Supporting Information

for

Combinatorial Single Particle Spectro-microscopic Analysis of Plasmon Coupling of Gold Nanorods on Mirror

Seth L Filbrun[1], Teng-Xiang Huang[1], Fei Zhao[1], Kuangcai Chen[1,2], Bin Dong[1,3*], Ning Fang[1,4*]

1. Department of Chemistry, Georgia State University, Atlanta, Georgia 30303, United States.
2. Imaging Core Facility, Georgia State University, Atlanta, Georgia 30303, United States.
3. Department of Chemistry and Biochemistry, University of Arkansas Fayetteville, Fayetteville, Arkansas 72701, United States.
4. The MOE Key Laboratory of Spectrochemical Analysis & Instrumentation, State Key Laboratory of Physical Chemistry of Solid Surfaces, Innovation Laboratory for Sciences and Technologies of Energy Materials of Fujian Province (IKKEM), Xiamen Key Laboratory of Analytical Molecular Nanotechnology, College of Chemistry and Chemical Engineering, Xiamen University, Xiamen, Fujian, China, 361005.

*Corresponding author. Email: bind@uark.edu (B.D.); nfang@xmu.edu.cn (N.F.).

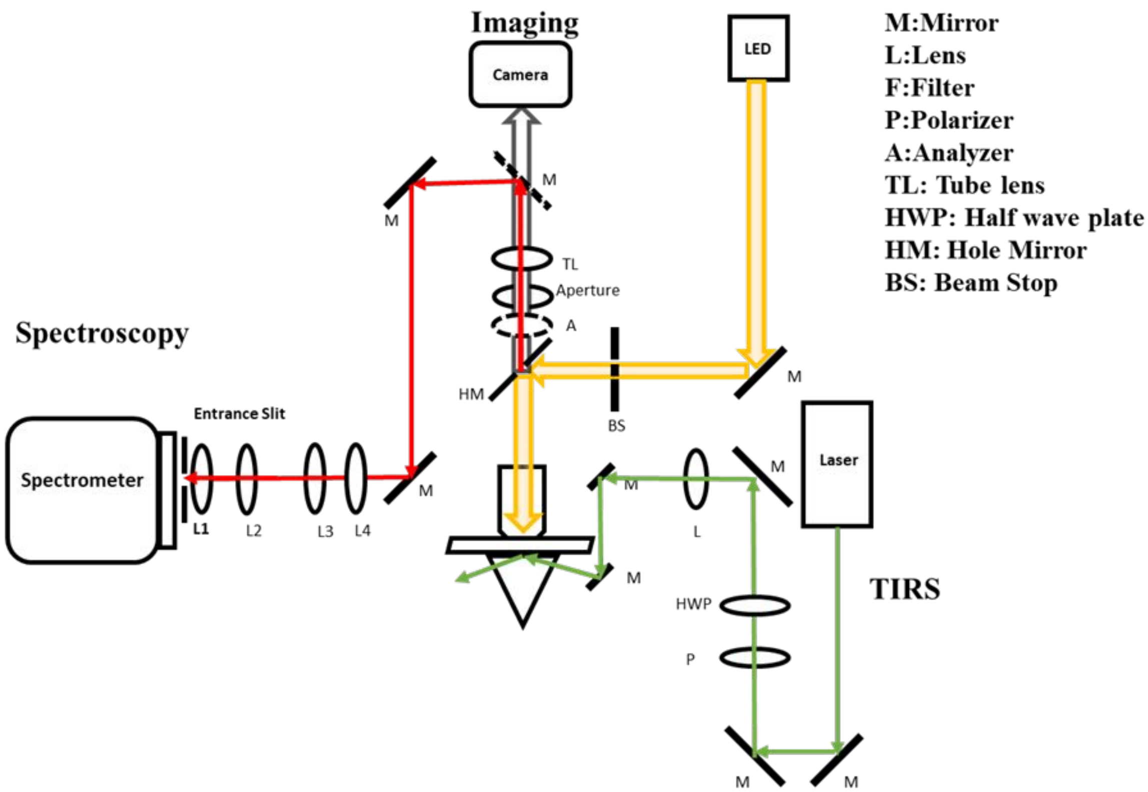

Figure S1. Detailed instrumental set up.

