Supplementary Information:

Self-reference plasmonic sensors based on double Fano resonances

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In the experiment, the actual focal spot can be adjusted by the effective NA or by decreasing the incident light beam size. However, the mode splitting becomes not obvious because of the poorly focused spot. By using a small NA lens (such as a lens with a focal length of f=35 mm) to adjust the spot radius, two typical measured transmission spectra are displayed in Figure S1(a)(b). Figure S1(a) gives the transmission spectrum of the sample that is just located at the focus (radius of r=10 μm), and the mode splitting is not observed. Figure S1(b) gives the transmission spectrum of the sample behind the focus with the spot size of r=30 μm. It is observed that the right Fano resonance mode splits into two, but the mode splitting of the left Fano resonance is not obvious. As a result, the left Fano resonance (linewidth of $\Delta\lambda$=35 nm) in Figure S1(b) is not sharper than that (linewidth of $\Delta\lambda$=15 nm) in Fig. 2(d). Using a lens with focal length of f=100 mm, two typical measured transmission spectra are displayed in Figure S1(c)(d). The mode splitting is not observed anymore because of the poorly focused spot. The left Fano resonances (linewidth of $\Delta\lambda$=35 nm) in Figure S1(c)(d) are not sharper than that (linewidth of $\Delta\lambda$=15 nm) in Fig. 2(d). Hence, the adjustment of the actual focal size by effective NA cannot help us to obtain the shaper and high-contrast Fano resonance.

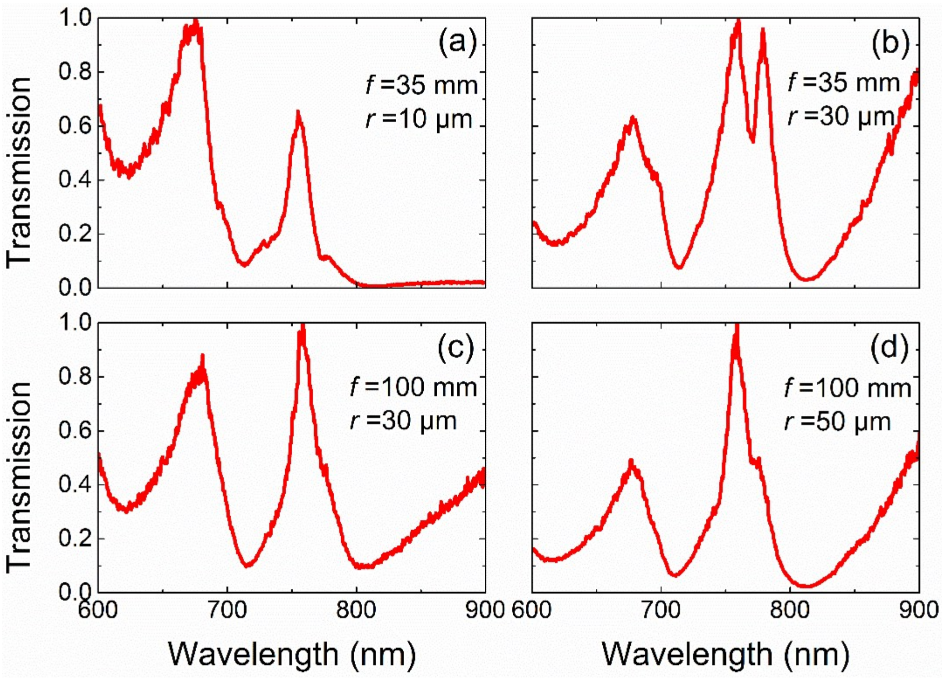

Figure S1. Transmission spectra with the illuminating spot size of (a) *r*=10 µm and (b) *r*=30 µm when the Gaussian beam that is focused by a lens with *f*=35 mm. Transmission spectra with the illuminating spot size of (c) *r*=30 µm and (d) *r*=50 µm when the Gaussian beam that is focused by a lens with *f*=100 mm.

By decreasing the incident light beam size, the radius of the focal spot after the objective (Mitutoyo 20×, NA=0.4) is increased to be about *r*=10 µm. The measured transmission spectra of the sample at the focus and behind the focus are displayed in Figure S2(a)(b). The mode splitting is nearly not observed for the left Fano resonance because of the poorly focused spot. As a result, the Fano profile is not sharp. Hence, the adjustment of the actual focal size by decreasing the incident light beam size cannot help us to achieve a better sensing performance either.

