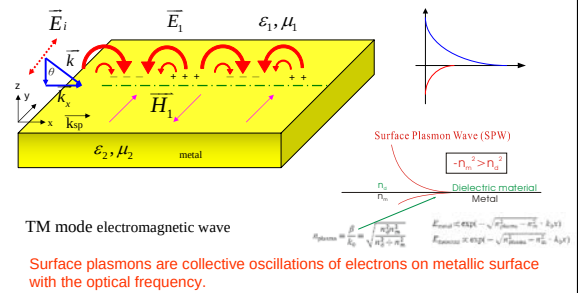
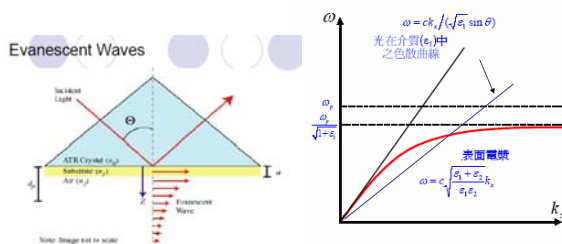


Sensitive Biosensing Using Surface Plasmons in metallic Nanostructures

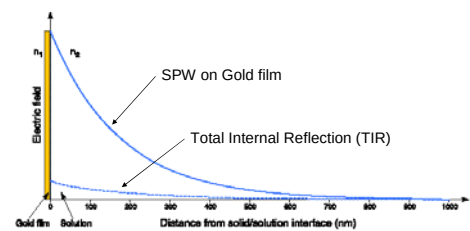
Surface plasmon



Surface plasmon Wave



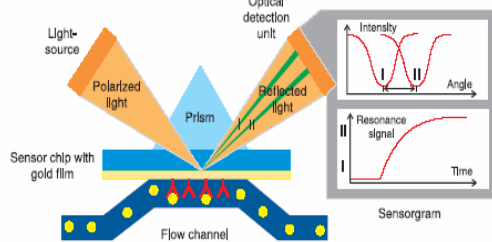
Advantage of using gold film



- Gold:** Non-magnetic, surface plasmon wave is p-polarized (TM) and due to its electromagnetic and surface propagating nature, creates enhanced evanescent wave

• Surface Plasmon Resonance for Sensitive Biosensing

BiaCore x



$$n_p \sin \theta = k_x = \omega / c \sqrt{\frac{\epsilon_1 \epsilon_2}{\epsilon_1 + \epsilon_2}} \sim k_0 \sqrt{\epsilon_2} = k_0 n_2$$

The dielectric constant of metal is negative and much larger than ϵ_2 .

Comparisons of SPR sensor

Theoretical sensitivity to variations in the refractive index of analyte and resolution of model SPR sensing structures: (a) prism-based system (BK7 glass – gold 50 nm thick – analyte with the refractive index of 1.32); (b) grating-based system (grating with the pitch and depth of 800 and 70 nm, respectively – gold – analyte with the refractive index of 1.32)*; optical constants of gold were taken from [16]

Detection approach	Angular interrogation		Wavelength interrogation		Intensity measurement	
Optical system used for excitation of SPW	Sensitivity (deg RIU ⁻¹) Resolution (RIU) [†]		Sensitivity (nm RIU ⁻¹) Resolution (RIU) [‡]		Sensitivity (% RIU ⁻¹) Resolution (RIU) [§]	
	$\lambda = 630$ nm	$\lambda = 850$ nm	$\lambda = 630$ nm	$\lambda = 850$ nm	$\lambda = 630$ nm	$\lambda = 850$ nm
Prism coupler-based SPR sensor	191 5×10^{-5}	97 1×10^{-4}	970 2×10^{-3}	13 800 1×10^{-4}	3900 5×10^{-3}	13 000 1×10^{-3}
Grating coupler-based SPR sensor	43 2×10^{-4}	39 2×10^{-4}	309 6×10^{-3}	630 3×10^{-3}	1100 2×10^{-4}	4400 5×10^{-3}

* The following SPR instrumentation accuracies were assumed:

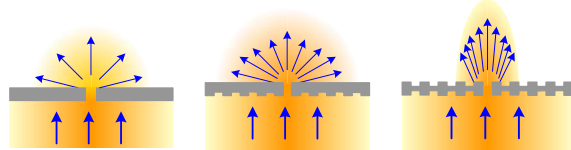
[†] 1×10^{-4} deg for angular resolution [10].

