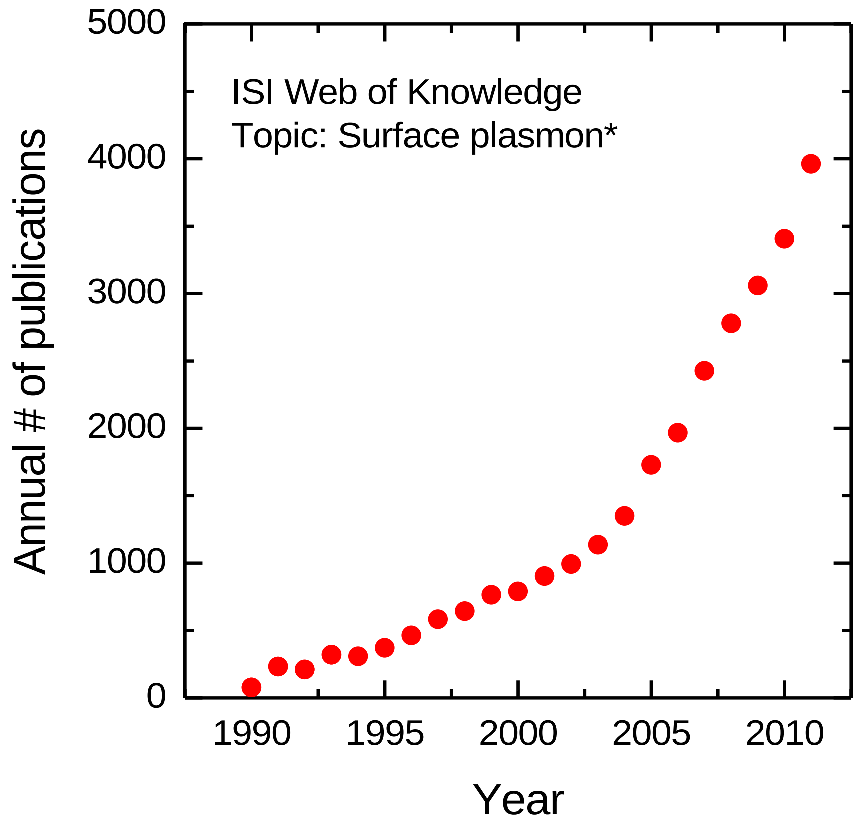
Kristján Leósson/Science Institute/University of Iceland

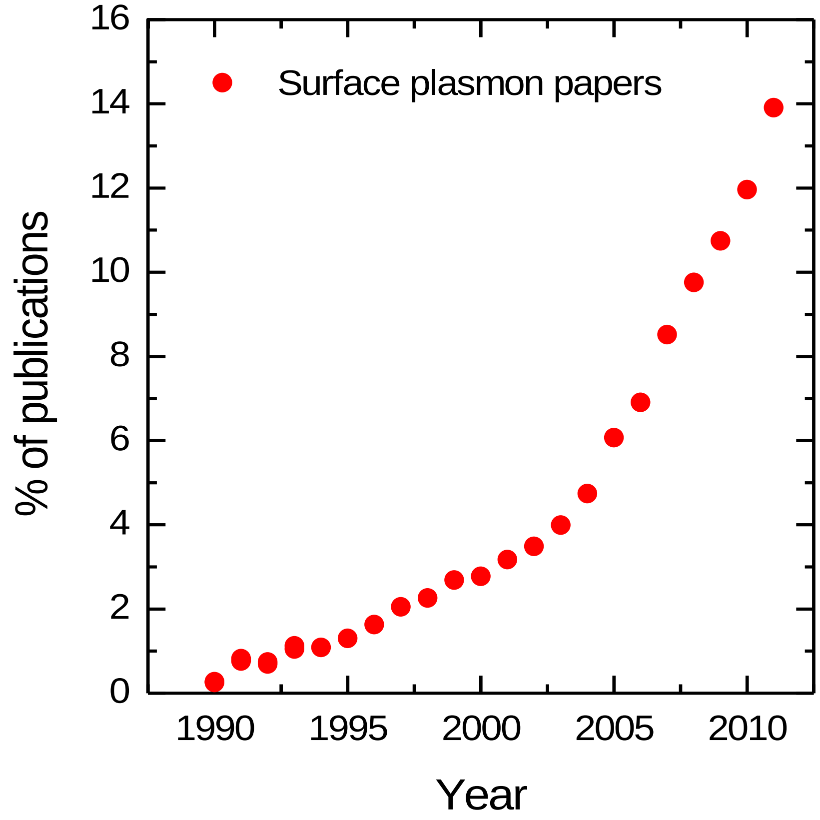
ADVANCES ON NANOPHOTONICS IV – Erice Sicily 2012