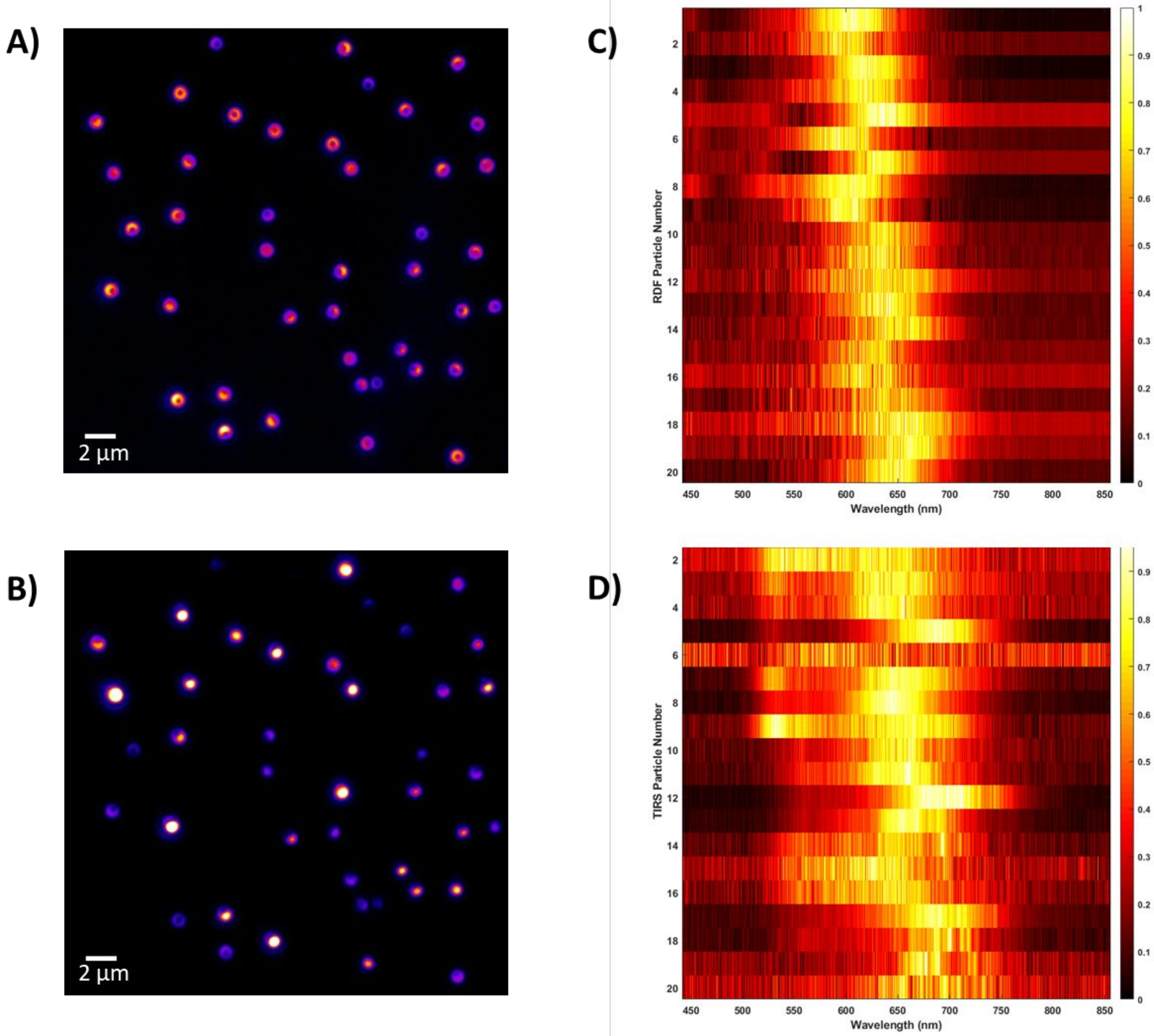

Figure S2. Scattering images and spectra from 20 single AuNRs on gold film under RDFS (A, C) and TIRS (B, D). Particle numbers in (C) and (D) correspond to the same particle for each illumination method. Each spectrum is normalized.

