Supplementary Material

Broadband optical absorption based on single-sized metal-dielectric-metal plasmonic nanostructures with high with high-ε″ metals

*Wei Wang, Yurui Qu, Kaikai Du, Songang Bai, Jingyi Tian, Meiyan Pan, Hui Ye, Min Qiu and Qiang Li**

***Device Fabrication*:**

The W MIM absorber is fabricated as follows (see supporting information Fig. S5). Firstly, a 130-nm-thick W film and a 70-nm-thick Al_2O_3 are sequentially deposited on a glass substrate by magnetron sputtering. Secondly, a 100-nm-thick PMMA resist is spun onto the Al_2O_3 film and baked for 3 minutes. The nanodisk array is then defined by E-beam lithography (EBL) and developed in 1:3 methyl isobutyl ketone/isopropyl alcohol (IPA) solution. Finally, another 15-nm-thick tungsten film is sputtered and the nanodisk array is obtained after lift-off. During the deposition of the tungsten film, the pressure of the sputtering is about 1.5 Pa. The flow rates of argon controlled by mass flow-meters in the range of 100 sccm. The substrate is heated for sputtering under 200 ℃.

***Optical Simulations*:**

Commercial software COMSOL Multiphysics based on finite element methods is used in the simulation. Periodic boundary conditions are imposed around the unit of the absorber. The boundary conditions are set to be periodic for the x and y directions. Simulations are performed in three-dimentional computional domain using non uniform structured mesh. The sizes of the minimum meshes are set as 2 nm for the nanodisk. A polarized plane wave is normally incident from the plane wave source placed above the structure.

***Optical Characterizations*:**

The absorption (A) is measured with a home-made reflection measurement set-up (see supporting information Fig. S6). The light beam from a super-continuum light source is focused through an objective lens. The light could be confined to about 50 μm in diameter when reaching the sample. For the reflection, another identical lens is exploited to couple the light into an optical spectrum analyzer. Since the transmission can be neglected considering the 130-nm-thick W film, the absorption (A) can be obtained by A=1-R where R represents the reflection.

1. Real part of relative permittivity for high-ε'' (Ni, Ti and W) and low-ε'' (Au) metals.

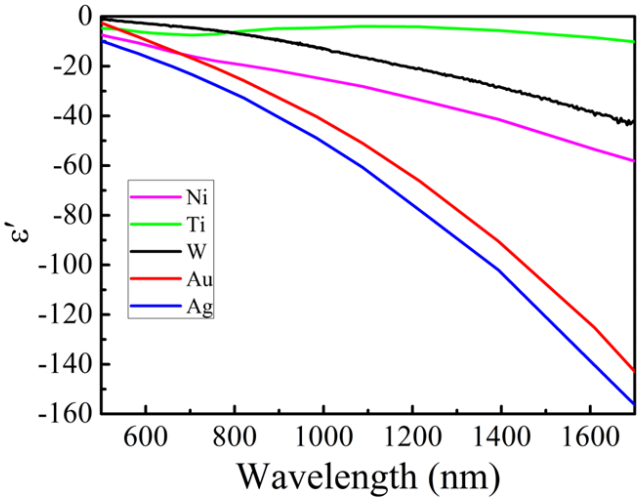

Figure S1. Real parts of refractive index for high-ε″ (Ni, Ti and W) and low-ε″ (Au) metals.

2. The electric field distributions in the x-z planes bisecting the top nanodisks for the W MIM absorber and Au MIM absorber at typical wavelength.

