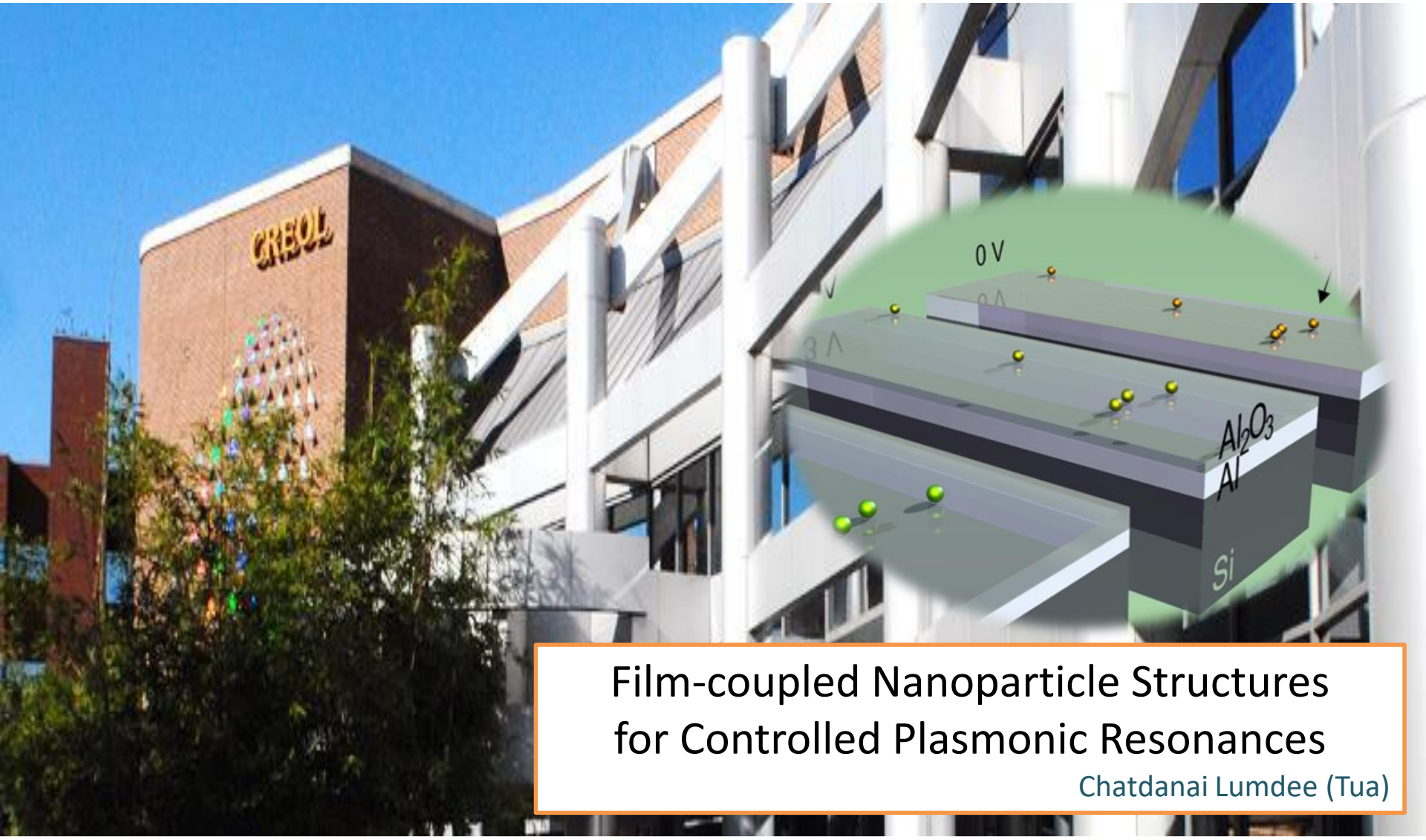
Graduate Research Symposium

12/12/2013



Film-coupled Nanoparticle Structures for Controlled Plasmonic Resonances

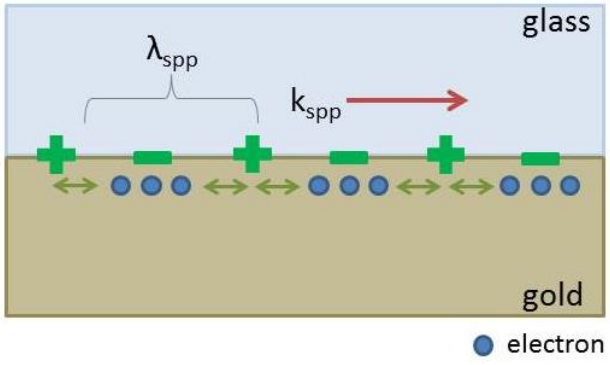
Chatdanai Lumdee (Tua)

Introduction

What is plasmon?

Plasmon is a collective movement of charges …

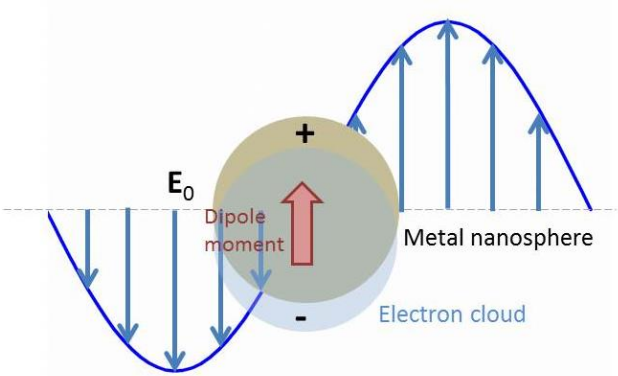
Surface Plasmon



Metal-dielectric interface

Confined in normal(z) direction

Localized Plasmon



Metal nanostructures

E-field enhancement around the nanostructure

Applications

Bio-sensing, photovoltaics, non-linear enhancement, beam shaping, plasmonic laser, etc.

