Advancing Electrical Metrology with Graphene and Topological Insulators

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Since 2017, epitaxial graphene (EG) has been the base material for the US national standard for resistance. Nanoscale devices based on EG have been expanded to include specially designed arrays to rapidly expand access to quantized resistance at values other than $h/2e^2$ via mathematical star-mesh transformations. In addition to these developments, an alternative research avenue in electrical metrology has also formed around the use of magnetically doped topological insulators (MTIs), which seek to replace graphene as a standard due to its exhibition of the quantum anomalous Hall effect (or zero-field quantized resistance) [1-3]. Here we present results on both material systems to show the benefits gained by the metrology community, along with benefits applicable to many research endeavours focused on the fabrication of small-scale devices.

References

[1] E. J. Fox, I. T. Rosen, Y. Yang, G. R. Jones, R. E. Elmquist, X. Kou, L. Pan, K. L. Wang, D. Goldhaber-Gordon. *Phys. Rev. B,* 98, 075145, 2018
[2] M. Götz, K. M. Fijalkowski, E. Pesel, M. Hartl, S. Schreyeck, M. Winnerlein, S. Grauer, H. Scherer, K. Brunner, C. Gould, F. J. Ahlers. *Appl. Phys. Lett*. 112, 072102, 2018
[3] Y. Okazaki, T. Oe, M. Kawamura, R. Yoshimi, S. Nakamura, S. Takada, M. Mogi, K. S. Takahashi, A. Tsukazaki, M. Kawasaki, Y. Tokura. *Nat. Phys*. 13, 1-5, 2021

Figures

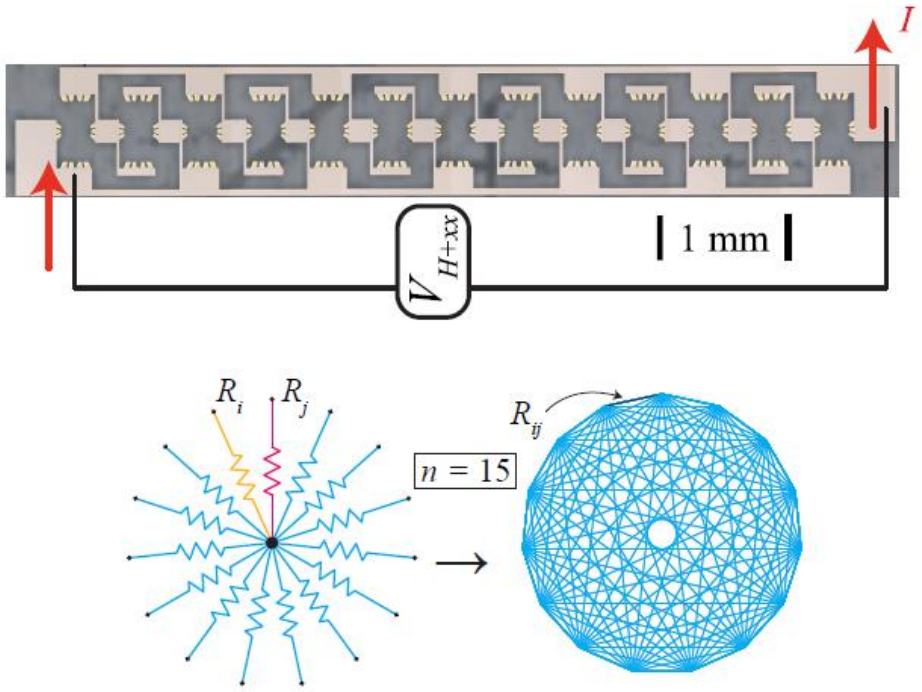

Figure 1: (Top) An example 13-element graphene-based array for obtaining quantized resistances other than $h/2e^2$. (Bottom) A mathematical star-mesh transformation for a 10 GΩ quantum electrical standard is illustrated, representing a possible configuration that is within fabrication capacities.