Approaching Schottky-Mott Limit in Van Der Waals Metal Semiconductor Contacts

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SUMMARY

UCLA researchers in the Department of Chemistry and Biochemistry have successfully achieved *van der Waals* ohmic contact in metal-semiconductor junctions with an interface S-parameter approaching the Schottky-Mott limit.

BACKGROUND

The performance of the metal-semiconductor (MS) junctions is critical for the operation of semiconductor devices. Usually an ohmic contact is desired for the MS junctions, for when the thermal energy is below the Schottky barrier height, electrical charges can be transported easily across the transistor and the external circuitry. The theoretical prediction of the Schottky barrier, idealized for the interface S-parameter reaching the Schottky-Mott limit of S=1, has never been experimentally achieved due to the inevitable interfacial chemical disorder and the consequent effect of Fermi level pinning (FLP). Ohmic contact in the traditional semiconductor industry is generally achieved through aggressive processes, such as high temperature annealing to reduce interface disorder, and heaving doping to reduce Schottky barrier width. These processes are not applicable for many delicate materials, and still yield low S-parameters when best applied. Addressing the plague of the FLP effect is crucial for fabricating high-performance semiconductor devices.

INNOVATION

UCLA researchers have successfully demonstrated an entirely new and general method for creating *van der Waals* ohmic MS contacts. Atomically flat metal thin films are directly laminated onto dangling-bond free 2D semiconductors without direct chemical bonding. The interface S-parameter was measured as S=0.96, the closest approach to the Schottky-Mott limit S=1 in semiconductor history, opening up the possibility of overcoming the FLP effect and systematically tailoring the Schottky barrier by design. This method allows creation of high performance devices from atomically thin 2D semiconductors and many other delicate semiconductors.

APPLICATIONS

- Fabrication with delicate materials
- High performance ohmic contact interfaces/junctions
- General integration of highly disparate materials for functional interfaces

ADVANTAGES

- Low energy integration process
- Sharp and atomically clean MS interface
- High-performance ohmic contact on semiconductor junctions
- Nearly unity interface S-parameter
- Tailor the experimental Schottky barrier by design

RELATED MATERIALS

- Liu, Y., Guo, J., Zhu, E., Liao, L., Lee, S.-J., Ding, M., Shakir, I., Gambin, V., Huang, Y., and Duan, X. Approaching the Schottky–Mott limit in van der Waals metal–semiconductor junctions, Nature, 2018.

PATENT STATUS

CONTACT

UCLA Technology Development Group
ncd@tdg.ucla.edu
tel: 310.794.0558.

INVENTORS

- Duan, Xiangfeng

OTHER INFORMATION

KEYWORDS

interface, junction, semiconductor, metal, Schottky–Mott, ohmic contact, S-parameter, Fermi level pinning, FLP effect, Schottky barrier, integration, fabrication, contacts

CATEGORIZED AS

- **Engineering**
  - Engineering
- **Semiconductors**
  - Design and Fabrication

RELATED CASES

2018-597-0

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	11,575,006	02/07/2023	2018-597

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- Ultrafine Nanowires As Highly Efficient Electrocatalysts
- Chemical Vapor Deposition Growth of the Large Single Crystalline Domains of Monolayer and Bilayer
- Double-Negative-Index Ceramic Aerogels For Thermal Superinsulation
- Single-Atom Tailoring of Platinum Nanocatalysts for High-Performance Multifunctional Electrocatalysis
- Vertical Heterostructures for Transistors, Photodetectors, and Photovoltaic Devices
- Palladium Alloy Hydride Nano Materials
- High Performance Thin Films from Solution Processible Two-Dimensional Nanoplates

UCLA Technology Development Group

10889 Wilshire Blvd., Suite 920,Los Angeles,CA 90095

tdg.ucla.edu

Tel: 310.794.0558 | Fax: 310.794.0638 | ncd@tdg.ucla.edu