Van der Waals Integration beyond 2D Materials

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The heterogeneous integration of dissimilar materials is a long pursuit of material science community and has defined the material foundation for modern electronics and optoelectronics. The current material integration strategy such as chemical epitaxial growth usually involves strong chemical bonds and is typically limited to materials with strict structure match and processing compatibility. Materials with substantially different lattice structures cannot be epitaxially grown together without generating too much interfacial defects that seriously alter/degrade their intrinsic properties. Alternatively, *van der Waals* integration, in which pre-formed building blocks are physically assembled together through weak *van der Waals* interactions, offers a bond-free material integration approach. The flexible "physical assembly" process used in *van der Waals* integration is not limited to materials that have similar lattice structures or require similar synthetic conditions. It can thus open up vast possibilities for damage-free integration of highly distinct materials beyond the traditional limits posed by lattice matching or process compatibility requirements, as exemplified by the recent blossom in the *van der Waals* integration of a broad range of 2D heterostructures. Here I will discuss *van der Waals* integration as a general material integration approach for creating diverse heterostructures with minimum integration-induced damage and interface states, enabling high-performing devices (including high speed transistors, diodes, flexible electronics) difficult to achieve with conventional "chemical integration" approach [1-10]. Recent highlights include the formation of *van der Waals* metal/semiconductor contacts free of Fermi level pinning to enable the first experimental validation of the Schottky-Mott rule since the initial prediction in 1930s [9]; and the development of *van der Waals* thin films for high performance large area electronics [10]; and the creation of a new class of van der Waals 2D-moecular superlattices with radically different layers yet atomic precision in each layer [7].

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