【Grant-in-Aid for Transformative Research Areas（A）】

Section II

Title of Project： Science of 2.5 Dimensional Materials: Paradigm Shift of Materials Science Toward Future Social Innovation

AGO Hiroki
(Kyushu University, Global Innovation Center (GIC), Distinguished Professor)

Number of Research Area：21A206　Researcher Number：10356355

【Purpose of the Research Project】

Materials science has established the basis of our modern society through the development of emergent internet of things (IoT) technologies. Traditional materials science is mainly based on the precise control of bulk materials with strong chemical bonds. On the other hand, two-dimensional (2D) materials, such as graphene, offer innovative ways to make new materials by integrating different layers via weak van der Waals interaction. This is accomplished by artificially stacking 2D materials with controlled compositions and twist angles, an approach that is expected to significantly expand the frontier of materials science. Furthermore, the well-defined 2D nanospace existing between individual layers of stacked 2D materials provides the opportunity to explore novel phenomena and to synthesize new materials.

In this Research Area we propose to explore the "Science of 2.5 dimensional materials" by introducing the new concepts of "freedom of assembly" and "2D nanospace", in combination with the synthesis of a wide variety of 2D materials. We will develop academic research based on this unique “2.5D” concept to achieve world-leading results, that can be developed for the next social innovation.

【Content of the Research Project】

To realize the above purposes and establish a new research field of “2.5D materials”, we organize five groups in this research area: (A01) materials synthesis, (A02) material assembly, (A03) analytical methods, (A04) novel physical properties, and (A05) electronic, photonic, and energy applications.

We will develop synthesis methods of high-quality 2D materials, such as graphene, transition metal dichalcogenides (TMDCs), hexagonal boron nitride (hBN), superconductors, ferromagnets, and molecular monolayers to be used as building blocks of 2.5D materials. These layered materials are assembled by our original robotic stacking system, and used as a host of the intercalated molecules and ions to create novel 2.5D materials with intriguing properties. In particular, we will focus on the moiré physics appeared in 2.5D materials stacked with controlled angles. We will also develop analytical methods that suit to 2.5D materials in terms of high sensitivity and high spatial/energy resolution. Furthermore, we will develop applied research in fields like energy generation, ultra-low power transistors, high density rechargeable batteries, and flexible electronics. In order to promote collaborative research in our area, we will also make four collaboration facilities that allow the common use of equipment like the robotic stacking system, material growth systems, and high-level analytical instruments.

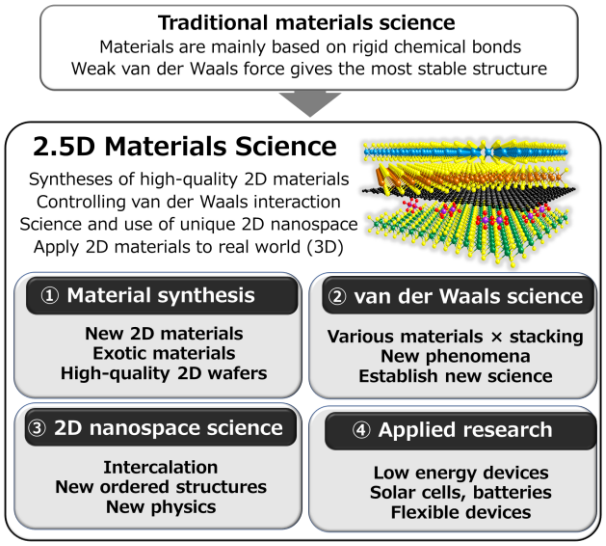

Figure 1. Research activities of this project

【Expected Research Achievements and Scientific Significance】

We are expecting a paradigm shift in materials science through the extensive research on “2.5D materials” by controlling the van der Waals interactions and using the interlayer nanospace. Our extensive research in this area will strongly impact on diverse areas of physics and chemistry as well as electronics and engineering. We also encourage and support young researchers to develop their research and to contribute to the next generation of scientists. Furthermore, as the research in this area can be developed to a wide range of applications, our 2.5D materials are expected to be used in our daily life, leading to future social innovation.

【Key Words】

2D materials: Atom-thick layered materials that exhibit unique physical properties different from their bulk counterparts.

2.5D materials: Layered materials with controlled stacking and an interlayer nanospace for hosting different materials. The dimension symbolically expresses a new degree of freedom of 2D layered materials.

【Term of Project】 FY2021-2025

【Budget Allocation】 1,117,300 Thousand Yen

【Homepage Address and Other Contact Information】

https://25d-materials.jp