**Supporting Information**

**Maskless Micro/Nanopatterning and Bipolar Electrical-Rectification of MoS2 Flakes Through Femtosecond Laser Direct Writing Processing**

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**Supplementary figures and analysis.**



Figure S1. XPS spectra of pristine (P-) MoS2. XPS peak-split results of a) Mo 3d, b) O 1s, and S 2p spectra of P-MoS2.



Figure S2. XPS peak-split results of S 2p spectra of FLP-MoS2.

***Surface moderate modification of MoS2 flakes through femtosecond laser pulse processing for FET (-1 and -2).*** Figure S3 and S4 show the electrical test results for two MoS2 FET, which are MoS2 FET-1 and MoS2 FET-2, before and after surface modified.

Figure S3a and c show the drain−source current (*IDS*) versus drain−source voltage (*VDS*) characteristics of MoS2 FET-1 before and after surface moderate modification under different gate voltages (*VG*) ranging from -10 to 10 V. For these output characteristic curve, the drain−source current changed linearly with the drain−source voltage, indicating nearly ohmic contact for these FET device. Figure S3b and d show the drain−source current (*IDS*) versus gate voltages (*VG*) characteristics of MoS2 FET-1 before and after surface moderate modification under different drain−source voltage (*VDS*) ranging from 0.05 to 0.5 V. These transfer characteristic curve of pristine/undamaged and surface moderate modified MoS2 FET exhibited n-type conduction. To further compare the change in electronic properties of this device, the on/off ratio, carrier mobility (μ), and subthreshold swing (SS) were calculated. For pristine/undamaged MoS2 FET-1, the on/off ratio, carrier mobility (μ), and SS were respectively 2.84×103, 13.87 cm2 V-1 s-1, and 14.3 V/dec; for surface modified MoS2 FET-1, the on/off ratio, carrier mobility (μ), and SS were respectively 1.85×105, 1.55 cm2 V-1 s-1, and 9.4 V/dec. These results indicated that after femtosecond laser modification processed, the on/off ratio of MoS2 FET-1 was increased by two magnitude, whereas the carrier mobility was decreased. The increase of on/off ratio might be attributed to the thinning effect of femtosecond laser on MoS2 flake.[1](#_ENREF_1) And the decrease of carrier mobility might be attributed to the defect states on laser modified-MoS2, which can reduce the portion of mobile carriers in conduction band and increase the portion of trapped carriers that do not contribute to charge transport, hence leading to the degradation of effective mobility.[2](#_ENREF_2)



Figure S3 Electrical test of MoS2 FET-1 before and after surface modification. a) Output and b) transfer characteristic curve of MoS2 FET-1 before surface modification. c) Output and d) transfer characteristic curve of MoS2 FET-1 after surface modification. e) SEM image of MoS2 FET-1 after surface modification.

Figure S4a and c show the drain−source current (*IDS*) versus drain−source voltage (*VDS*) characteristics of MoS2 FET-2 before and after surface moderate modification under different gate voltages (*VG*) ranging from -10 to 10 V. For these output characteristic curve, the drain−source current changed linearly with the drain−source voltage, indicating nearly ohmic contact for these FET device. Figure S4b and d show the drain−source current (*IDS*) versus gate voltages (*VG*) characteristics of MoS2 FET-2 before and after surface moderate modification under different drain−source voltage (*VDS*) ranging from 0.75 to 1.5 V. These transfer characteristic curve of pristine/undamaged and surface moderate modified MoS2 FET exhibited n-type conduction. To further compare the change of electronic properties of this device, the on/off ratio, carrier mobility (μ), and subthreshold swing (SS) were calculated. For pristine/undamaged and surface modified MoS2 FET-2, the on/off ratio and carrier mobility (μ) were no changed, which were respectively 1.13×105 and 3.5×10-2 cm2 V-1 s-1, and SS were 18.5 and 11.7 V/dec, respectively. However, the drain−source current (*IDS*) of surface modified MoS2 FET-2 increased quicker and reached saturation faster with the increase of gate voltages (*VG*) compared with that of pristine/undamaged MoS2 FET-2.



Figure S4 Electrical test of MoS2 FET-2 before and after surface modification. a) Output and b) transfer characteristic curve of MoS2 FET-2 before surface modification. c) Output and d) transfer characteristic curve of MoS2 FET-2 after surface modification. e) SEM image of MoS2 FET-2 after surface modification.

Reference

1. Chen, M.; Nam, H.; Wi, S.; Ji, L.; Ren, X.; Bian, L.; Lu, S.; Liang, X. Stable few-layer MoS2 rectifying diodes formed by plasma-assisted doping. *Applied Physics Letters* **2013,** *103*, 142110.

2. Bertolazzi, S.; Bonacchi, S.; Nan, G.; Pershin, A.; Beljonne, D.; Samorì, P. Engineering Chemically Active Defects in Monolayer MoS2 Transistors via Ion-Beam Irradiation and Their Healing via Vapor Deposition of Alkanethiols. *Advanced Materials* **2017,** *29*, 1606760.