Introduction

Localized Surface Plasmon Resonance (LSPR)

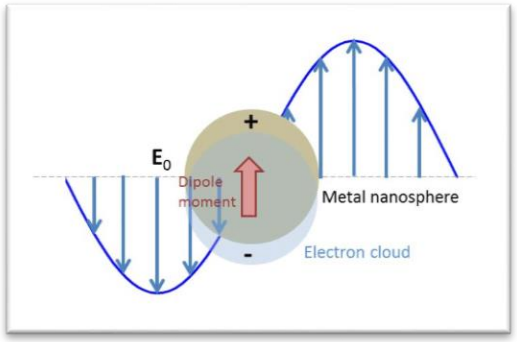
Provide a strong field enhancement in a very confined volume

→ Strong signal enhancement and sensitive to local environment

Why controlling resonance frequency?

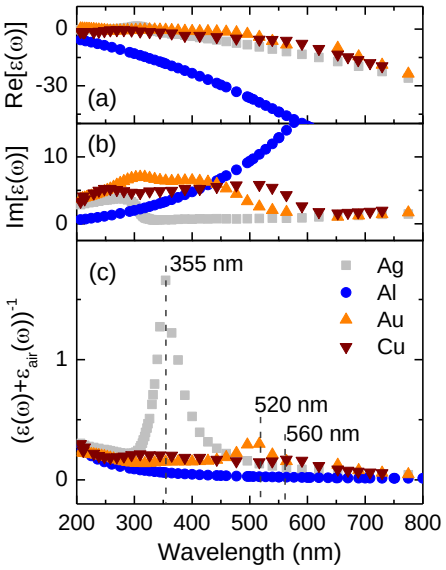
To match the applications, working conditions

How?

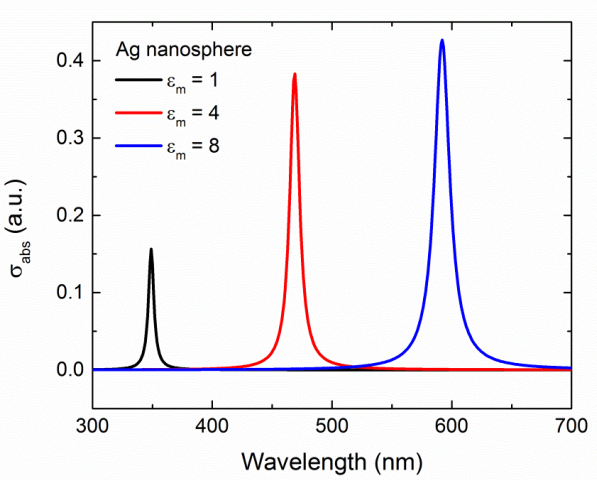


Particle's size, shape, …

Material - Particle



Material - Host



Introduction

Localized Surface Plasmon Resonance (LSPR)

Provide a strong field enhancement in a very confined volume

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Why controlling resonance frequency?

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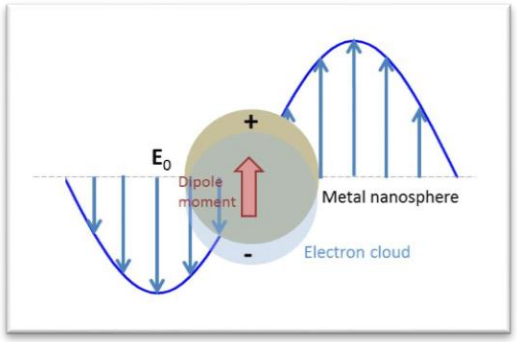
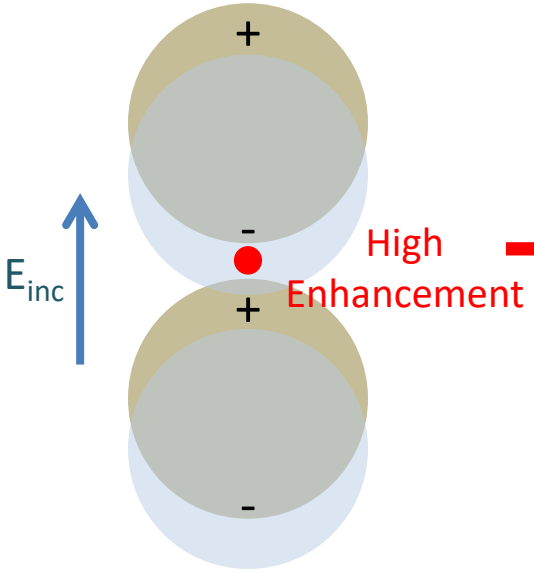