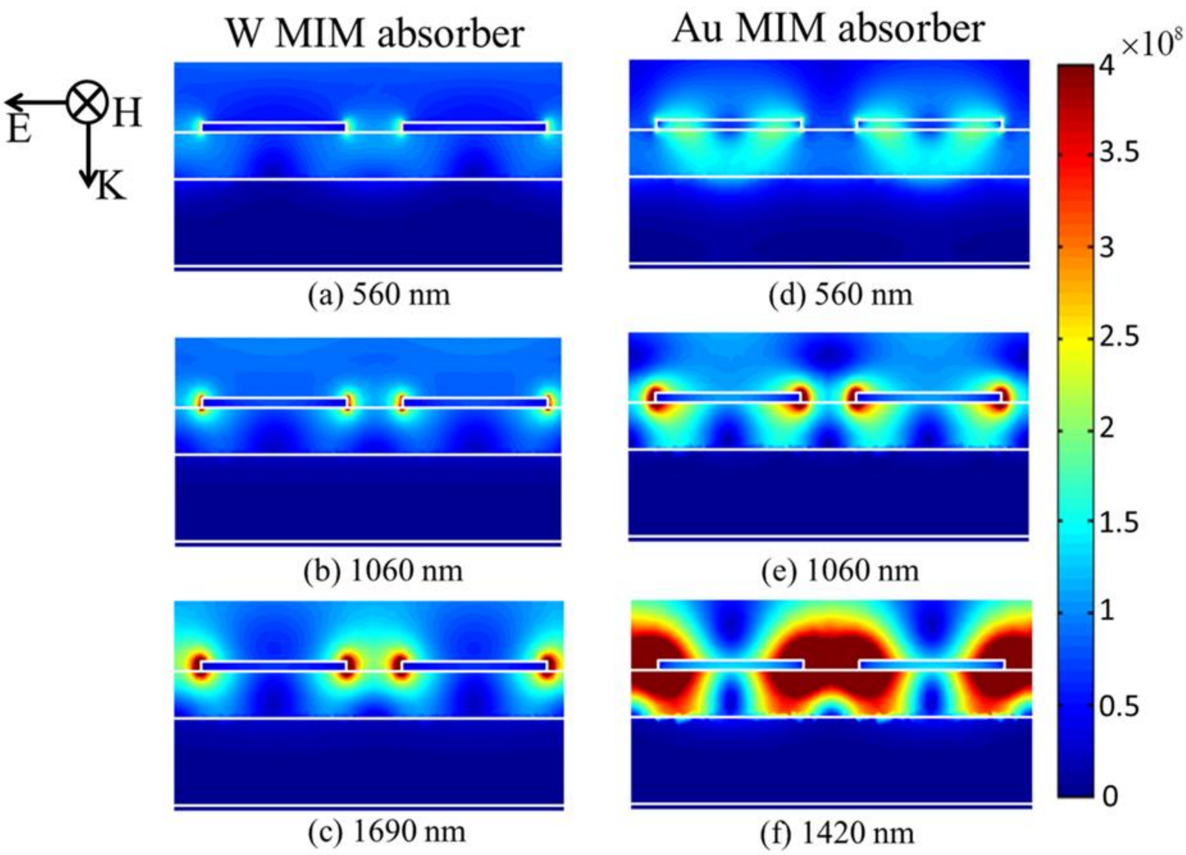

Figure S2. (Color online) The electric field distributions in the x-z planes bisecting the top nanodisks for the W MIM absorber and Au MIM absorber at typical wavelength. The color contour shows the magnitude of the electric field.

