

TW-P061

## Effects of metal contacts and doping for high-performance field-effect transistor based on tungsten diselenide (WSe<sub>2</sub>)

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Transition metal dichalcogenides (TMDs) with two-dimensional layered structure, such as molybdenum disulfide (MoS<sub>2</sub>) and tungsten diselenide (WSe<sub>2</sub>), are considered attractive materials for future semiconductor devices due to its relatively superior electrical, optical, and mechanical properties. Their excellent scalability down to a monolayer based on the van der Waals layered structure without surface dangling bonds makes semiconductor devices based on TMD free from short channel effect. In comparison to the widely studied transistor based on MoS<sub>2</sub>, researchs focusing on WSe<sub>2</sub> transistor are still limited. WSe<sub>2</sub> is more resistant to oxidation in humid ambient condition and relatively air-stable than sulphides such as MoS<sub>2</sub>. These properties of WSe<sub>2</sub> provide potential to fabricate high-performance field-effect transistor if outstanding electronic characteristics can be achieved by suitable metal contacts and doping phenomenon.

Here, we demonstrate the effect of two different metal contacts (titanium and platinum) in field-effect transistor based on WSe<sub>2</sub>, which regulate electronic characteristics of device by controlling the effective barrier height of the metal-semiconductor junction. Electronic properties of WSe<sub>2</sub> transistor were systematically investigated through monitoring of threshold voltage shift, carrier concentration difference, on-current ratio, and field-effect mobility ratio with two different metal contacts. Additionally, performance of transistor based on WSe<sub>2</sub> is further enhanced through reliable and controllable n-type doping method of WSe<sub>2</sub> by triphenylphosphine (PPh<sub>3</sub>), which activates the doping phenomenon by thermal annealing process and adjust the doping level by controlling the doping concentration of PPh<sub>3</sub>. The doping level is controlled in the non-degenerate regime, where performance parameters of PPh<sub>3</sub> doped WSe<sub>2</sub> transistor can be optimized.

**Keywords:** triphenylphosphine, WSe<sub>2</sub>, FET

TW-P062

## Role of edge patterning and metal contact for extremely low contact resistance on graphene

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Graphene, a single atomic layered structure of graphite, has drawn many scientific interests for attractive future electronics and optoelectronics beyond silicon-based technology because of its robust physical, optical, and electrical properties. But high metal-graphene contact resistance prevents the successful integration of high speed graphene devices and circuits, although pristine graphene is known to have a novel carrier transport property. Meanwhile, in the recently reported metal-graphene contact studies, there are many attempts to reduce the metal-graphene contact resistance, such as doping and one-dimensional edge contact. However, there is a lack of quantitative analysis of the edge contact scheme through variously designed patterns with different metal contact.

We first investigate the effects of edge contact (metal-graphene interface) on the contact resistance in terms of edge pattern design through patterning (photolithography + plasma etching) and electrical measurements. Where the contact resistance is determined using the transfer length method (TLM). Finally, we research the role of metal-kind (Palladium, Copper, and Titanium) on the contact resistance through the edge-contacted devices, eventually minimizing contact resistance down to approximately 23  $\Omega \cdot \mu\text{m}$  at room temperature (approximately 19  $\Omega \cdot \mu\text{m}$  at 100 K).

**Keywords:** graphene, edge contact, metal contact