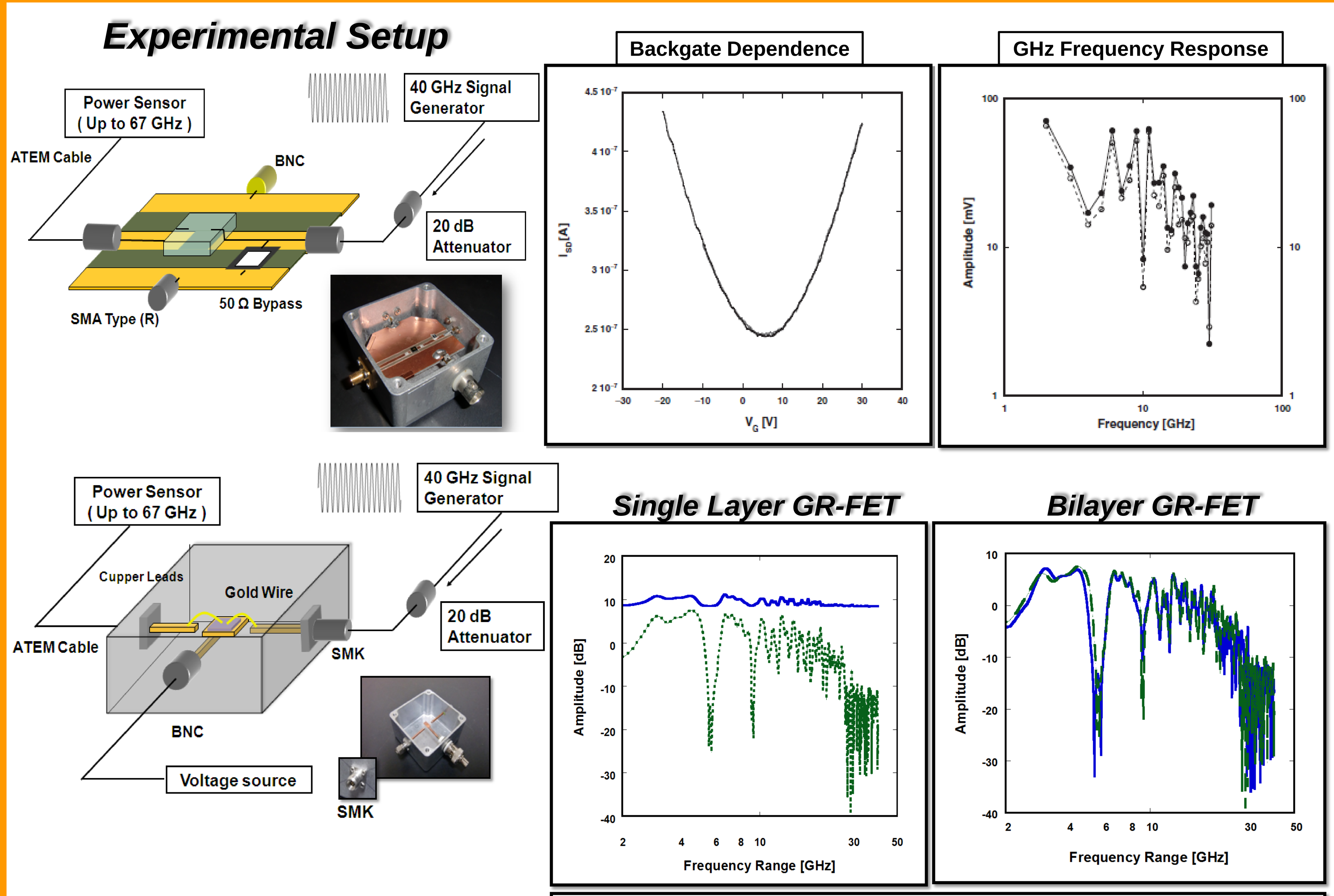


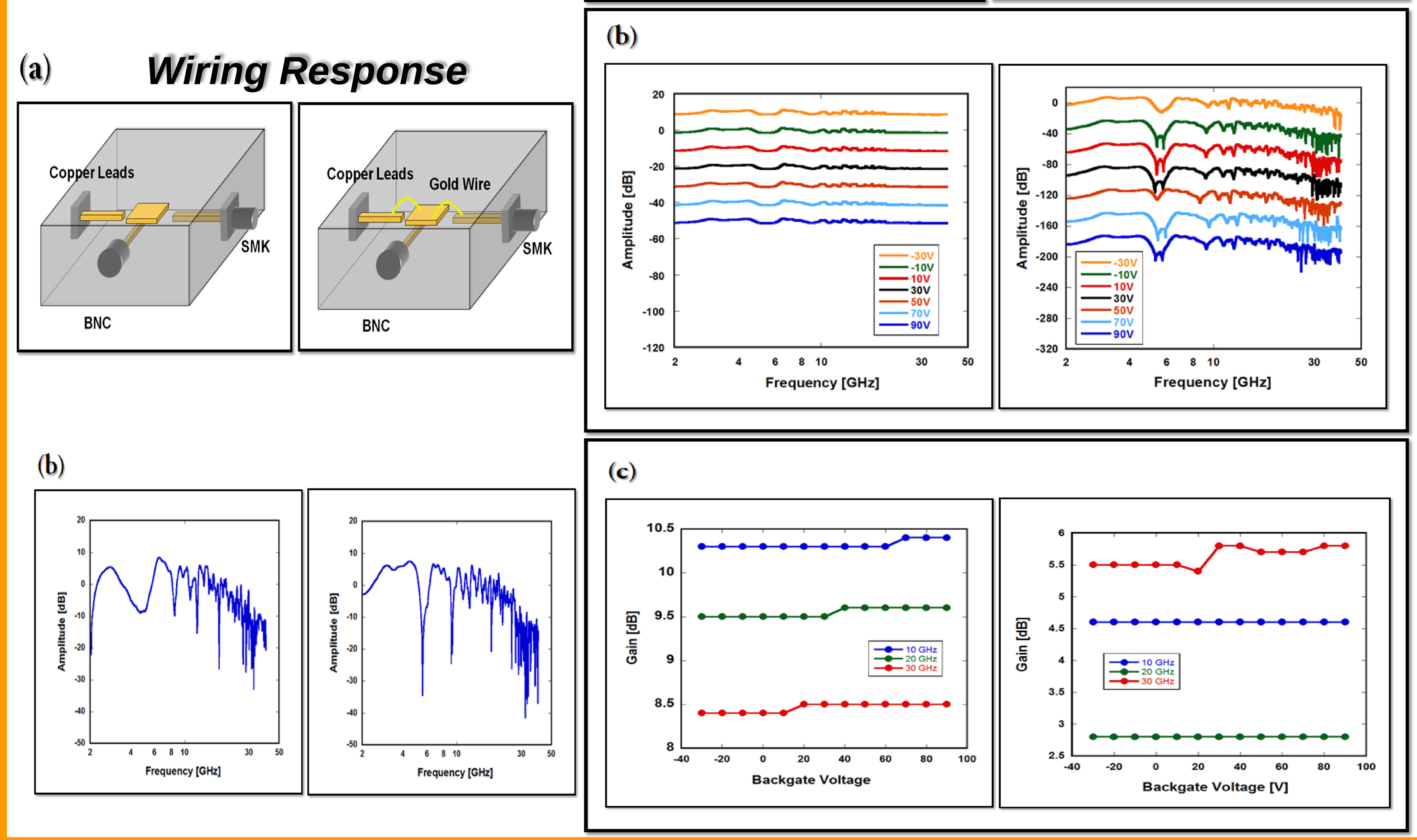
Backgate Voltage Dependence