[‡] For wavelength interrogation, 0.02 nm [33].

[§] For the intensity measurement, 0.2% of the optical power [33].

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Extraordinary transmissions in nano metallic structures



Aperture diameter $< \lambda$
→ Output light wave is fully diffracted into a half-sphere

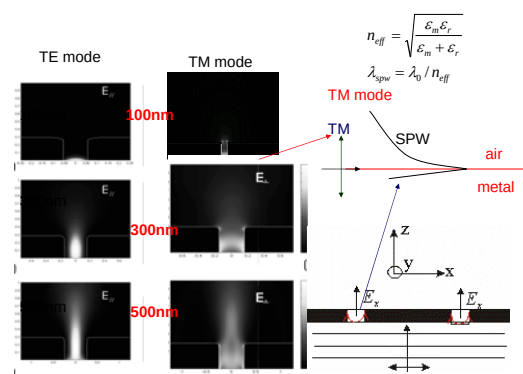
By patterning the input side with concentric periodic groove

→ The transmission is boosted at certain wavelengths.

By patterning both sides with concentric periodic groove

→ The transmission is boosted and focused

E. W. Ebbesen, 1998(Nature) E. W. Ebbesen, 2002 (Science)



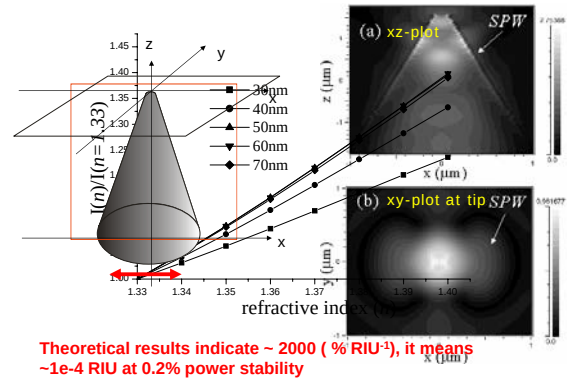
Surface Plasmons can be generated in a metallic nano gap!

Advantages of prism-based SPR system
high sensitivity, ~typically, 10^{-6} RIU by precise angle or wavelength measurement.

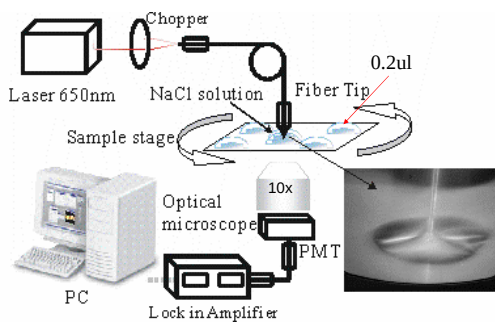
Disadvantages: Bulky, expensive, difficult for high-throughput detections and requires a large amount of sample solution.

Using plasmonic effect (SPR or LSR) in a metallic nano-gap. It has the advantages of
(1) High sensitivity
(2) Small sample volume
(3) High throughput

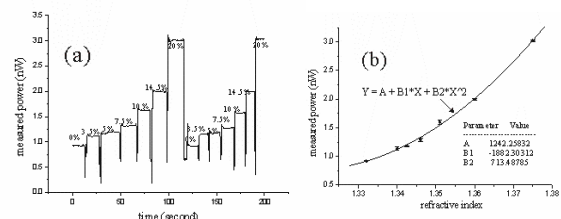
3D-FDTD simulation results



Experimental Setup



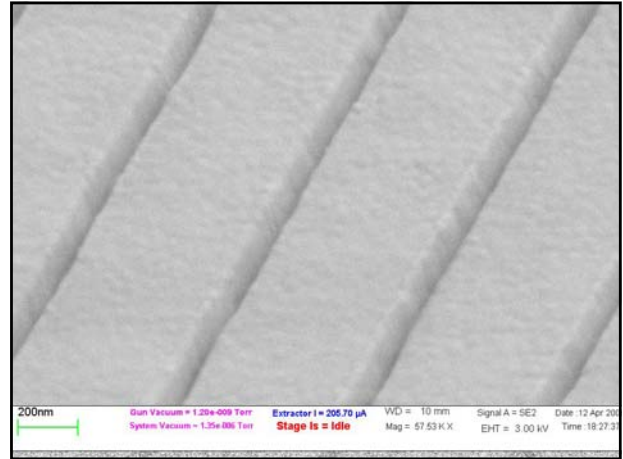
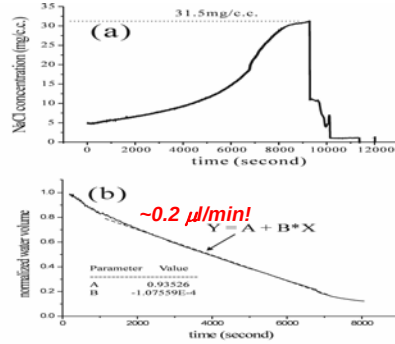
Sensitivity Measurement



