# Large-scale growth and integration of high-quality 2D materials for 2.5D materials science

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Two-dimensional (2D) materials have attracted great interest because of their unique physical properties and various applications. The control of van der Waals (vdW) interaction and utilization of vdW nanospace are expected to extend the field of materials science, and such research direction can be expressed with a new concept of "Science of 2.5D materials", as illustrated in Figure 1 [1].

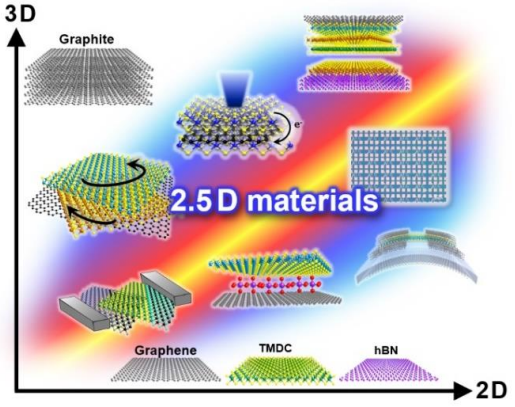


**Figure 1:** Concept of 2.5D materials [1].

In this presentation, our recent research is introduced based on this 2.5D concept, first showing the controlled CVD growth of bilayer graphene (BLG) and the intercalation of metal chloride molecules and alkaline metals, revealing new unique 2D structures with increased electrical conductivity [2-4]. We have also developed the CVD growth of high-quality and large-area multilayer hBN to be used as a building block of various 2.5D materials, such as graphene field-effect transistors (FETs) [5].

I will also introduce our new result of the tape transfer of 2D materials, which is expected to accelerate the 2D/2.5D materials research and applications (Figure 2) [6]. We achieved clean and user-friendly transfer of graphene, $MoS_2$, $WS_2$, and hBN using the UV tapes whose adhesive force can be decreased about 1/10 by UV light illumination. We do not need to use organic solvent so that we can transfer them onto plastics, and the robust tape allows "cut-and-transfer" for site-selective transfer, which saves 2D materials and production cost.

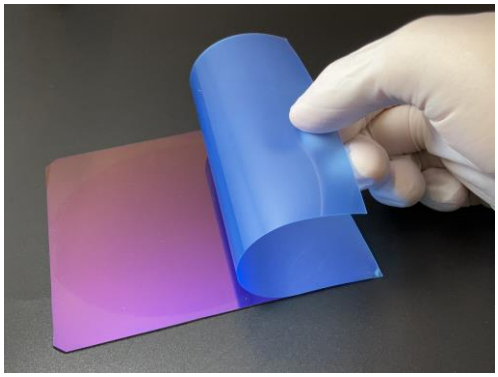

**Figure 2:** Tape transfer of 2D materials [5]. This photograph shows transfer of 4-inch monolayer graphene on a $SiO_2$ substrate [6].

Finally, I will introduce our group research project named, "Science of 2.5 Dimensional Materials: Paradigm Shift of Materials Science Toward Future Social Innovation (2021-2026)" which is supported by MEXT, Japan [7].

References

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