Material - Particle

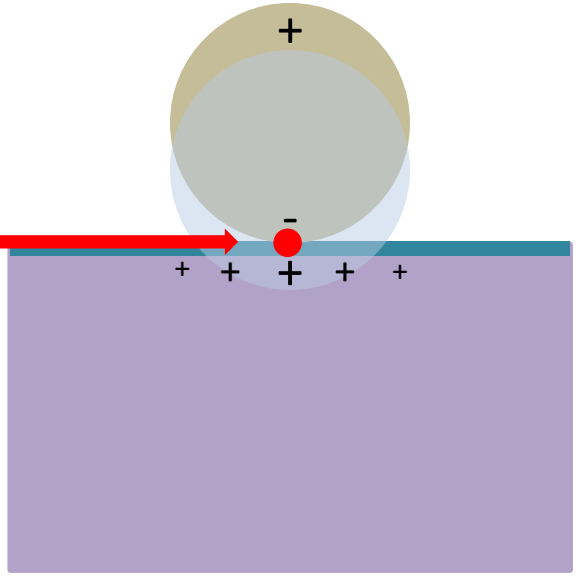
Material - Host

Particle's size, shape, …

Couple with another particle



Couple with a substrate

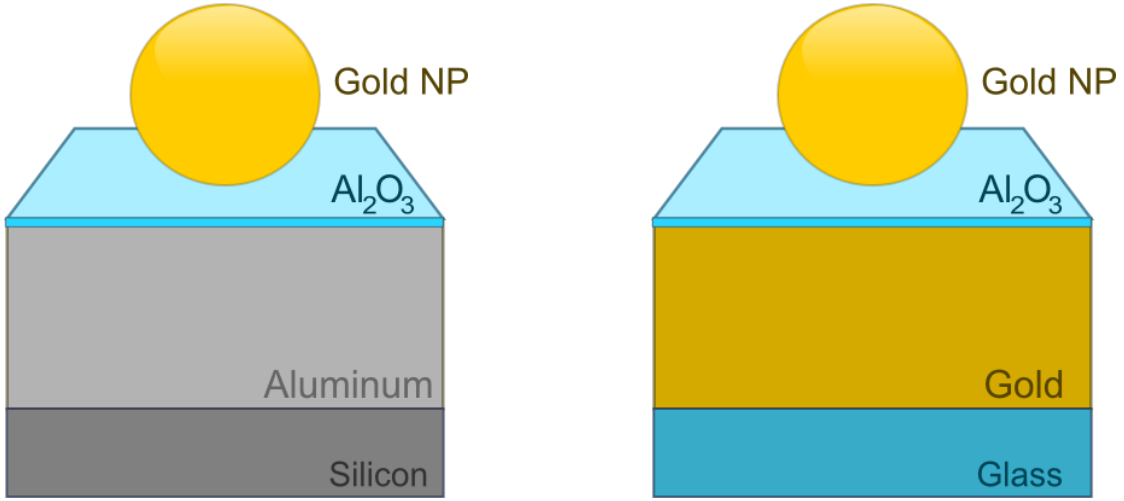


Film-coupled nanoparticles

Two film-coupled nanoparticle systems

Gold nanoparticles on an oxidized aluminum — Lumdee et al., ACS Nano 6, 6301 (2012)

Gold nanoparticles on Al_2O_3 coated gold films — Lumdee et al., J. Phys. Chem. C 117, 19127 (2013)



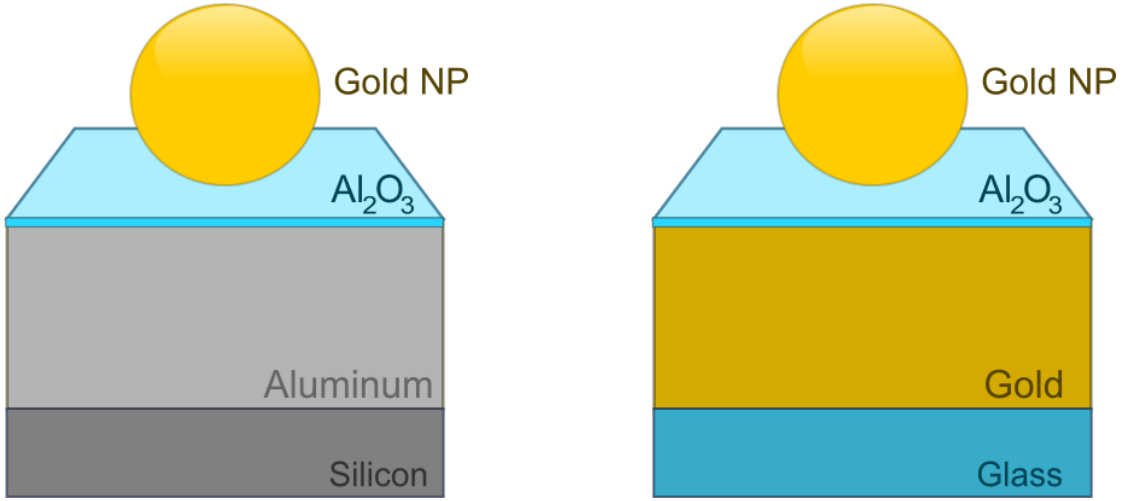
Film-coupled nanoparticles

Why gold nanospheres and Al_2O_3?

Gold nanoparticles on an oxidized aluminum — Lumdee et al., ACS Nano 6, 6301 (2012)

Gold nanoparticles on Al_2O_3 coated gold films — Lumdee et al., J. Phys. Chem. C 117, 19127 (2013)