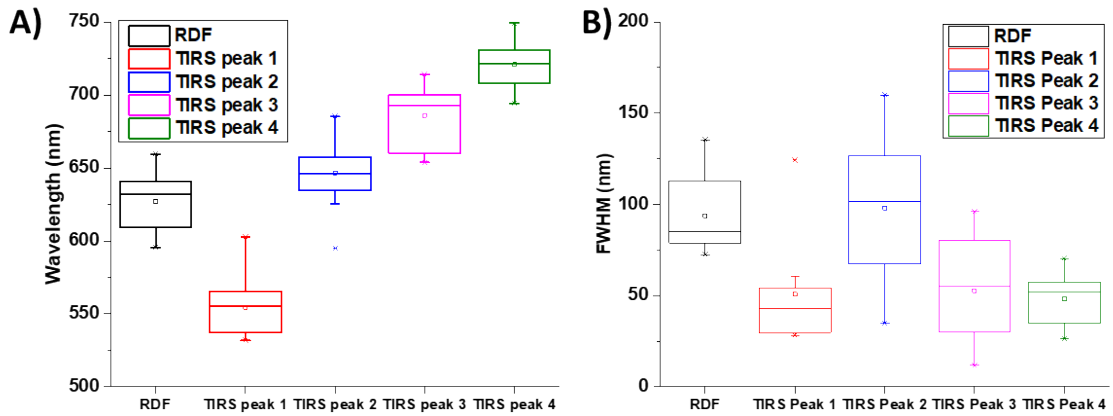

Figure S3. Statistics of Peak positions (A) and full width at half maximum (FWHM, B) from the Lorentzian fitting scattering spectra of many single AuNRs on gold film from RDFS and TIRS in Figure S2.

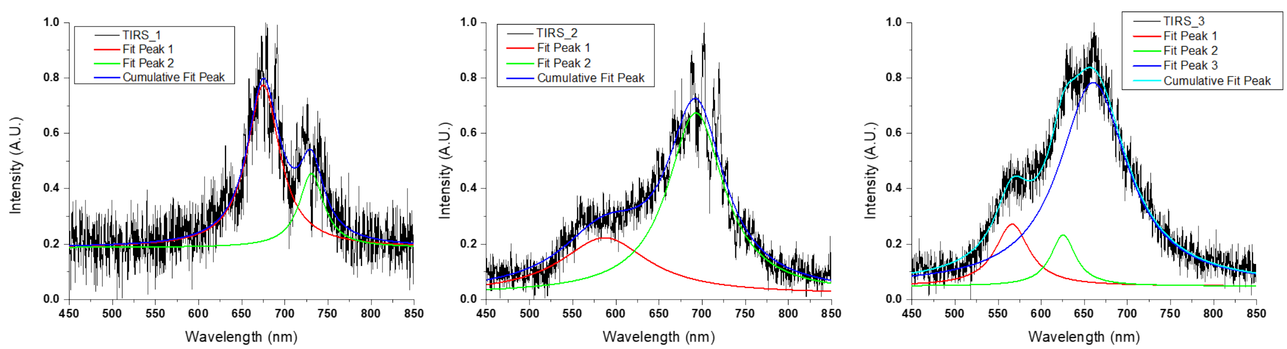

Figure S4. Raw TIRS scattering data and Lorentz peak fitting used in figure 3 in the main text. This data was collected at 5s integration time and fitted with a Lorentzian function using the multipeak fitting tool in Origin lab.

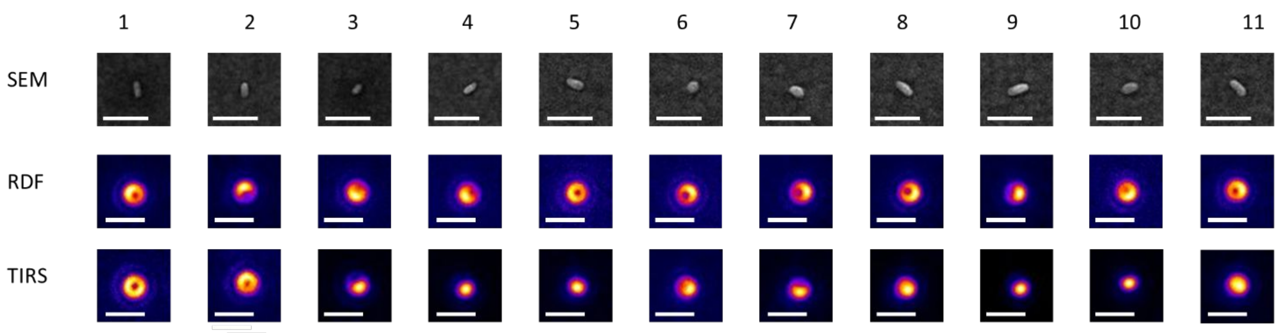

Figure S5. Scanning electron microscopy images correlated with scattering images from TIRS and RDFS of the same particles. Scale bars inset are (2 µm for the optical images and 500 nm for the SEM images)

