Plasmonic enhancement of photocurrent in MoS_2 field-effect-transistor

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Introduction

In the past few years, intensive research efforts have been devoted to the investigation of two-dimensional (2D) materials, such as graphene and various transition metal chalcogenides. Molybdenum disulfide (MoS_2) is a typical representative of transition metal chalcogenide material family.

Here, we demonstrate a plasmonic enhancement of photocurrent in MoS_2 field-effect-transistor decorated with gold nanoparticles (NPs), with significantly enhanced photocurrent peaked at the plasmon resonant wavelength around 540 nm. Our findings offer a possibility to realize wavelength selectable photodetection in MoS_2 based phototransistors.

FET devices from thin flakes of MoS_2

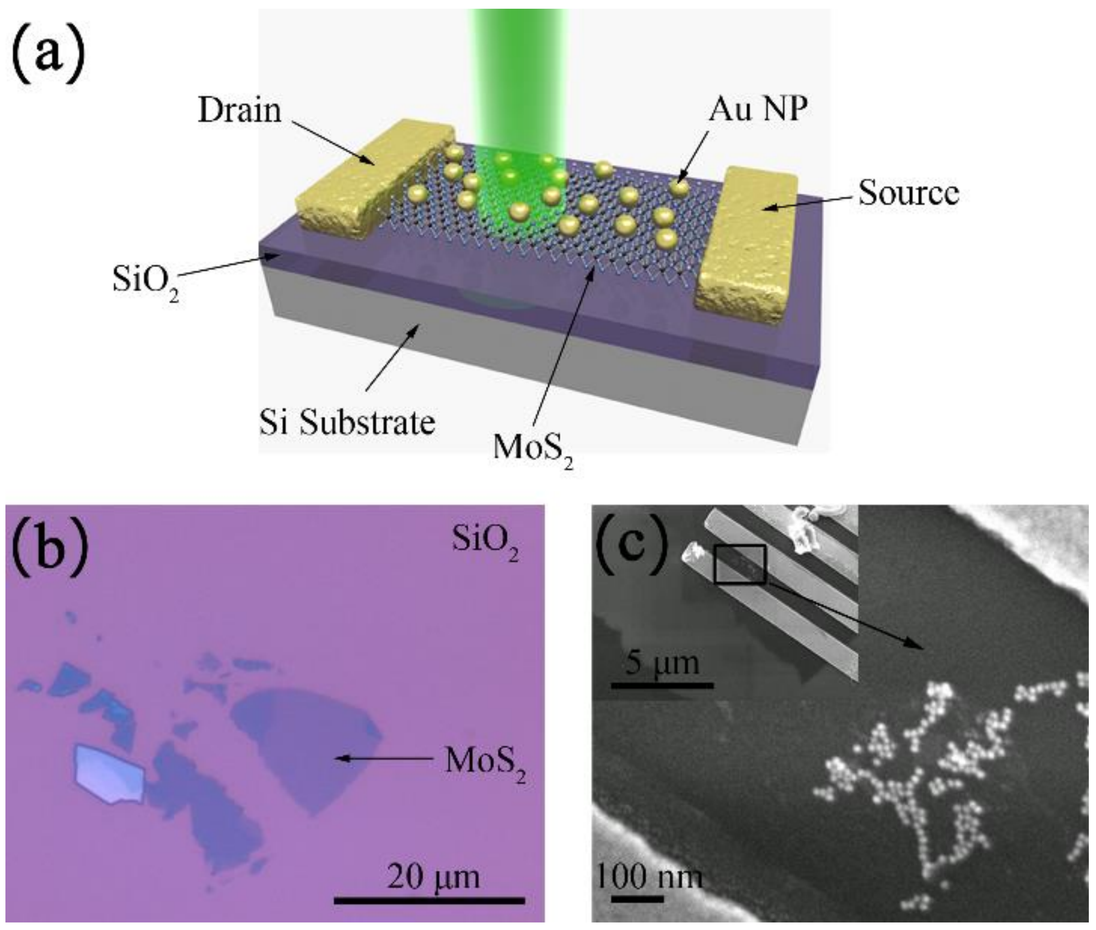

FIG. 1. (a) Three-dimensional schematic view of the MoS_2 transistor. **(b)** Optical image of MoS_2 (4 to 5 layers) deposited on top of 300 nm SiO_2/Si substrate. Scale bar, 20 μm. **(c)** Scanning electron microscopy image of Au nanoparticles on MoS_2 surface. Scale bar, 100 nm. Inset: Scale bar, 5 μm.