Gold nanosphere and Al_2O_3 are thermally and chemically stable



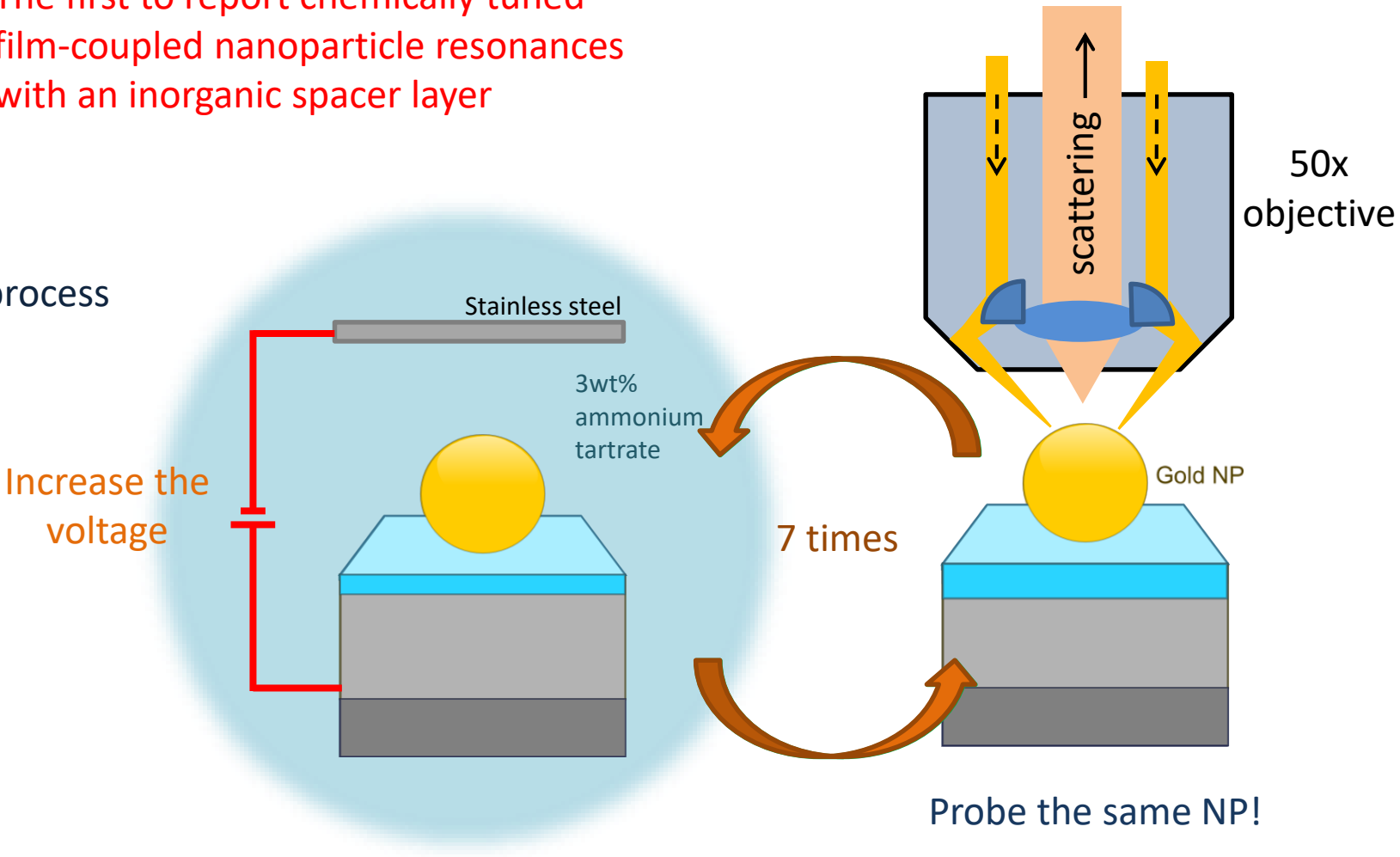
Film-coupled nanoparticles

Gold nanoparticles on an oxidized aluminum

Lumdee et al., ACS Nano 6, 6301 (2012)

The first to report chemically tuned film-coupled nanoparticle resonances with an inorganic spacer layer

