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# Large area THz mapping of electrically controlled graphene conductance

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We demonstrate non-contact, mapping of gate-controlled conductance of single layer graphene films by terahertz time-domain spectroscopy (THz-TDS). The applied technique measures the broadband, frequency-resolved sheet conductance of graphene films in the region from approx. 0.1-2 THz modulated by an electrostatic back-gate, and thus facilitates non-contact and spatially resolved characterization of conductance, carrier mobility, carrier density, carrier scattering rate, and chemical/substrate doping level at a fast acquisition rate for large area graphene films.

It has been shown recently that the intraband dominated THz response of CVD graphene films can be controlled by an electrostatic

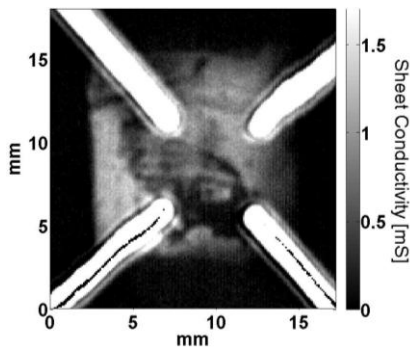


Fig. 1 THz graphene conductance image with back-gate. Frequency range is

1.0-1.1 THz. Gate-voltage is 0 V

signal applied to a semi-transparent silicon back-gate, also serving as substrate [1],[2]. Here we extend the approach, by demonstrating spatially resolved, gate-controlled, broadband THz conductance mapping of large area graphene films with high contrast, pronounced gate-modulation and high acquisition rates, as shown in fig. 1. A  $\rho=10 \Omega\text{cm}$ , semi-THz-transparent silicon substrate covered with 300 nm  $\text{SiO}_2$  serves as electrostatic back-gate for Fermi level control in the graphene film. THz mappings are compared with supporting  $\mu$ -Raman mapping to allow insight into correlations between large-area variations in THz electronic properties and  $\mu$ -Raman signal.

Because of its non-contact nature and high acquisition rate, we propose that the technique is highly suited for direct, quantitative mapping of important properties such as carrier mobility, carrier density, substrate/chemical doping level, and scattering rate of large area CVD graphene films in the industry.

## References

- [1] L. Ren, Q. Zhang, J. Yao, Z. Sun, R. Kaneko, Z. Yan, S. Nanot, Z. Jin, I. Kawayama, M. Tonouchi, J. M. Tour, and J. Kono, *Nano Lett.*, **vol. 12**, pp. 3711–3715, 2012.
- [2] J. Horng, C.-F. Chen, B. Geng, C. Girit, Y. Zhang, Z. Hao, H. A. Bechtel, M. Martin, A. Zettl, M. F. Crommie, Y. R. Shen, and F. Wang, *Physical Review B*, **vol. 83**, no. 16, Nov. 2011.

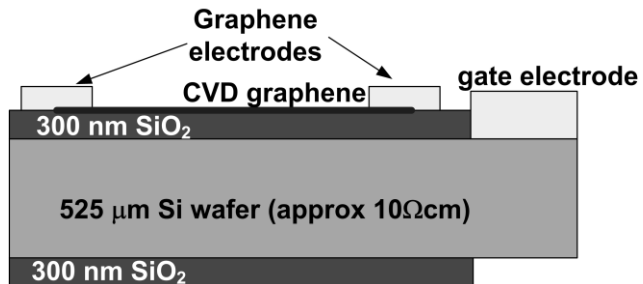


Fig. 2 Substrate design used for electrostatically controlled graphene THz conductance mapping.