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High-performance MoS2 field-effect transistors

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A team of researchers from Purdue University, SEMATECH and SUNY College of Nanoscale Science and Engineeringwill present at the 2014 Symposium on VLSI Technology on their work involving high-performance molybdenum disulfide (MoS_2) field-effect transistors (FETs).

The team's research is an important milestone for the realization of the ultra-scaled low-power 2D MoS_2 FETs and the advancement of photonic and electronic devices based on transition metal dichalcogenide (TMD) materials such as solar cells, phototransistors and low-power logic FETs. The research is supported by Semiconductor Research Corporation (SRC), the world's leading university-research consortium for semiconductors and related technologies, and SEMATECH.

As part of the research, the team leveraged MoS_2, which has been studied closely in recent years by the semiconductor industry due to its potential applications in electrical and optical devices. However, high contact resistance value limits the device performance of MoS_2 FETs significantly. One method to resolve this issue is to dope the MoS_2 film, but doping the atomically thin film is nontrivial and requires a simple and reliable process technique. The technique used by the research team provides an effective and straightforward way to dope the MoS_2 film with chloride-based chemical doping and significantly reduces the contact resistance.

"Compared with other chemical doping materials such as PEI (polyethylene imine) and potassium, our doping technology shows superior transistor performance including higher drive current, higher on/off current ratio and lower contact resistance," said Professor Peide Ye, College of Engineering, Purdue University.

In order to obtain high-performance FETs, three parts of the device should be carefully engineered: semiconductor channel (carrier density and its mobility); semiconductor-oxide interface; and semiconductor-metal contact. This research is particularly aimed at eliminating the last major roadblock toward demonstration of high-performance MoS_2 FETs, namely, high contact resistance.

The MoS_2 FETs using the doping technique, which were fabricated at Purdue University, can be reproduced now in a semiconductor manufacturing environment and show the best electrical performance among all the reported TMD-based FETs. The contact resistance (0.5 kΩ·µm) with the doping technique is 10 times lower than the controlled samples. The drive current (460 µA/µm) is twice of the best value in previous literature.

"Due to recent advances such as the research being presented at the VLSI symposium, 2D materials are gaining a lot of attention in the semiconductor industry," said Satyavolu Papa Rao, director of Process Technology at SEMATECH. "The collaborative effort among world-class researchers and engineers from this team is a prime example of how consortium-university-industry partnerships further enable the development of cutting-edge process techniques."

"Improved contacts are always desirable for all electronic and optical devices," said Kwok Ng, Senior Director of Device Sciences at SRC. "The doping technique presented by this research team provides a valid way to achieve low contact resistance for MoS_2 as well as other TMD materials."

Provided by Integrity Global

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