General plasma doping strategy for two-dimensional transition metal dichalcogenides based on self-assembled nanostructures

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Modification of electrical and optical properties of transition metal dichalcogenides (TMDs) while maintaining its two-dimensionality is essentially required to apply it to various applications. Charge transfer effect from highly electronegative or affinitive chemical components or molecules deposited on few-layer TMDs has been intensively studied. [1, 2] In addition, plasma treatment methods demonstrated p-doping effects for thick MoS_2. [3] However, there exist significant challenges for achieving the stability, uniformity, and non-degenerated doping level.

Herein, we report universal doping approach for various TMDs (MoS_2, and WS_2) via well-controlled nanostructures fabricated from block copolymer (BCP). These nanostructures can passivate nanoscale local areas on the surface of TMDs during a plasma-based doping process. The scale and geometry of BCP nanostructures is determined by total molecular weight and volume fraction of each block. Moreover, they contribute to the conservation of intrinsic matrix simultaneously. We employed argon and oxygen plasma to partially remove sulfur atoms from MoS_2 and to add oxygen atoms for modifying the optical and electrical properties. As a result, our method controls the effective plasma-influenced area and can adjust electron concentration from 1.9×10^{11} cm^{-2} to 8.11×10^{11} cm^{-2} via the generation of extra carriers. Based on the controllability of BCP pattern coverage and plasma treatment time and sources, a similar approach can be applied to other TMDs for the facile modulation of electronic properties..

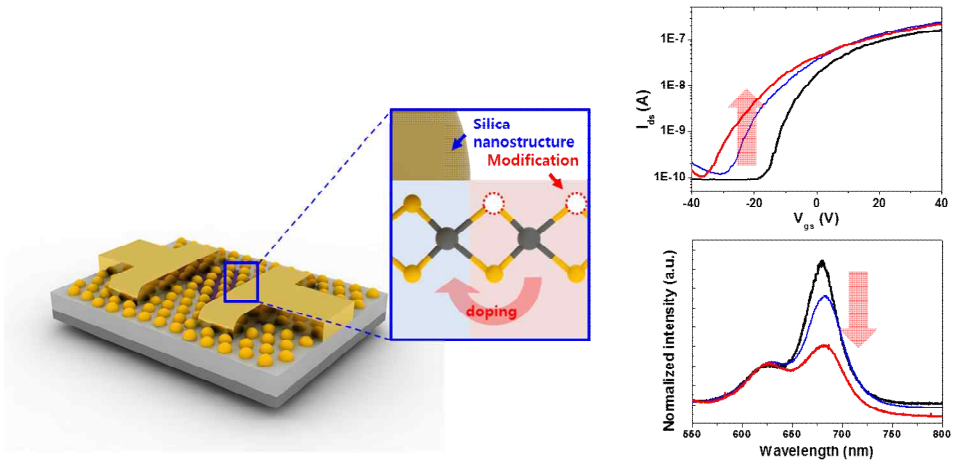

Fig. 1. Conceptual doping strategy and modification of electrical/optical properties

References

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