Intensity Increase with salt water concentration. Good repetition of the measurement
The results indicate ~ 3704 ($\% \text{ RIU}^{-1}$), it means $\sim 5.4\text{e-}5$ RIU at 0.2% power stability

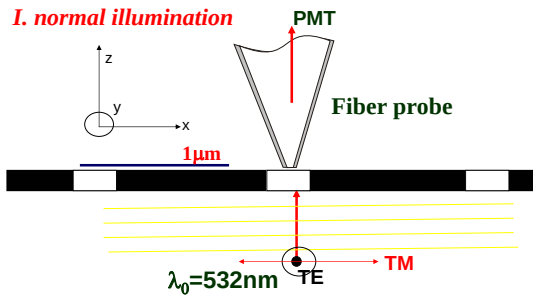
Evaporation rate measurement

Water evaporation in salt water

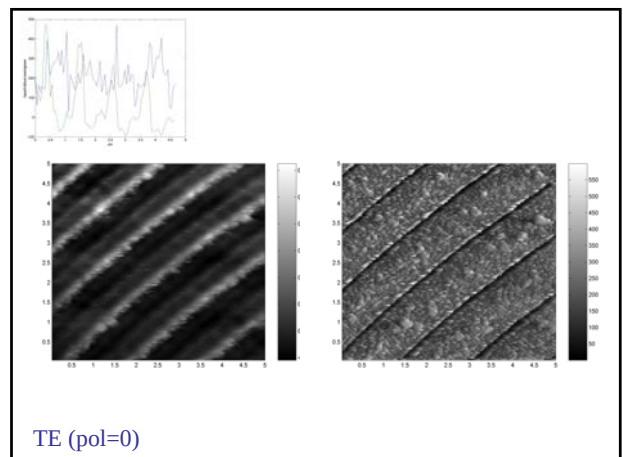


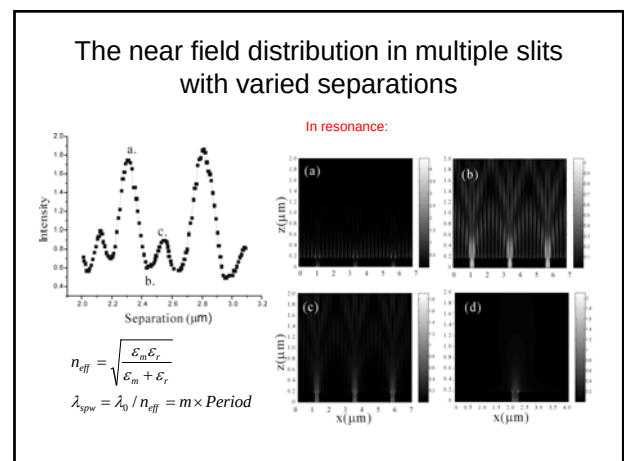