The process

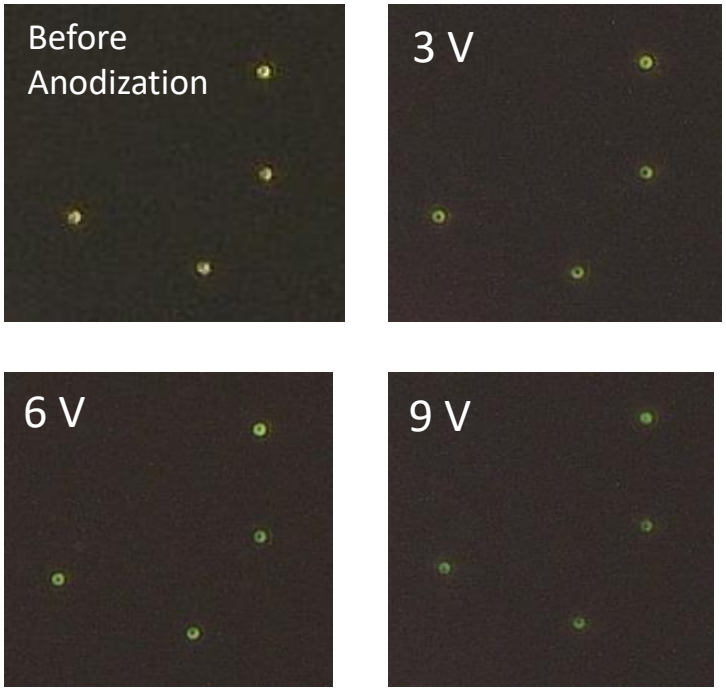


Film-coupled nanoparticles

Gold nanoparticles on an oxidized aluminum

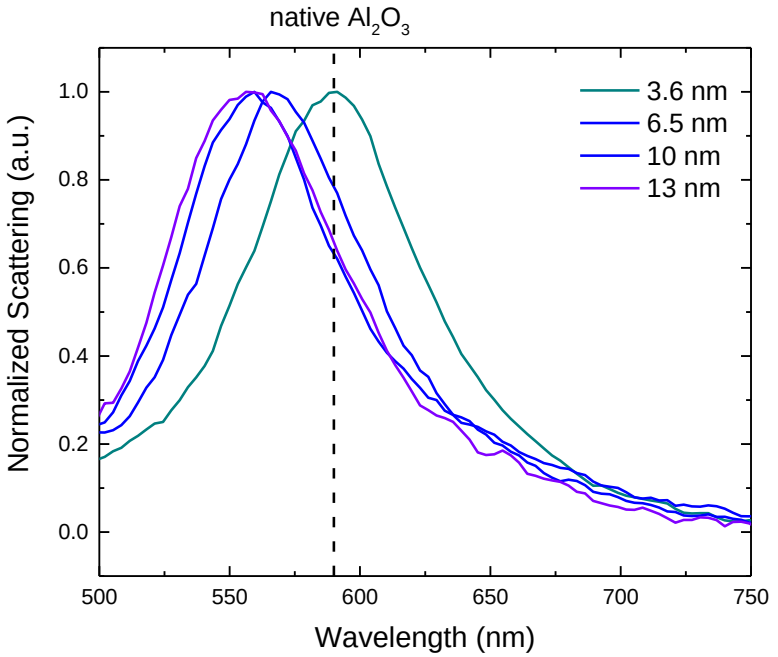
Lumdee et al., ACS Nano 6, 6301 (2012)

Microscopy images



Ring-shaped scattering?

Scattering spectra



Good: NP-to-NP resonance control

Not quite: small tuning range (585-550 nm)

Problem: the native oxide

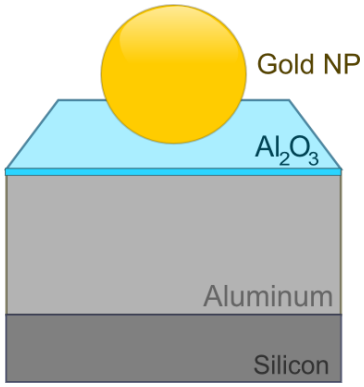
Film-coupled nanoparticles

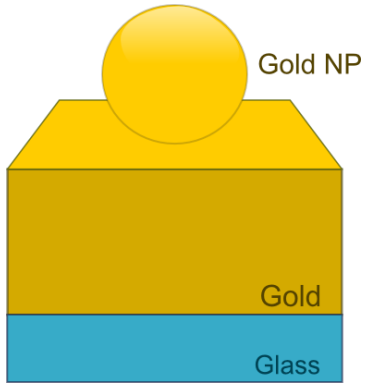
Gold nanoparticles on Al_2O_3 coated gold films

Lumdee et al., J. Phys. Chem. C 117, 19127 (2013)

Why a gold film is better than aluminum?

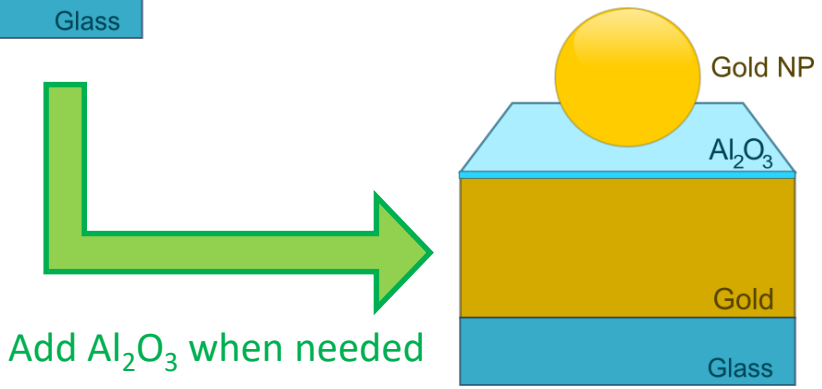
→ No native oxide





Getting the NP closer to the film

→ Larger tuning range



Film-coupled nanoparticles

Gold nanoparticles on Al_2O_3 coated gold films

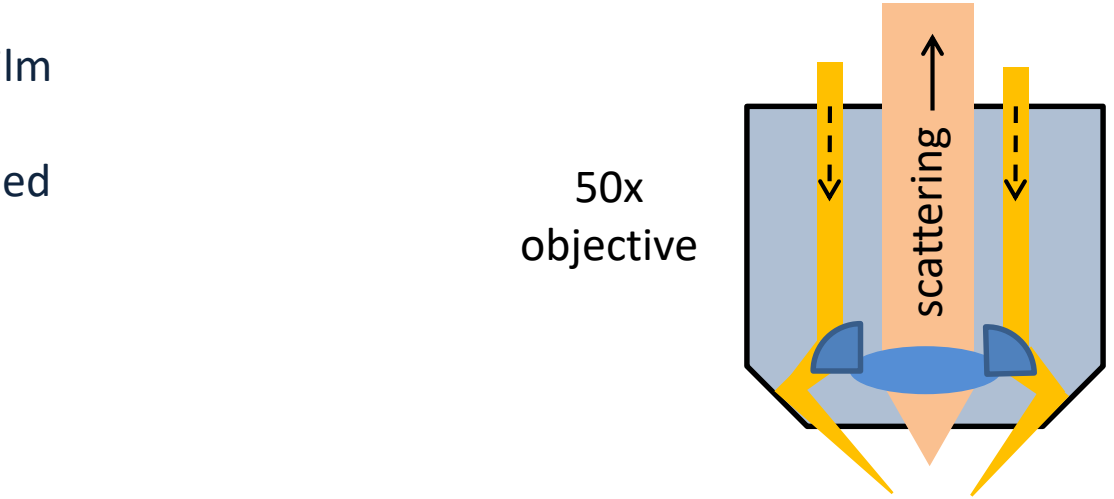
Lumdee et al., J. Phys. Chem. C 117, 19127 (2013)