Conclusion

In conclusion, we have demonstrated that the photocurrent of MoS_2 transistor device can be increased significantly by decorating the MoS_2 sheet with plasmonic Au nanoparticles. Combining the thin MoS_2 sheet with plasmonic Au NPs produces enhanced local optical field, which can contribute to the enhanced absorption of light in the MoS_2 transistor device.

In addition, the device shows maximum photocurrent enhancement at the wavelength corresponding to the Au nanoparticle plasmon resonance. Therefore, it is possible to realize MoS_2 based wavelength-selectable photodetection by tailoring the size and shape of the coupled plasmonic Au or silver nanostructures.

Photocurrent measurements

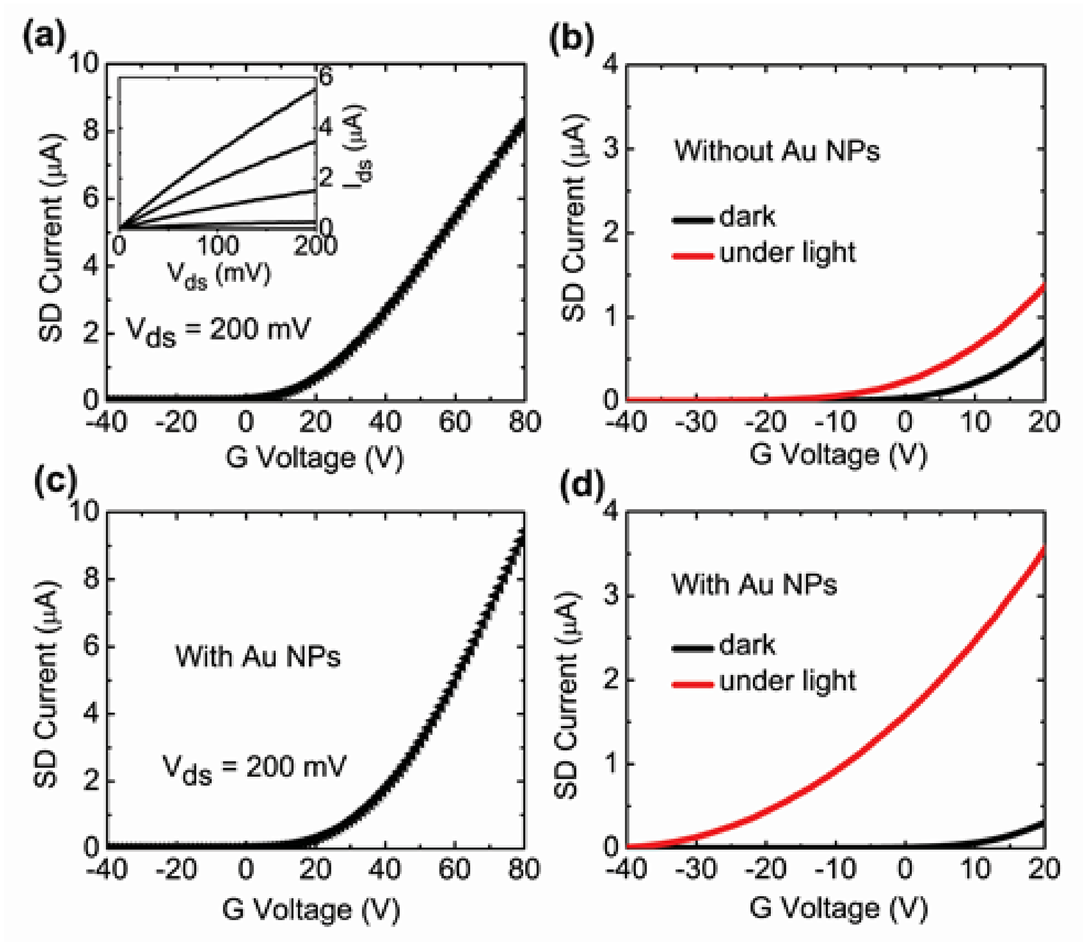

FIG. 2. (a) Transfer characteristics ($I\text{-}V_g$) for the back-gated MoS_2 transistor. Inset: $I_{ds} - V_{ds}$ curves acquired for V_{bg} values of 80, 60, 40, 20 and 0 V. **(b)** Typical transfer curves ($I\text{-}V_g$) for the same device under light illumination and dark. **(c)** Transfer characteristics ($I\text{-}V_g$) for the same MoS_2 transistor with Au nanoparticles deposited on top. **(d)** Typical transfer curves ($I\text{-}V_g$) for the same device under light illumination and dark with Au nanoparticles deposited on top.

