Electroluminescence and Energy Transfer in hBN-encapsulated Graphene Transistors

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In this talk, I will present our recent discovery of graphene's electroluminescence in the middle infrared. Electroluminescence is the phenomenon by which a material emits light in response to the passage of an electrical current. In solids, it is the prerogative of semiconductors and related organic materials, and it results from the radiative recombination of electrons and holes.

We investigate high-mobility graphene field-effect transistors encapsulated in hexagonal boron nitride (hBN) at ambient conditions. Despite the semimetallic nature of graphene, which theoretically precludes electroluminescence, we observe this phenomenon due to Zener-Klein tunneling, a carrier injection mechanism specific to 2D semimetals.

Our results reveal two important consequences of graphene electroluminescence. First, it leads to mid-IR emission in the far field. Second, it significantly affects the energy transfer within the hBN-encapsulated heterostructure. Using far-field mid-IR spectroscopy, we demonstrate the far-field electroluminescence of graphene at 6.5 µm, made possible by the elastic scattering of hyperbolic phonon polaritons (HPhPs) of hBN at heterostructure discontinuities. We quantify the associated radiative energy transfer using mid-IR pyrometry of the substrate receiving the thermal energy.
Surprisingly, we find that radiative energy transfer is reduced in hBN with nanoscale inhomogeneities, revealing the crucial role of the electromagnetic environment and opening interesting technological possibilities.

References

[1] L. Abou-Hamdan et al, "*Electroluminescence and energy transfer mediated by hyperbolic polaritons*", Nature **82,** 639, **2025**