

# Desired location doping of 2D semiconductors via E-beam patterned ultrathin polymer layer

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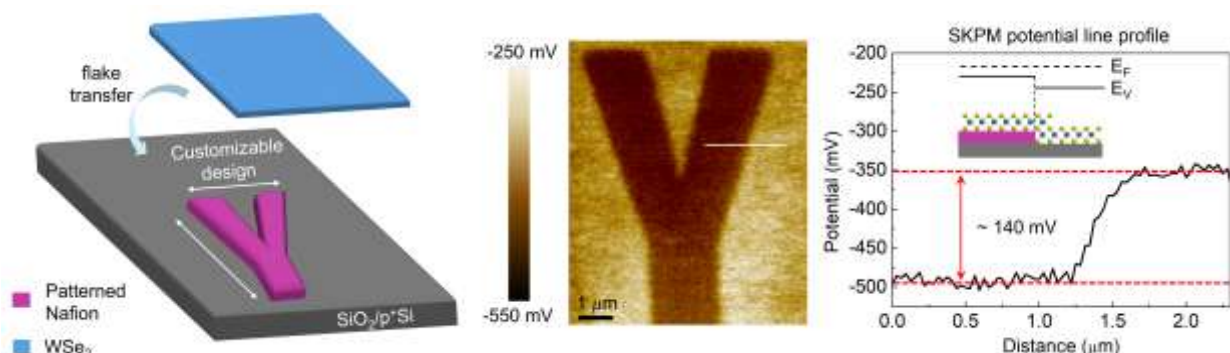
## Abstract

Desired or intended location doping in two dimensional (2D) semiconductors has been a persistent issue for 2D semiconductor based electronics along with contact resistance (RC) lowering. Such doping in 2D seems almost impossible unlike in 3D semiconductors, which use ion implantation. Furthermore, maintaining a stable doping state in 2D seems very difficult. Here, we report a strategy for intended location doping of 2D materials: hole carrier transfer from electron-beam-patterned sulfonated tetrafluoroethylene-based fluoropolymer-copolymer (Nafion) underlayer. Bottom-patterned ultrathin Nafion with a large work function excessively dopes p-type WSe<sub>2</sub>, so that its sheet resistance may become compatible for integrated circuit. Top-gated WSe<sub>2</sub> field-effect transistor channel with Nafion support for ungated region demonstrates 7 times higher mobility than without Nafion. As bottom-patterned for contact area, Nafion directly lowers RC to ~6 k $\Omega$ · $\mu$ m, which is maintained for 2 months in air ambient and survives N<sub>2</sub> anneal of 250 °C. Our Nafion approach for 2D doping and stable RC seems advanced and practically useful.

## References

- [1] Sewoong Oh, Heesun Bae, Jeehong Park, Hyunmin Cho, June Hyuk Lee, Gyu Lee, Jae Yeon Seo, Min Kyu Yang, Young Jai Choi, Deep Jariwala, Yeonjin Yi, Ji Hoon Park, Seongil Im, Mater. Sci. Eng. R Rep, 165 (2025) 100996
- [2] Sewoong Oh, Jeehong Park, Yeonjin Yi, Seongil Im, Ji Hoon Park, ACS Appl. Mater. Interfaces, (2026)

## Figures



**Figure 1:** Insert caption to place caption below figure

Electron-beam patterned underlayer Nafion excessively increases the hole density of p-type WSe<sub>2</sub>. SKPM image and potential line profile of p-WSe<sub>2</sub> on 'Y' patterned Nafion, resulting from the electron charge transfer or hole doping which causes E<sub>F</sub>-lowering or work function increase.