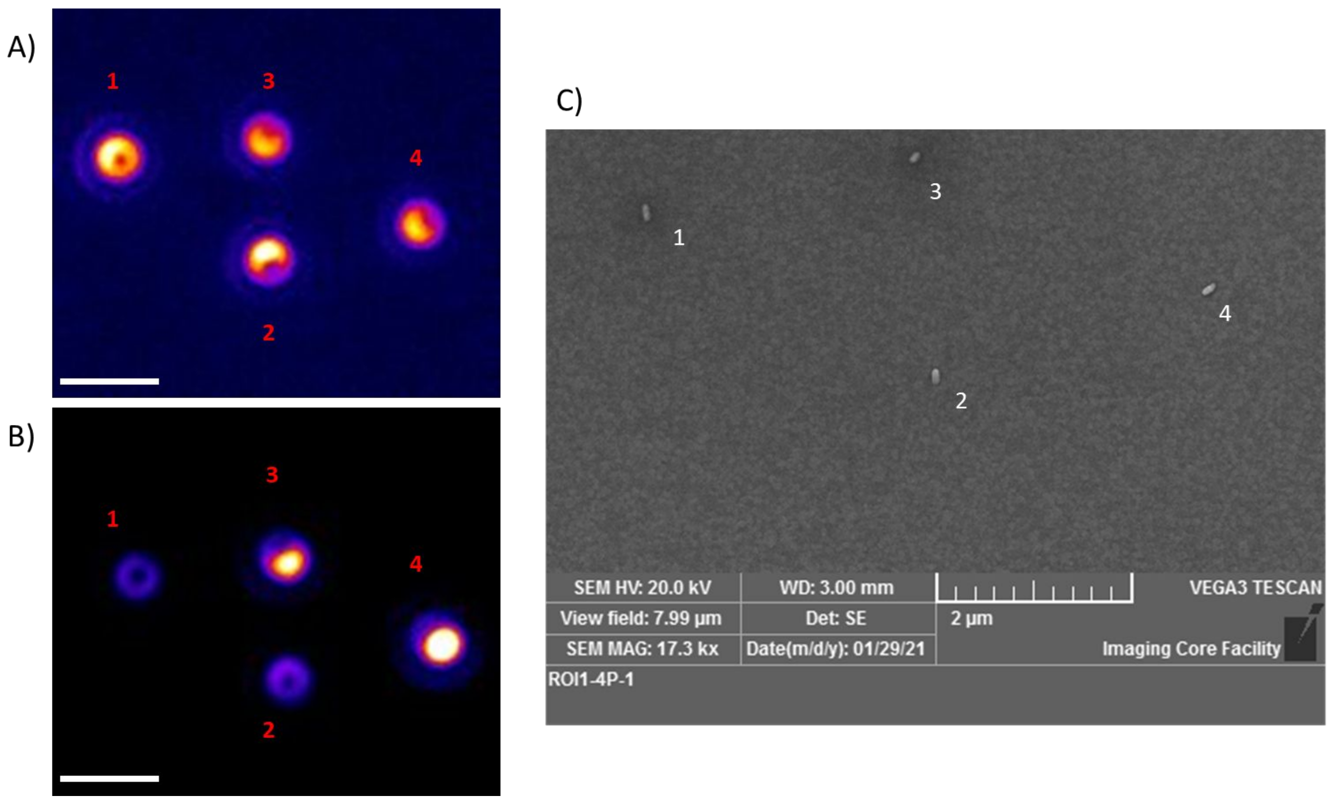

Figure S6. Correlated single particle images of gold nanorods (from figure 2) and their corresponding SEM. A) RDFS images of gold nanorods the numbering labels each induvial particle. B) TIRS images of the same particles in A showing different image patterns (scale bar 2 µm). C) SEM image of the same sample area with the particles labeled.

