Renzhi Ma
Pengzhan Sun, Wei Ma, Takayoshi Sasaki
National Institute for Materials Science, 1-1 Namiki, Tsukuba, Ibaraki 305-0044, Japan

MA.Renzhi@nims.go.jp

Exploration of Single-layer Nanosheets and Their Assemblies with Emergent Properties

I will introduce our recent progress on the preparation, characterization and diverse application prospects of single-layer nanoshees derived from layered oxides and hydroxides. In particular, we succeed in the controllable synthesis and chemical exfoliation of highly crystallized layered hydroxides with various metallic compositions (Mg, Fe, Co, Ni, Zn, Al, etc.) by rationally designing the oxidation state as well as by modifying the coordination geometry of metal cations. To harvest a synergistic effect, a superlattice-like nanocomposite through molecular-scale hetero-assembly of single-layer nanosheets and graphene derivatives was fabricated. The combination of conductive graphene directly adjacent to redoxable nanosheets can greatly improve the overall charge transfer efficiency of the composites. Electrochemical characterizations identified the nanocomposites as ideal electrode materials for the development of high-performance energy storage devices, as well as efficient electrocatalysts. We also show that, upon exfoliation, single-layer hydroxide nanosheets exhibited exceptionally high in-plane ion conductivities approaching 10^{-1} S cm^{-1}, which were the highest among anion conductors and comparable to proton conductivities in commercial proton exchange membranes (*e.g.*, Nafion). In contrast, cross-plane conductivities of restacked nanosheets were much poorer, which were 4-5 orders of magnitude lower than the in-plane values. These results clearly revealed an exceptionally high and anisotropic hydroxyl ion conduction in single-layer nanosheets as a benefit of exposing the whole 2D surfaces. The exotic 2D conducting properties might promise a great potential as inorganic solid ionic conductors in a large array of energy- or environment-related applications.

References

[1] P. Sun, R. Ma, and T. Sasaki, *Chemical Science* **9**, 33 (2018).
[2] P. Sun, R. Ma, X. Bai, K. Wang, H. Zhu, and T. Sasaki, *Science Advances* **3**, e1602629 (2017).
[3] W. Ma, R. Ma, C. Wang, J. Liang, X. Liu, K. Zhou and T. Sasaki, *ACS Nano* **9**, 1977 (2015).
[4] R. Ma, X. Liu, J. Liang, Y. Bando and T. Sasaki, *Adv. Mater.* **26**, 4173 (2014).

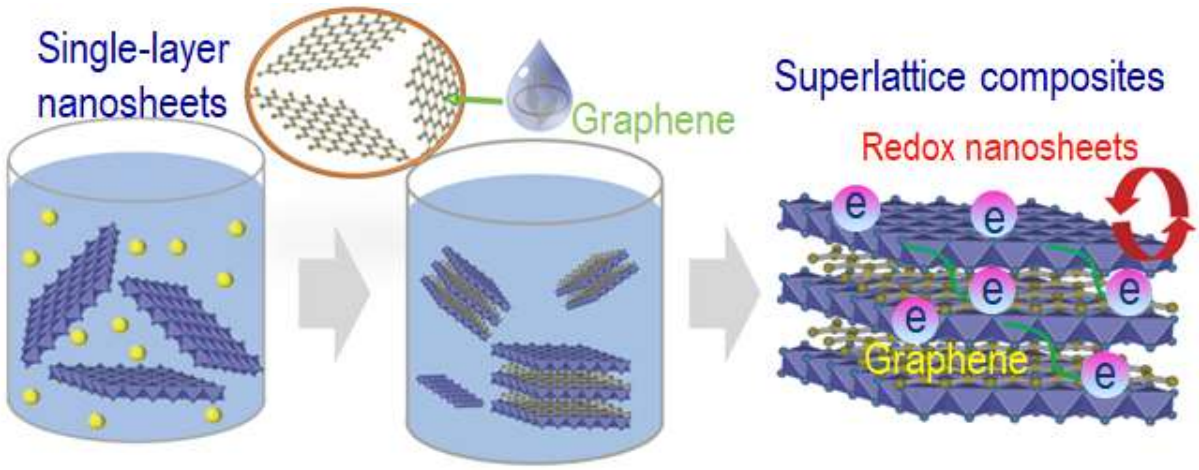

Figure 1: Molecular-scale hetero-assembly of single-layer nanosheets and graphene for superlattice-like composites.