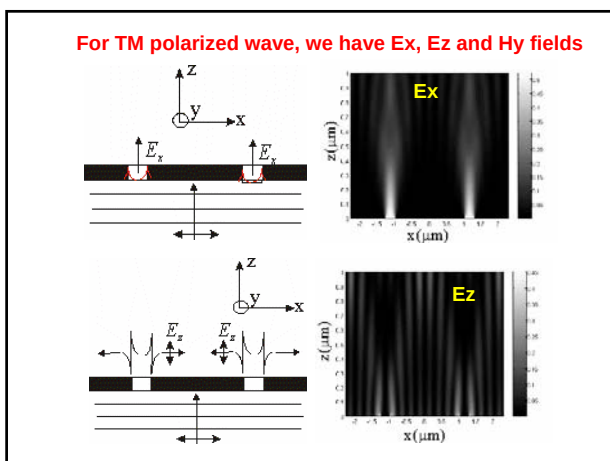
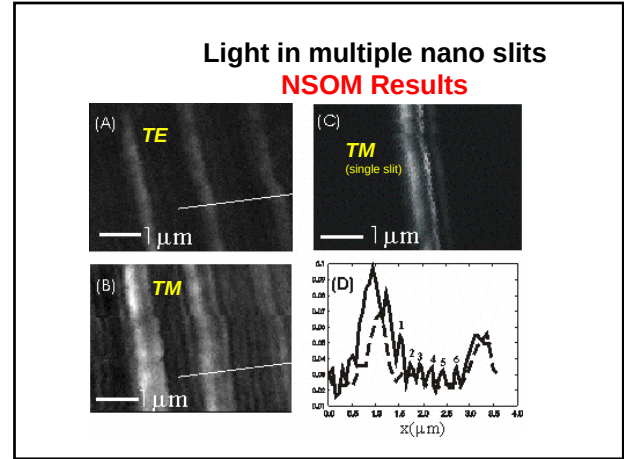
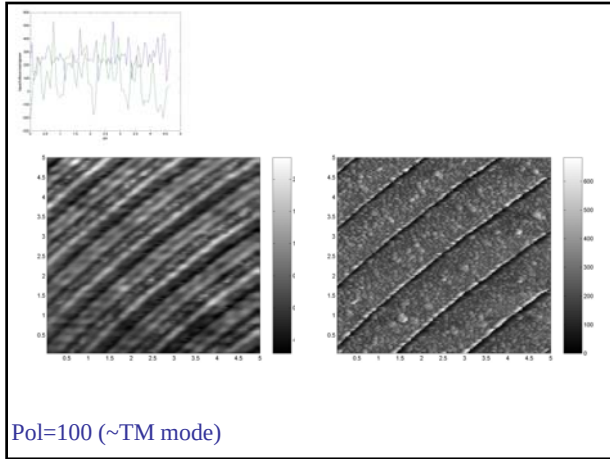
SNOM (or NSOM) in collection mode

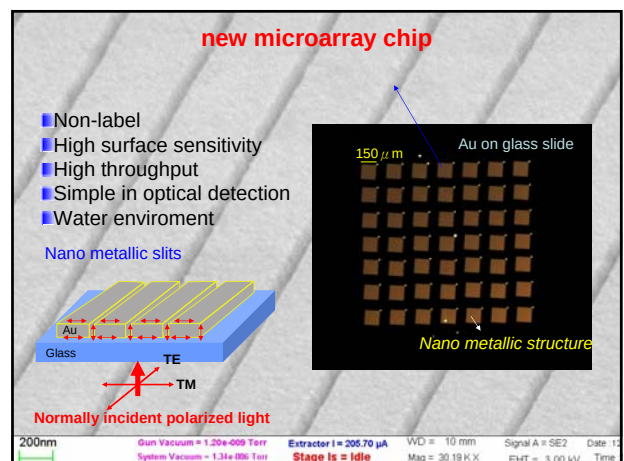
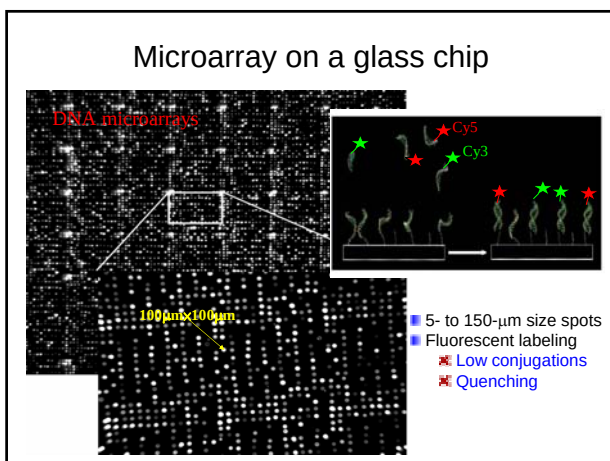
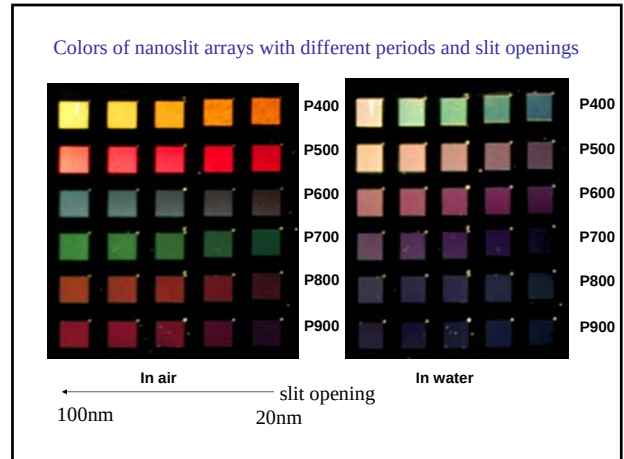
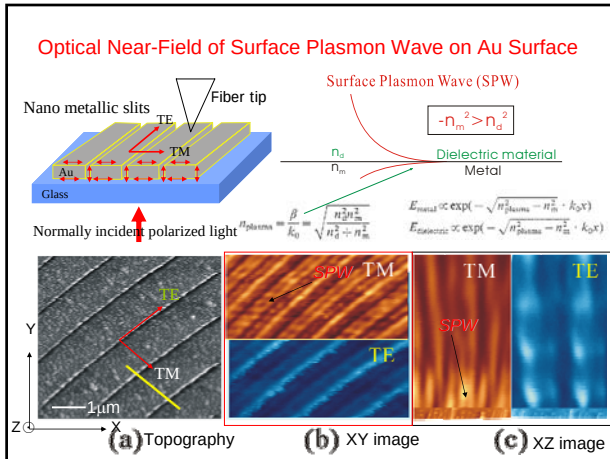
I. normal illumination