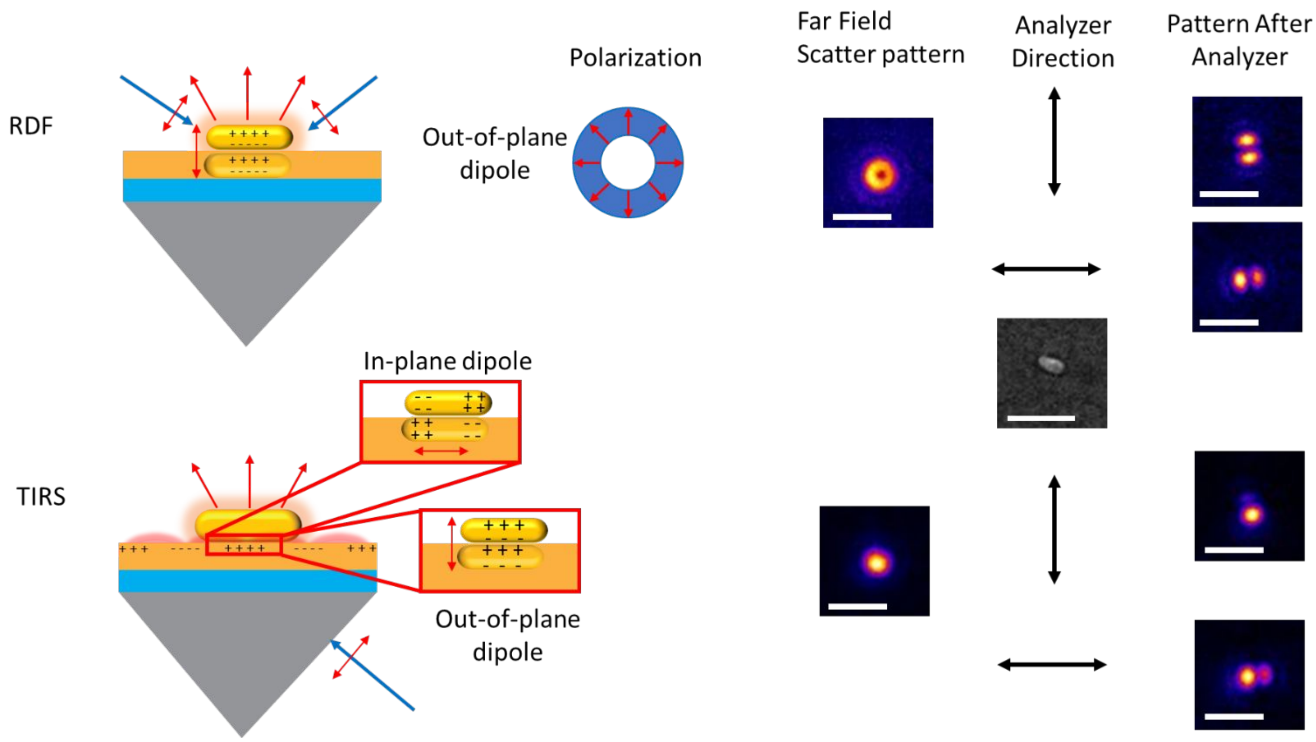

Figure S7. Scattering pattern as it relates to the dipole coupling. RDFS only has out of plane coupling and TIRS excites both in-plane and out-of-plane coupling. The analyzer separates out the in-plane and out-of-plane dipoles. Scale bars inset are (2 µm for the optical images and 500 nm for the SEM images)

Determine in-plane orientation of nanorods via optical imaging:

Throughout this data collection we have been using correlated scanning electron microscopy to determine the in-plane orientation; however, we found that when illuminating with TIRS the intensity changes with the analyzer angle change this is shown in figure 4 of the main text. When plotting the maximum intensity from the TIRS images against the analyzer angle we observe a sine shaped curve. The minimum of the curve correlates with the analyzer being parallel to the longitudinal axis of the gold nanorod; thus, this is used to determine the in-plane angle of the rod. The data is normalized by equation (1);

$$(I') = \frac{I - I_{min}}{I_{max} - I_{min}} \quad (1)$$

Where I' is the normalized intensity and I is the intensity taken from each image. **Figure S7** shows the normalized maximum intensity from each of the TIRS images, the analyzer was rotated clockwise with 10-degree increments, the corresponding SEM images from each of the particles are shown on the right side of the figure and the analyzer angle at 0 degrees is shown along with the TIRS excitation direction.

