
Pioneering Simulated Microgravity Studies of 2D Material Synthesis Using a Random Positioning Machine

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Gaining insights into the role of gravity in the synthesis and crystallization of two-dimensional (2D) materials is essential for both advancing basic scientific understanding and enabling future off-Earth manufacturing strategies. Although prior research aboard the International Space Station (ISS) [1] and through parabolic flights [2] has highlighted the unique effects of microgravity, these methods are constrained by limited experiment duration and scalability. To overcome these limitations, we propose a novel ground-based approach that leverages a Random Positioning Machine (RPM) [3] to simulate microgravity continuously and investigate its impact on the formation of layered materials relevant to 2D systems.

This study marks the first known use of RPM technology in the context of 2D material synthesis, offering a new experimental route to analyze how simulated microgravity influences nucleation behavior, structural evolution, and defect generation. We employ layered α -MoO₃ as a representative system due to its well-documented ability to form 2D nanosheets and films. Hydrothermal synthesis was selected for this investigation because of its strong dependence on gravity-sensitive phenomena such as buoyancy-driven flow, convection, and particle sedimentation [4], making it a particularly responsive process for detecting gravitational influences.

Our experiments aim to evaluate how reduced gravity conditions—specifically the suppression of convective and sedimentary forces—alter the nucleation process and defect characteristics during hydrothermal growth. The RPM-based platform we developed thus serves as a foundation for broader application in the field of 2D materials research under simulated microgravity.

By creating and validating this methodology, we bridge a significant experimental gap and open new pathways for gravity-tailored synthesis. The findings hold promising implications for next-generation devices and systems in areas such as nanoelectronics, sensors, energy storage, and space-based manufacturing technologies [5].

References

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