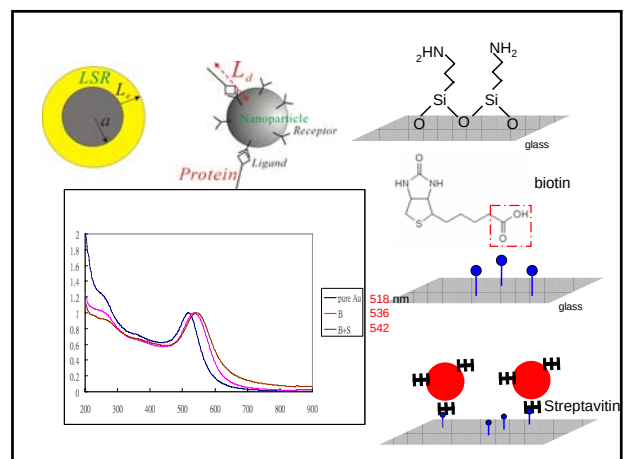
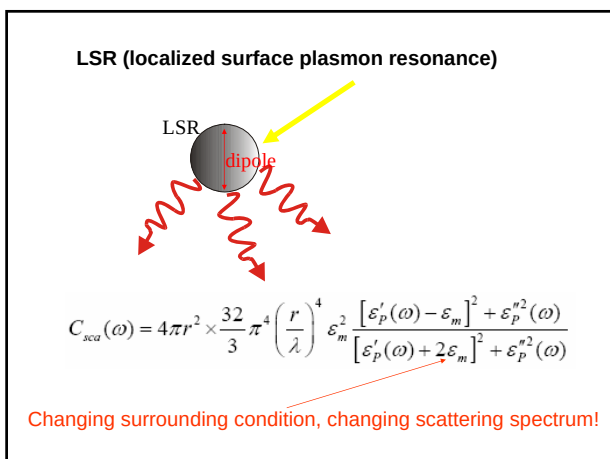
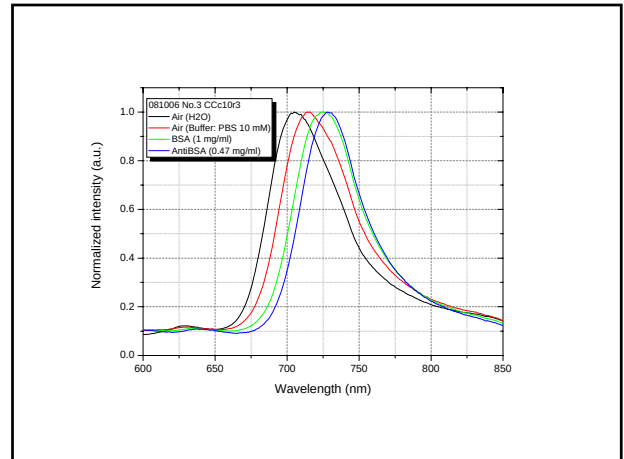
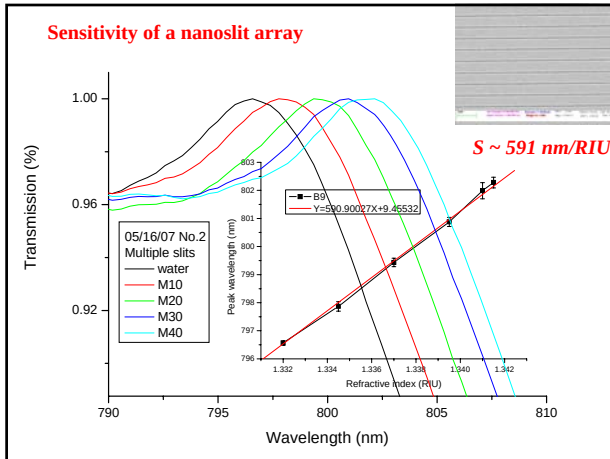