Getting the NP closer to the film

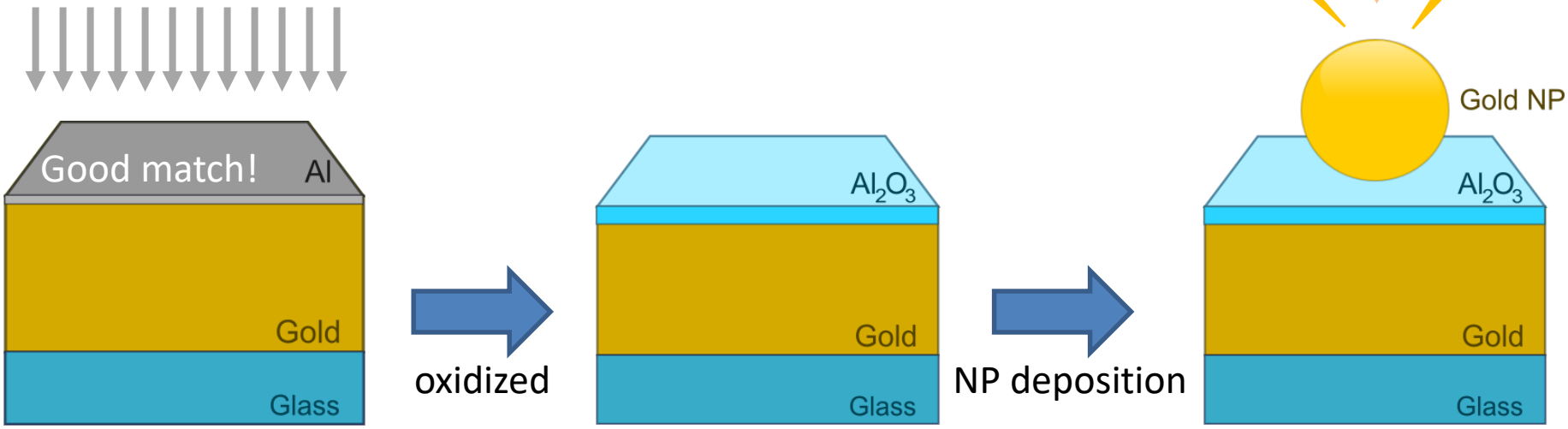
→ Larger tuning range

→ Add Al_2O_3 when needed

50x objective



The process



Catch: now the tuning is not on the same NP!

