

Diradical Electroluminescence in Atomically Engineered Graphene Nanoribbons

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Diradicals, molecules with two unpaired electrons, provide a unique platform for exploring spin–spin interactions and open-shell electronic structures[1,2]. Their potential in optoelectronics and quantum applications is, however, often limited by chemical instability and synthetic challenges[3]. On-surface synthesis of graphene nanoribbons (GNRs) offers a powerful route to overcome these limitations by enabling atomic-precision fabrication of well-defined nanostructures with tunable electronic properties[4]. Recent advances in topological design of GNRs have opened new possibilities to localize radical states at specific positions along the backbone[5,6].

In this presentation, I will demonstrate how atomic-scale engineering enables the synthesis of GNRs that host distinct diradical states. The excitonic emissions from these diradical GNRs are investigated using a scanning tunneling microscopy (STM) approach, combined with a transfer strategy that places the ribbons on a partially insulating surface[8]. The STM-induced electroluminescence reveals how the coupling between radical pairs shapes the luminescence pathways. This direct access to the light emission from coupled diradicals reveals the relationship between diradical electronic configurations and luminescence properties. Future work extending electroluminescence and magnetoluminescence to polyradical GNRs could uncover new regimes of spin-dependent light–matter interaction, with potential applications in quantum information processing and next-generation optoelectronic devices.

REFERENCES

1. M. Abe, Diradicals. Chem. Rev. 113, 7011-7088 (2013).
2. Y. Ishigaki, T. Harimoto, T. Shimajiri, T. Suzuki, Carbon-based Biradicals: Structural and Magnetic Switching. Chem. Rev. 123, 13952-13965 (2023).
3. Y. Zhu, Z. Zhu, S. Wang, Q. Peng, A. Abdurahman, Stable Luminescent Diradicals: The Emergence and Potential Applications. Angew. Chem. Int. Ed. 64, e202423470 (2025).
4. J. Cai; P. Ruffieux; R. Jaafar, et al., Atomically precise bottom-up fabrication of graphene nanoribbons. Nature 466, 470-473 (2010).
5. D. J. Rizzo et al., Inducing Metallicity in Graphene Nanoribbons via Zero-Mode Superlattices. Science 369, 1597-1603 (2020).
6. Q. Sun et al., Coupled Spin States in Armchair Graphene Nanoribbons with Asymmetric Zigzag Edge Extensions. Nano Lett. 20, 6429-6436 (2020).
7. S. Jiang; T. Neuman; A. Boeglin, et al., Topologically localized excitons in single graphene nanoribbons. Science 379, 1049-1054 (2023).