1. Tip/sample regulation by shear-force feedback method
2. Probe made by tapered fiber coated with metal

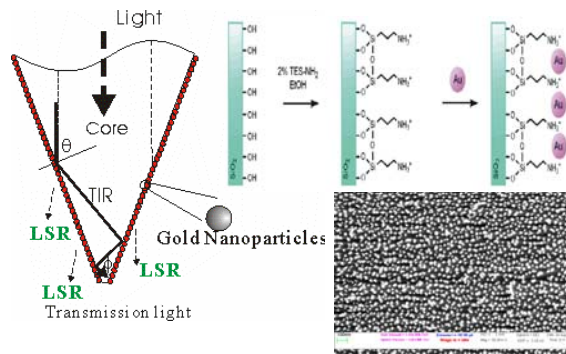




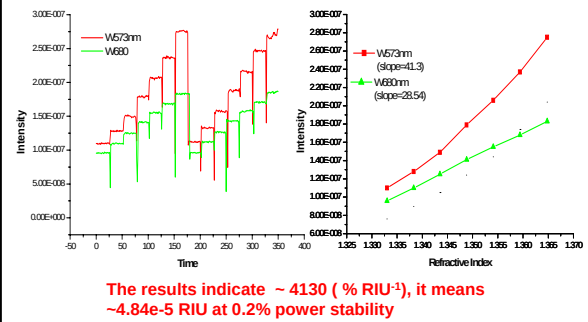




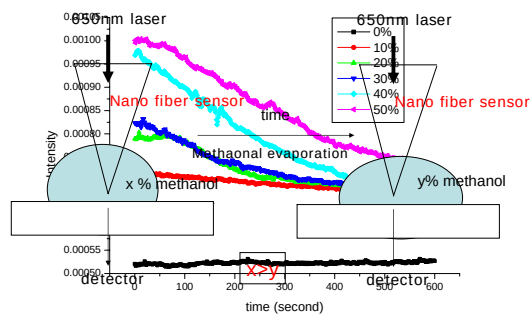
A nanotip with nano particles



Sensitivity Measurement

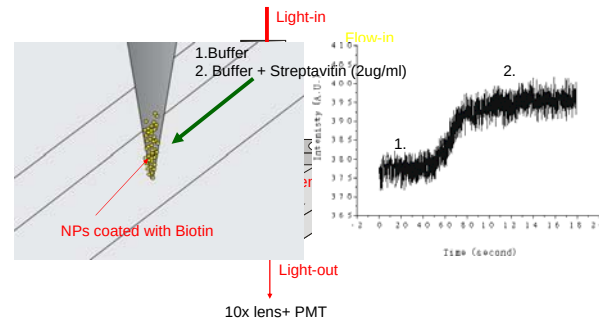


Methanol evaporation in methanol/water mixture



Applications

Dynamic measurement of bio-samples interactions



Conclusions

- Surface plasmons are generated in nanometer metallic gaps.
- Using plasmonic effect (SPR or LSR) in a metallic nano-gap. It has the advantages of
 - (1) High sensitivity
 - (2) Small sample volume
 - (3) High throughput