3. Absorption of absorber with different geometry and material.

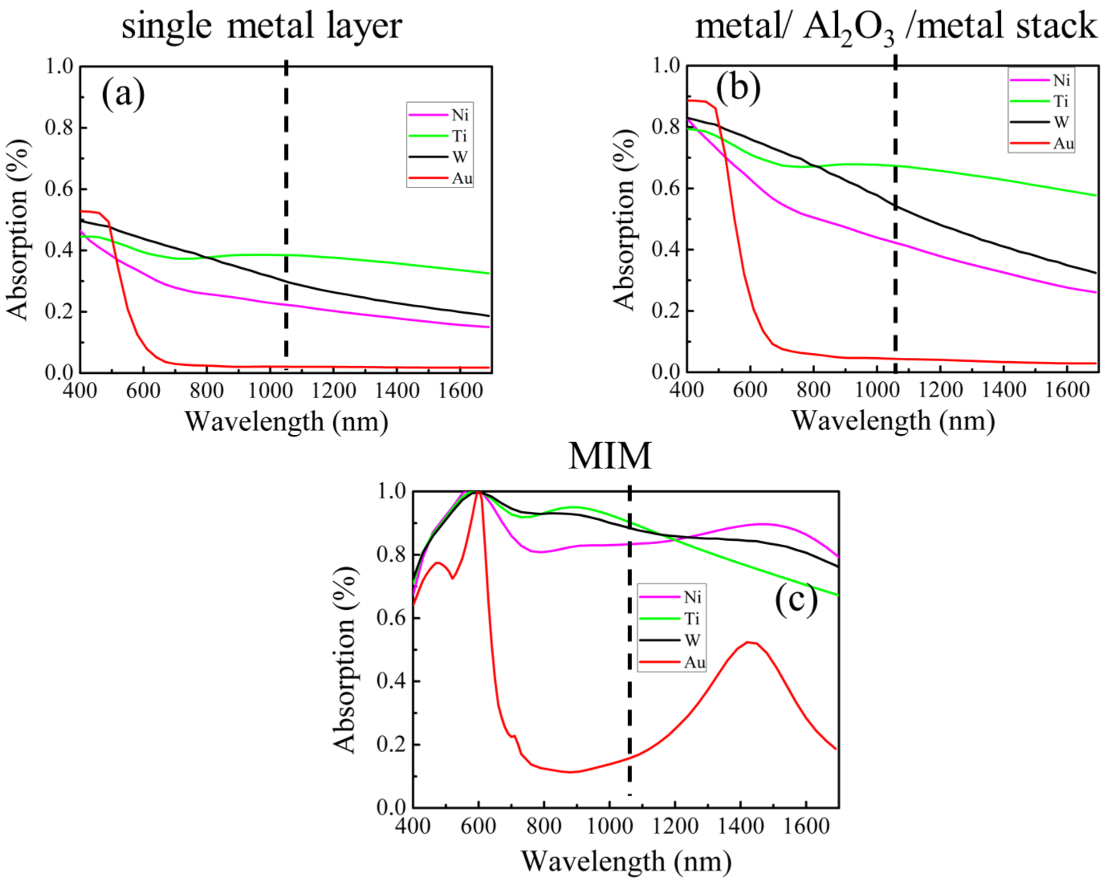

Figure S3. Comparison of simulated absorption in single metal layer (a), metal/Al_2O_3/metal stack (b) and MIM absorber (c) between high-ε'' (Ni, Ti and W) and low-ε'' (Au) metal.

4. Calculated absorption spectra of W and Au MIM absorber for different insulator thickness.

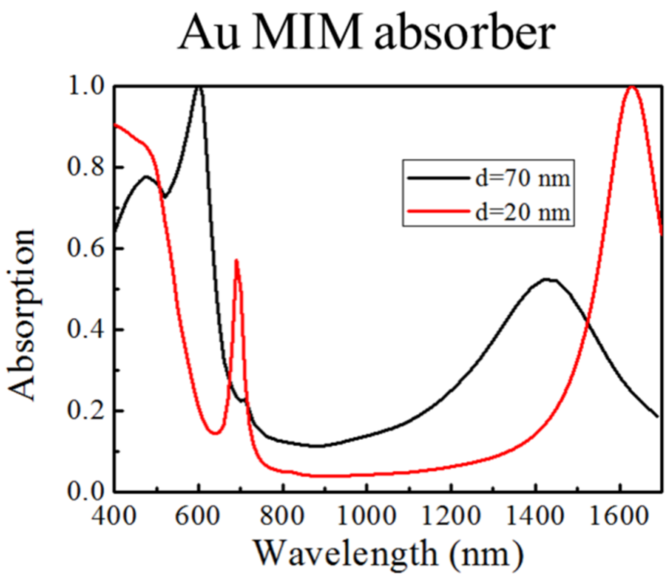

Figure S4. Comparison of absorption spectra of Au MIM absorber for two Al_2O_3 thicknesses: 70 nm and 20 nm.