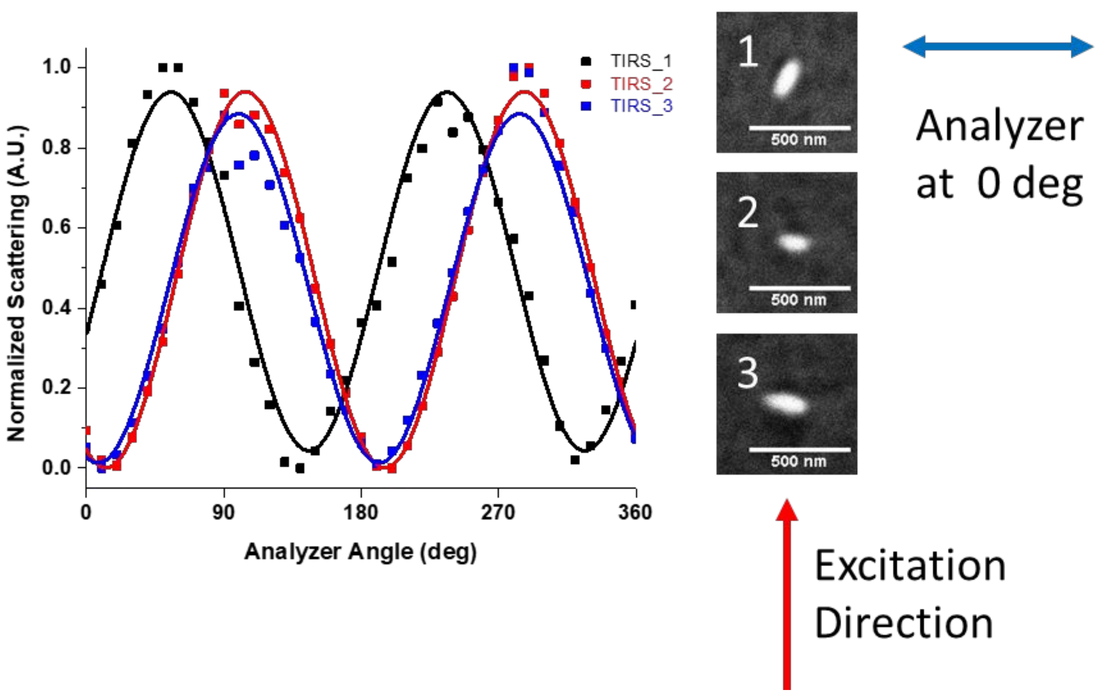

Figure S8. TIRS data for orientation determination. Maximum image intensity data recorded at each analyzer position and fitted with a sine squared function. The corresponding SEM images of the particles are displayed on the right. The TIRS excitation direction (relative to the SEM images) is shown on the bottom with the red arrow. The analyzer direction relative to the particles (in SEM image) is shown with the blue arrow and rotated clockwise in 10-degree increments.

