Fabrication and characterization of Au-nanopillar electrodes for MoS_2-based optoelectronic devices

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There have been increasing research attention for optoelectronic devices based on transition metal dichalcogenides (TMDs), since they have fascinating physical properties, such as sizable bandgap energy and large absorption coefficient. Despite the large absorption coefficient, atomically thin TMD layers exhibit limited optical absorption. Integration of plasmonic metal nanostructures with TMD layers are expected to improve the performance of the TMD devices. In TMD/metal nanostructures, excitation of surface plasmons can improve light absorption and tune the spectral response of the TMD layers. In this work, periodic Au-nanopillars (NP) were fabricated by evaporation of Au thin films on SiO_2-NP arrays which were prepared by electron-beam lithography and dry etching processes. MoS_2 monolayers grown by chemical vapor deposition method were wet-transferred on the Au-NP arrays to complete the MoS_2/Au-NP hybrid systems. Optical reflectance and photoluminescence spectra of not only MoS_2 monolayers on Au-NP but also MoS_2 monolayers on flat Au were investigated. Absorption in MoS_2 monolayers and electric field maps were calculated by finite-difference time-domain simulations. Kelvin probe force microscopy, which can measure local electric potential at sample surface, was used to study charge redistribution under light illumination. All the measured and calculated results showed that the Au-NPs efficiently collected photo-generated carriers on the MoS_2 layers. This work suggests that Au-NP arrays can work as electrodes for high-performance TMD-based optoelectronic devices.