Sputtering-Annealing Hybrid Process Enabling Industrial-Scale Production of van der Waals Heterostructures

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Two-dimensional materials (2D materials) are materials that consists of a single layer (or just a few atomic layers) of atoms, making it effectively two-dimensional in structure. Compared to bulk materials, 2D materials are extremely thin, have a large surface area, and exhibit unique electrical, optical, and mechanical properties. These characteristics are expected to drive innovative advances in next-generation electronic devices, energy conversion, and biosensing. In particular, graphene, the most famous among 2D materials has led to innovative technologies and applications due to its remarkable physical properties. Subsequent research on 2D materials other than graphene has led to the study of van der Waals heterostructures (vdWH), where these materials are combined with each other to create more functional materials. While 2D materials themselves have interesting properties, combining multiple 2D materials with various compositions, overlaps, twists, interlayer spaces, and fusions with other-dimensional materials can create a significantly broader range of possibilities. However, practical applications still face challenges such as improving material stability and reliability, establishing mass production techniques, and further research and development are expected in the future. This study aims to address these challenges by using the innovative 2D nano-material synthesis method developed by our group in recent years, the Sputter-Anneal Hybrid Process (SAHP) [1, 2], to realize the synthesis of unexplored nanomaterials through vdWH using graphene, hexagonal boron nitride (hBN), and other various 2D nanomaterials as building blocks, and to solve the technical challenges faced through device development.

References

[1] Yuki Hirata, Yuya Tamura, Bishnu Choudhary, Tetsuya Yamada, Kanta Yoshii, Hiroki Akasaka, Naoto Ohtake, ACS Applied Nano Materials, 22 (2025)
[2] Yuki Hirata, Kanta Yoshii, Mikito Yoshizato, Hiroki Akasaka, Naoto Ohtake, Advanced Engineering Material, 25 (2023).

Figures

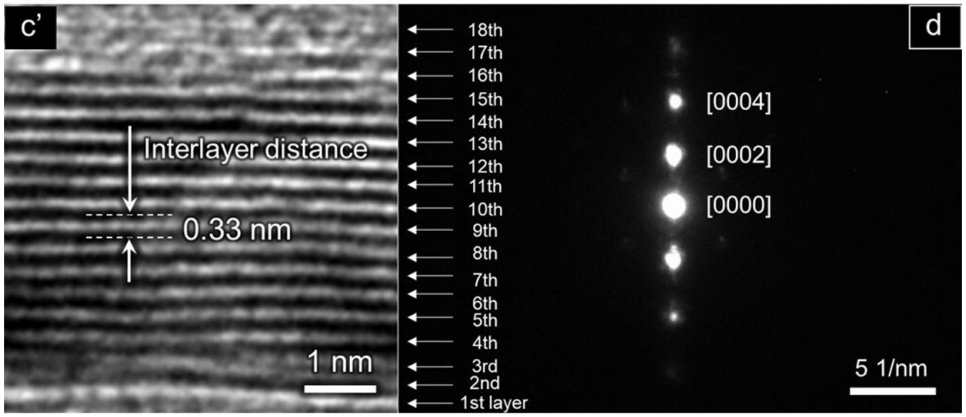

Figure 1: TEM observation of hBN synthesized on Nickel substrate by SAHP