Advances in the Synthesis of 2D Materials for Quantum Applications

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Abstract: We report advances in 2D material synthesis for quantum applications, including high-mobility graphene, AI-optimized growth, and phase-engineered $MoTe_2$ heterostructures.

The synthesis of high-quality 2D materials remains a cornerstone for advancing quantum technologies. This work highlights recent breakthroughs in the scalable production and phase engineering of 2D materials tailored for quantum applications. We first explored the role of interfacial oxygen in enhancing the growth of graphene on Cu(111)/sapphire via low-pressure chemical vapor deposition. This approach produced atomically flat, decoupled graphene with carrier mobilities rivaling exfoliated flakes, while also demonstrating quantum properties critical for advanced applications (Gebeyehu et al., Adv. Mater., 2024).

Complementing this, we utilized artificial intelligence (AI) to optimize the synthesis of graphene via adaptive Monte Carlo algorithms, achieving defect-free, high-quality material with superior reproducibility. This AI-driven framework marks a significant advancement in the efficient growth of 2D materials by dynamically learning optimal synthesis conditions without prior data dependence (Sabattini et al., arXiv, 2024).

Finally, we demonstrated a heterocontact-triggered 1H to 1T′ phase transition in monolayer $MoTe_2$ during chemical vapor deposition. This achievement enables the direct synthesis of lateral heterostructures, paving the way for low-resistance electronic devices and new opportunities in quantum material engineering (Khaustov et al., ACS Appl. Nano Mater., 2024).

Together, these advances underscore the convergence of experimental innovation and AI methodologies in realizing the scalable synthesis of 2D materials, unlocking new frontiers in quantum technologies and optoelectronics.