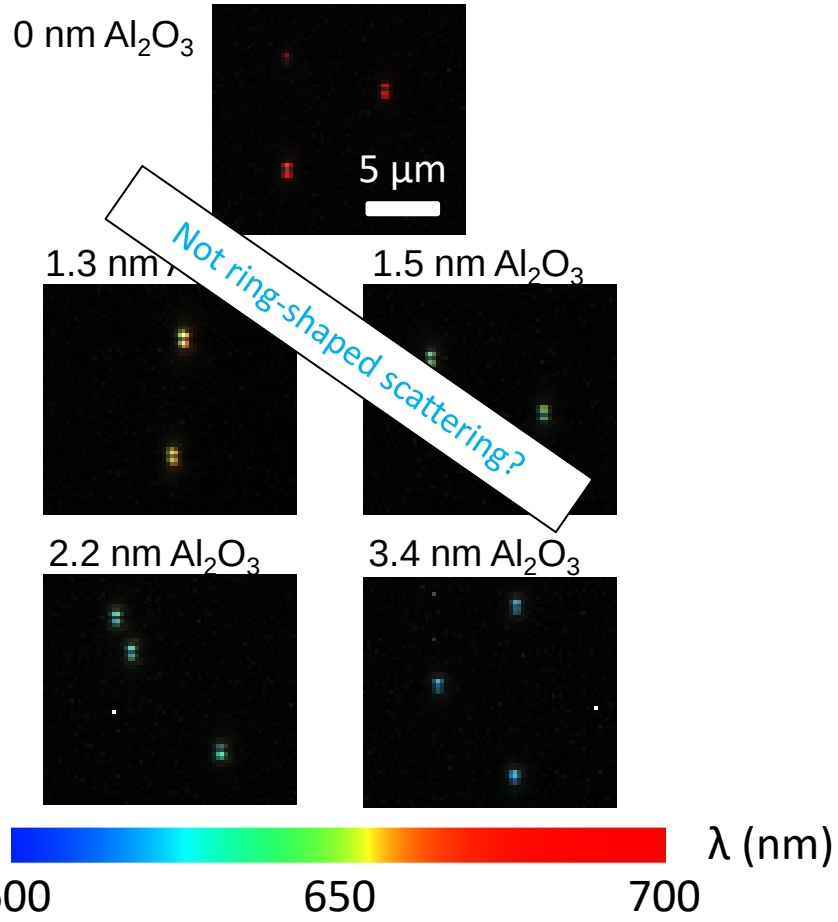
Film-coupled nanoparticles

Gold nanoparticles on Al_2O_3 coated gold films

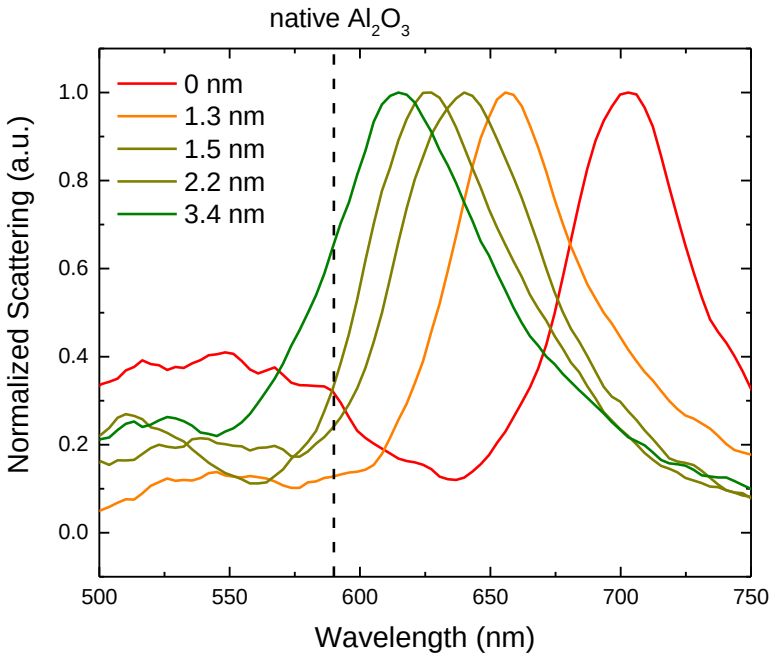
Lumdee et al., J. Phys. Chem. C 117, 19127 (2013)

Microscopy images

HSi-440C Hyperspectral Imaging (Gooch & Housego)



Scattering spectra



Good: Improve tuning range (690-610 nm)

But not NP-to-NP tuning

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Two film-coupled nanoparticle systems

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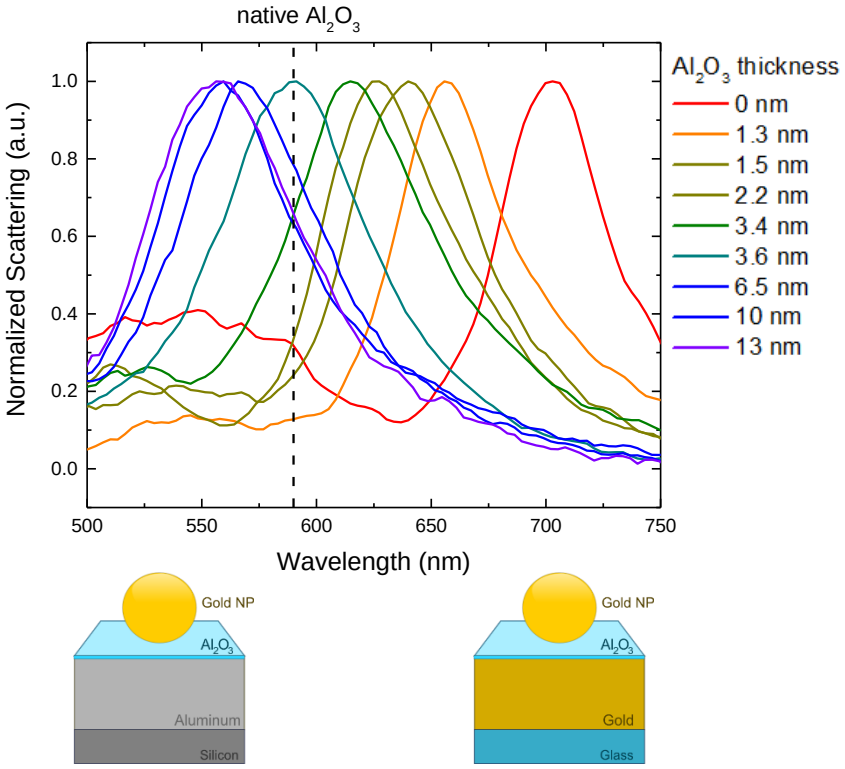
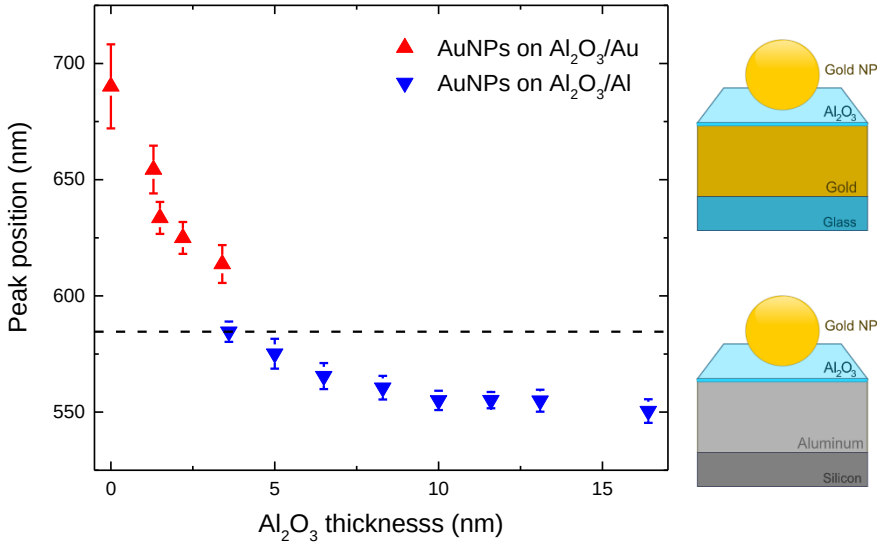




Total tuning range of 140 nm
(690-550 nm = far red to green)

Laser irradiation

Gold nanoparticles on Al_2O_3 coated gold films

Lumdee et al., J. Phys. Chem. C 117, 19127 (2013)

