# STM investigation of novel structures of Gallenene intercalated in epitaxial Graphene

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The development of novel two-dimensional materials is a key focus in the search for next-generation functional materials with unique physical and electronic properties [1]. Two-dimensional gallium (gallenene) is an emerging material in the Xenes family [2]. Due to the difficulty in its isolation, there are still few experiments related to its fabrication and the resulting structure. In this work, we fabricate gallenene samples via the intercalation in epitaxial graphene grown on silicon carbide [3, 4]. We investigated the atomic structure of intercalated gallenene using scanning tunneling microscopy (STM), low-energy electron diffraction (LEED), and Raman spectroscopy. Our results reveal the formation of novel gallium structures, including different atomic arrangements and different moiré patterns. To increase our understanding of the formation of these structures, their stability has been monitored along with successive thermal treatments.
Our findings highlight several aspects of the atomic structure of the gallium/graphene system shedding a new light on this platform with potential applications in nanoelectronics and quantum technology.

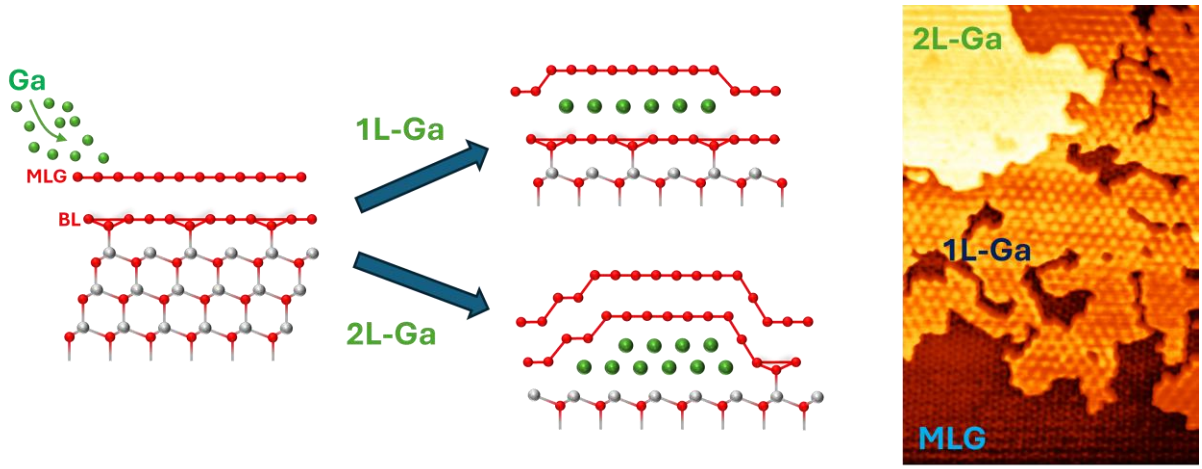


Fig. 1. **Left: sketch of the Ga deposition on monolayer epitaxial graphene (MLG) and the subsequent intercalation as a single layer gallenene (1L-Ga) and bilayer Ga (2L-Ga). Right: 60x100 nm$^2$ STM image which shows both 1L-Ga and 2L-Ga.**

## References

[1] C. Dong et al., *Air-Stable, Large-Area 2D Metals and Semiconductors*, ACS Nanosci. **4**, 115−127 (2024)
[2] V. Kochat et al., *Atomically thin gallium layers from solid-melt exfoliation*, Sci. Adv. **4**, e1701373 (2018)
[3] C. Riedl et al., *Structural properties of the graphene-SiC(0001) interface as a key for the preparation of homogeneous large-terrace graphene surfaces*, Phys. Rev. B **76**, 245406 (2007)
[4] N. Briggs et al., *Epitaxial graphene/silicon carbide intercalation: a minireview on graphene modulation and unique 2D materials*, Nanoscale **11**, 15440-15447 (2019)