5. The procedure of the MIM absorber fabrication.

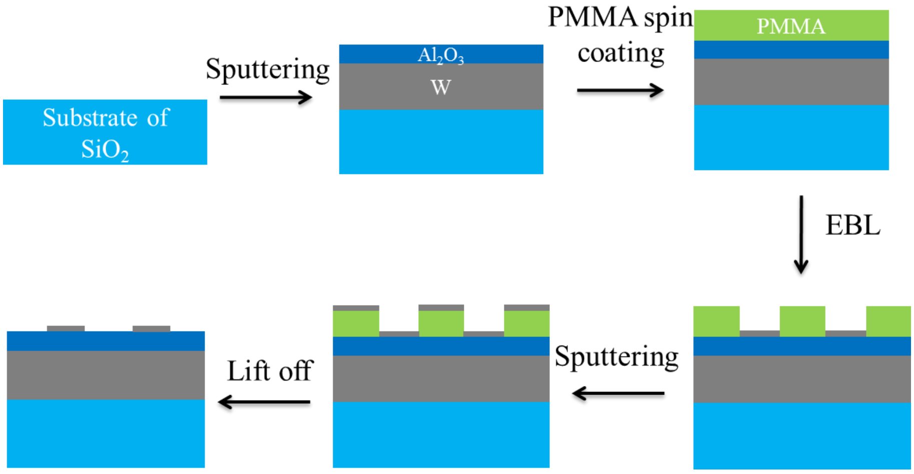

Figure S5. The procedure of the PMMA/W absorber fabrication. Firstly, a 130-nm-thick W film and 70-nm-thick Al_2O_3 film is deposited on glass substrate in a chamber of a high-vacuum sputtering system. Secondly, a 100-nm-thick PMMA is spun onto the Al_2O_3 film as electron beam (E-beam) resist and baked for 3 minutes. The nanodisk array is then defined by E-beam lithography (EBL) and developed in 1:3 methyl isobutyl ketone/isopropyl alcohol (IPA) solution. Finally, another 15-nm-thick W film is sputtered and the nanodisk array is obtained after lift-off by ultrasonic processing in acetone for 3 minutes.

6. Homemade reflection measurement setup.

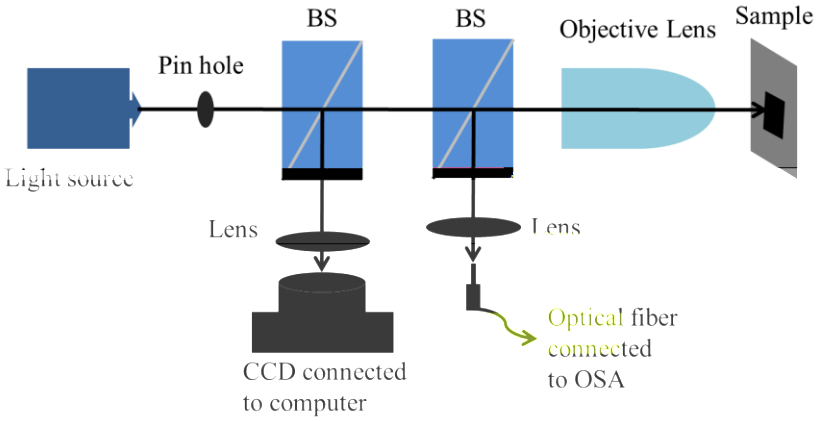

Figure S5. The reflection spectra are obtained by a homemade setup. The light first passes through a pinhole with a diameter of 100 μm and two beam splitters, then is focused by an objective lens (Mitutoyo, M Plan Apo NIR, 50×). When reaching the nanostructure, the light beam diameter is confined to 50 μm. The reflected light from the absorber, after being focused by another lens (f=45 mm), is collected by a multimode fiber (Thorlabs M31L03), which is connected to an optical spectrum analyzer (OSA, YOKOGAWA AQ-6315A/-6315B). A CCD are placed behind a lens collecting light reflected to observe the nanostructures. The reflectance spectrum is normalized by the reflectance of an aluminum film.