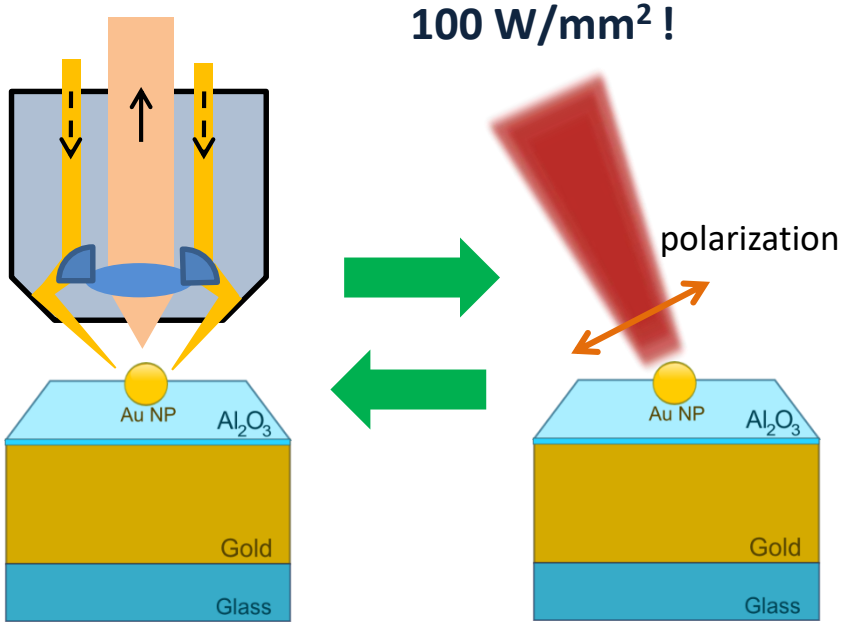
Gold and Al_2O_3 = chemically stable and thermally stable?

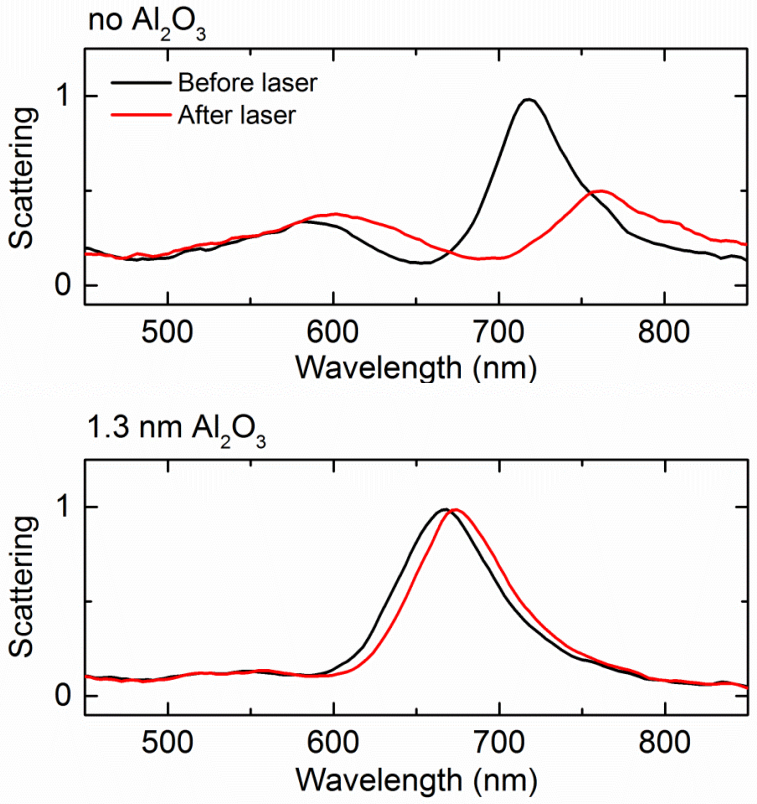
for bio-sensing,
compare with other works using organic spacer layers

To check

Indirect verification!

100 W/mm² !





Summary

Localized surface plasmon resonances of metal nanostructures

→ provide confined and high field enhancement

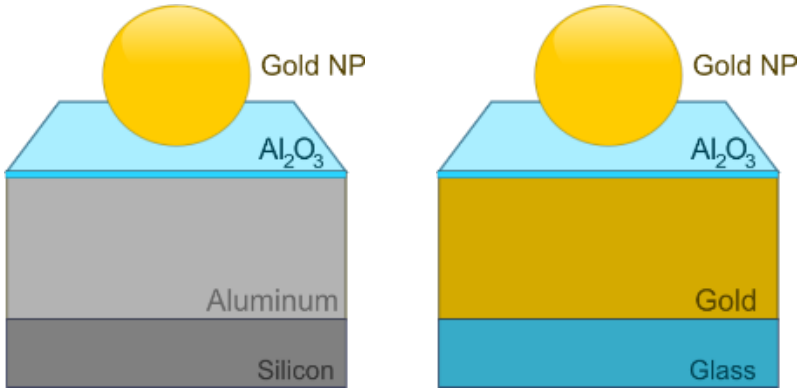
Applications

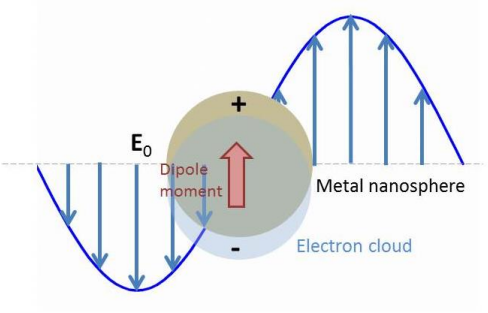
Bio-sensing, photovoltaics, non-linear enhancement, beam shaping, plasmonic laser, etc.

Film-coupled nanoparticle structure

An easy way to control plasmon resonances of nanoparticles (140 nm tuning)

Inorganic spacer layer helps improve stability under laser irradiation





Questions, comments, suggestions? ☺