Wavelength-dependent photocurrent enhancement

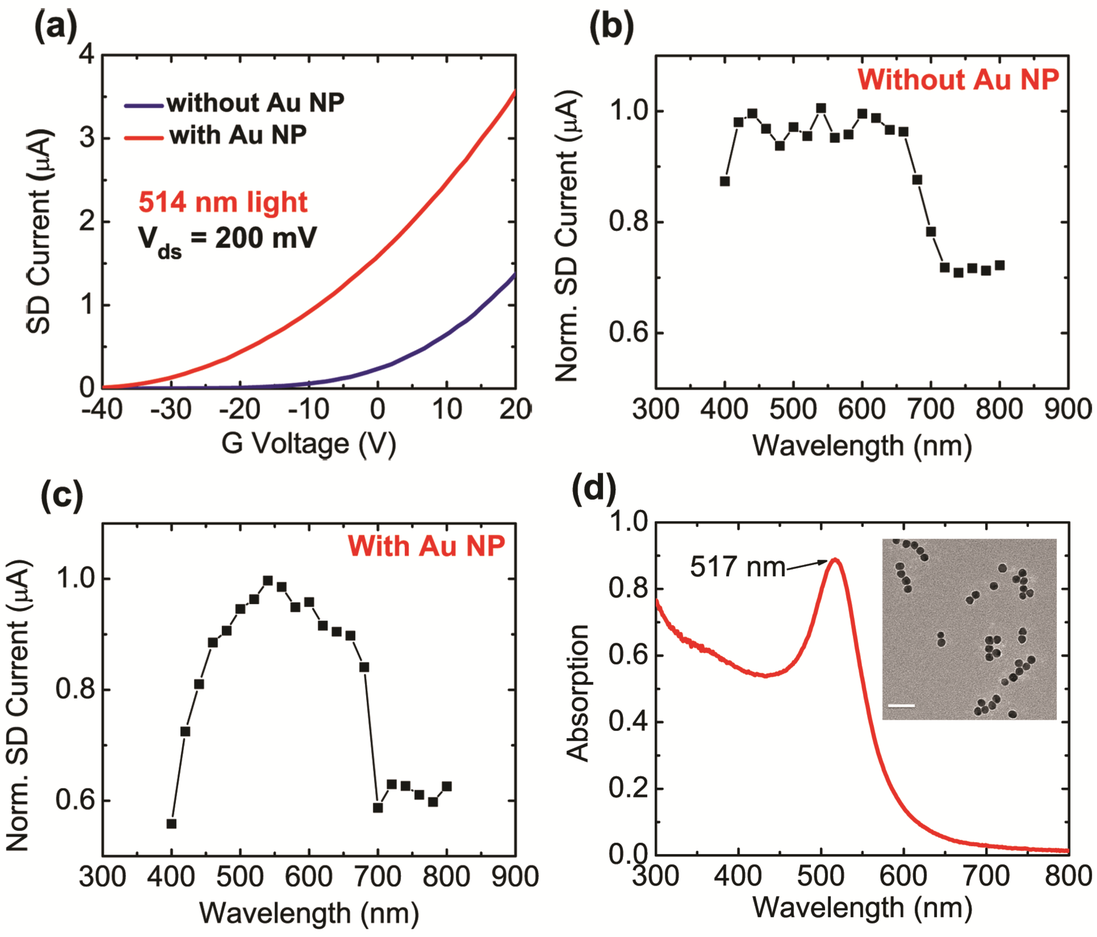

FIG. 3. (a) A comparison of the outputs of device under 514 nm light illumination without and with Au NPs in small gate voltage range (< 20 V). **(b)** and **(c)** Photocurrent of the device as a function of excitation wavelength of the illumination source at constant optical power without and with Au particles, respectively. (SD Voltage: 200 mV, G Voltage: 20 V) **(d)** Ultraviolet-visible (UV-vis) spectra of Au nano-particles in solution. Inset: A transmission electron microscopy (TEM) image of Au nano-particles (15 nm). Scale bar: 50 nm.