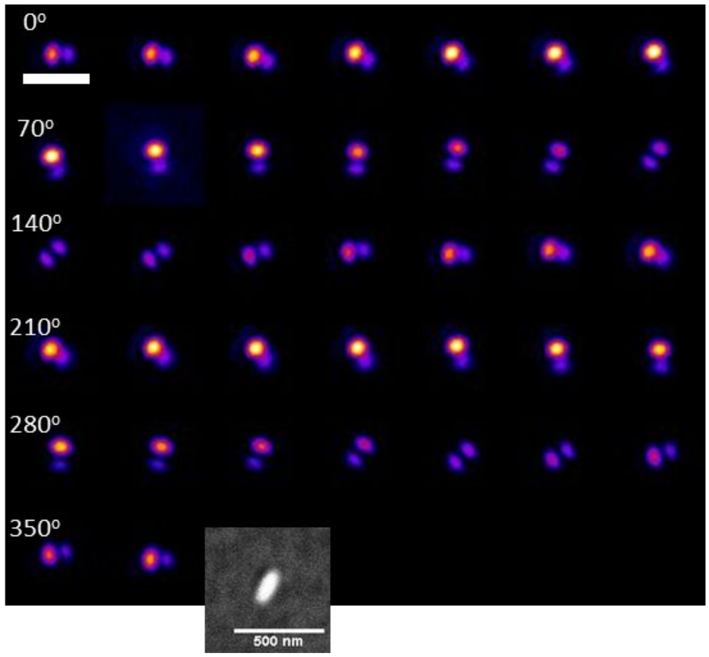

Figure S9. TIRS images from every 10 degrees of a 360-degree rotation of particle 1 from figure 5 and figure S7. SEM image for the particle is shown in the inset. Scale bars inset are (2 μm for the optical images and 500 nm for the SEM images)

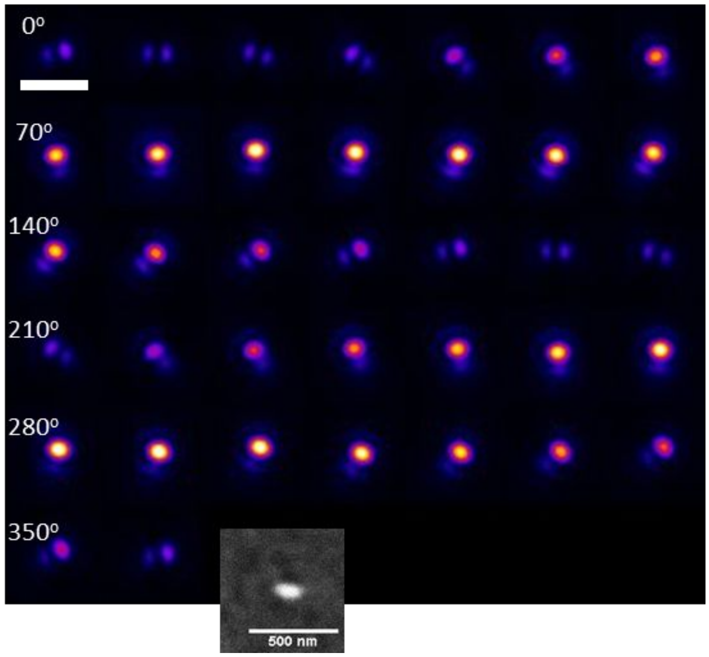

Figure S10. TIRS images from every 10 degrees of a 360-degree rotation of particle 2 from figure 5 and figure S7. SEM image for the particle is shown in the inset. Scale bars inset are (2 μm for the optical images and 500 nm for the SEM images)

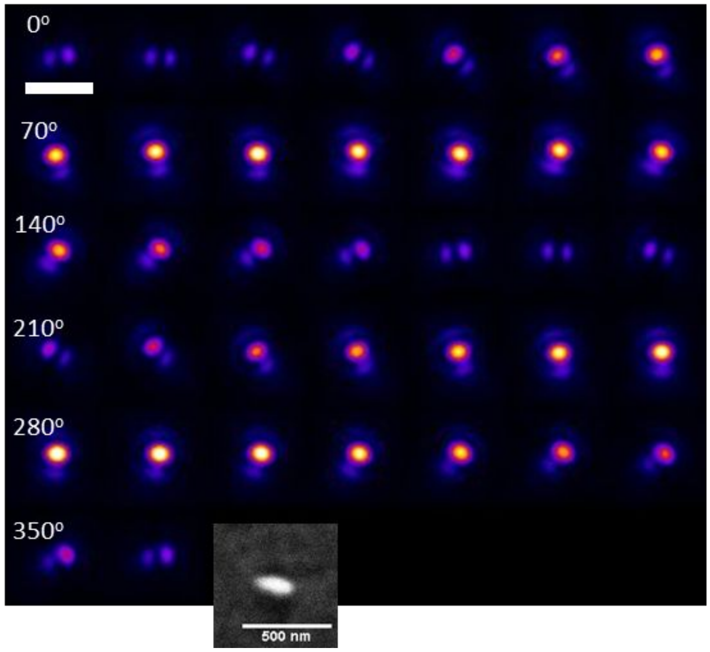

Figure S11. TIRS images from every 10 degrees of a 360-degree rotation of particle 3 from Figure 5 and Figure S7. SEM image for the particle is shown in the inset. Scale bars inset are (2 μm for the optical images and 500 nm for the SEM images).