GHz Frequency Response

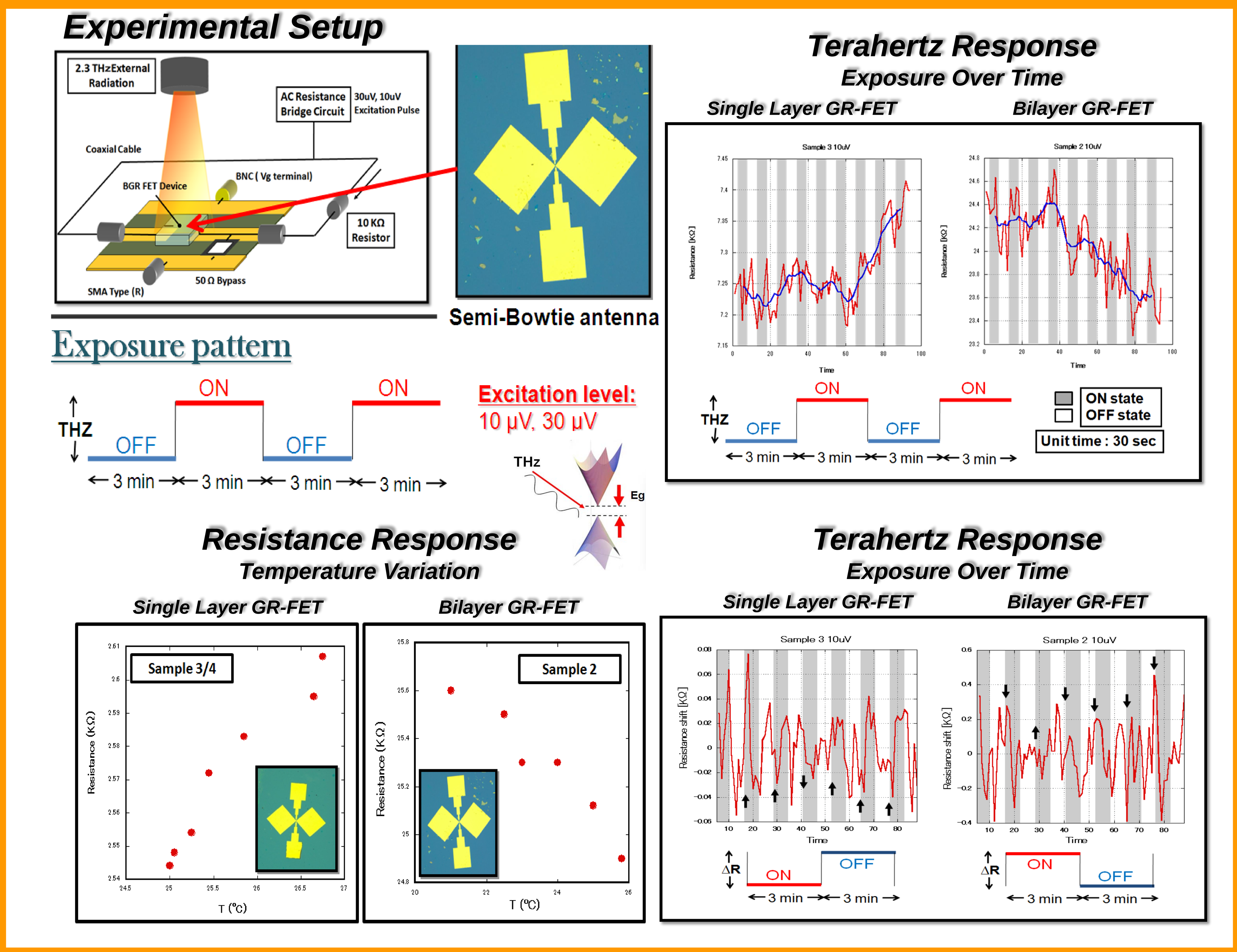
Experimental Setup





THz Frequency Response

Experimental Setup



Acknowledgments

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JSPS 日本学術振興会 Japan Society for the Promotion of Science