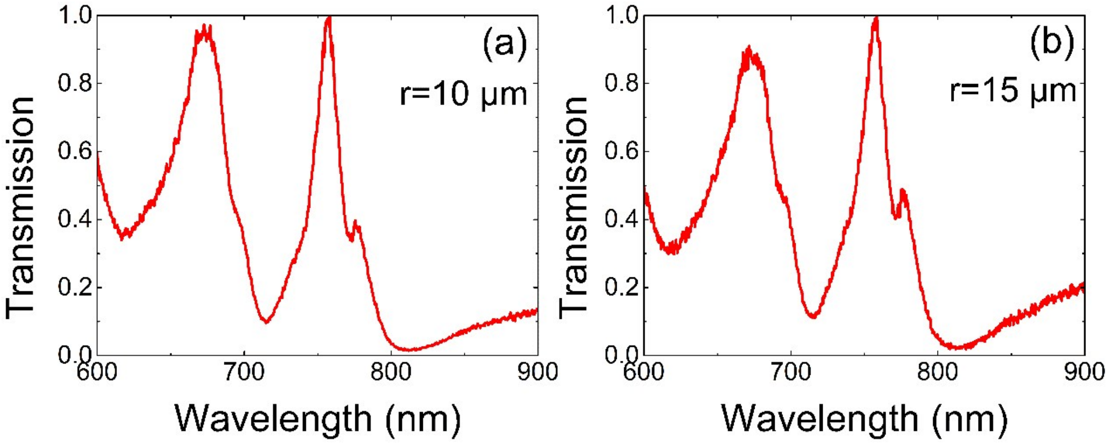

Figure S2. Transmission spectra of the gold grating with the illuminating spot size of (a) r=10 μm and (b) r=15 μm by decreasing the incident light beam size.

We also have measured the transmission spectra of the metallic slit array under the oblique incident light with different angles, and the results are displayed in Figure S3(a-e). The mode splitting can be observed, similar to the pervious works. [1-5] However, the sharp and high-contrast Fano profiles cannot be obtained simultaneously, which is different from the phenomenon in Fig. 2(d).

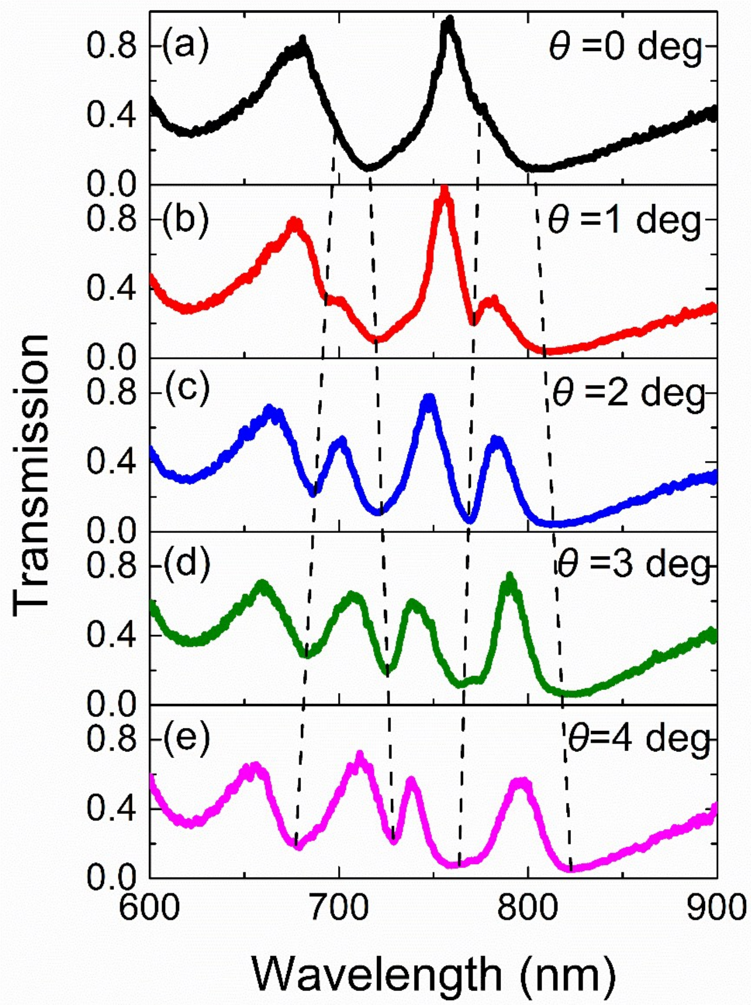

Figure S3. Measured transmission spectra when the sample is illuminated by the obliquely incident light with incident angle of (a) 0°, (b) 1°, (c) 2°, (d) 3°, and (e) 4°. The sample is located at the focus of the lens with *f*=100 mm.

In summary, by using the effective NA or decreasing the incident light beam size to adjust the actual focal spot, the focused spot becomes poor, and the mode splitting is nearly not observed for the left Fano resonance. Moreover, by using the oblique incident light, the sharp and high-contrast Fano profiles cannot be obtained simultaneously.

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