Realization of Plasmonic Devices

BIO

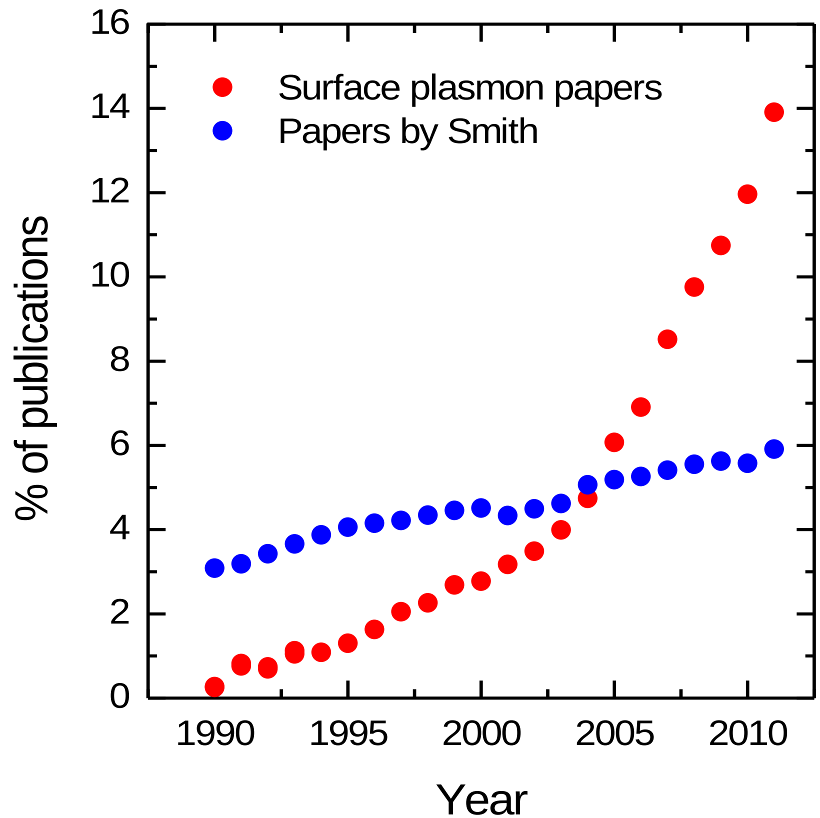
1994	B.Sc. Engineering Physics, Canada
1996	M.Sc. Physics, Iceland/France/Germany
2002	Ph.D. Electrical Engineering, Denmark
2001	Co-founded MMP A/S
2004	Co-founded Lumiscence A/S
2005-	Senior Research Scientist University of Iceland

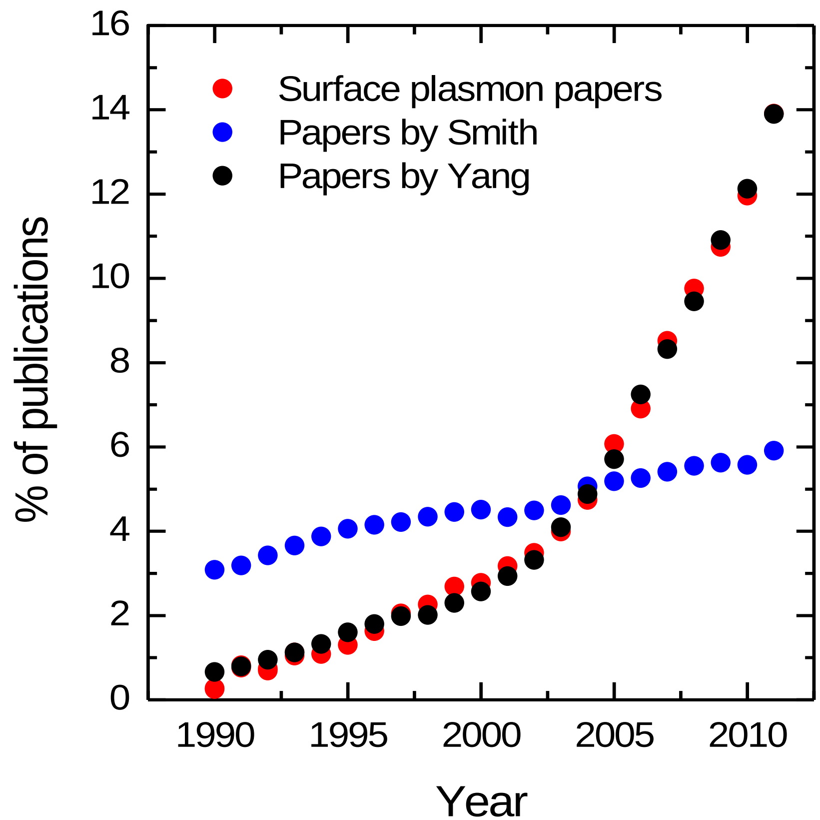

ISI Web of Knowledge
Topic: Surface plasmon*
Annual # of publications
0
1000
2000
3000
4000
5000
1990
1995
2000
2005
2010
Year



Surface plasmon papers
% of publications
0
2
4
6
8
10
12
14
16
1990
1995
2000
2005
2010
Year


SIGILLUM


Surface plasmon papers
Papers by Smith
% of publications
Year
0
2
4
6
8
10
12
14
16
1990
1995
2000
2005
2010



Surface plasmon papers
Papers by Smith
Papers by Yang
% of publications
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6
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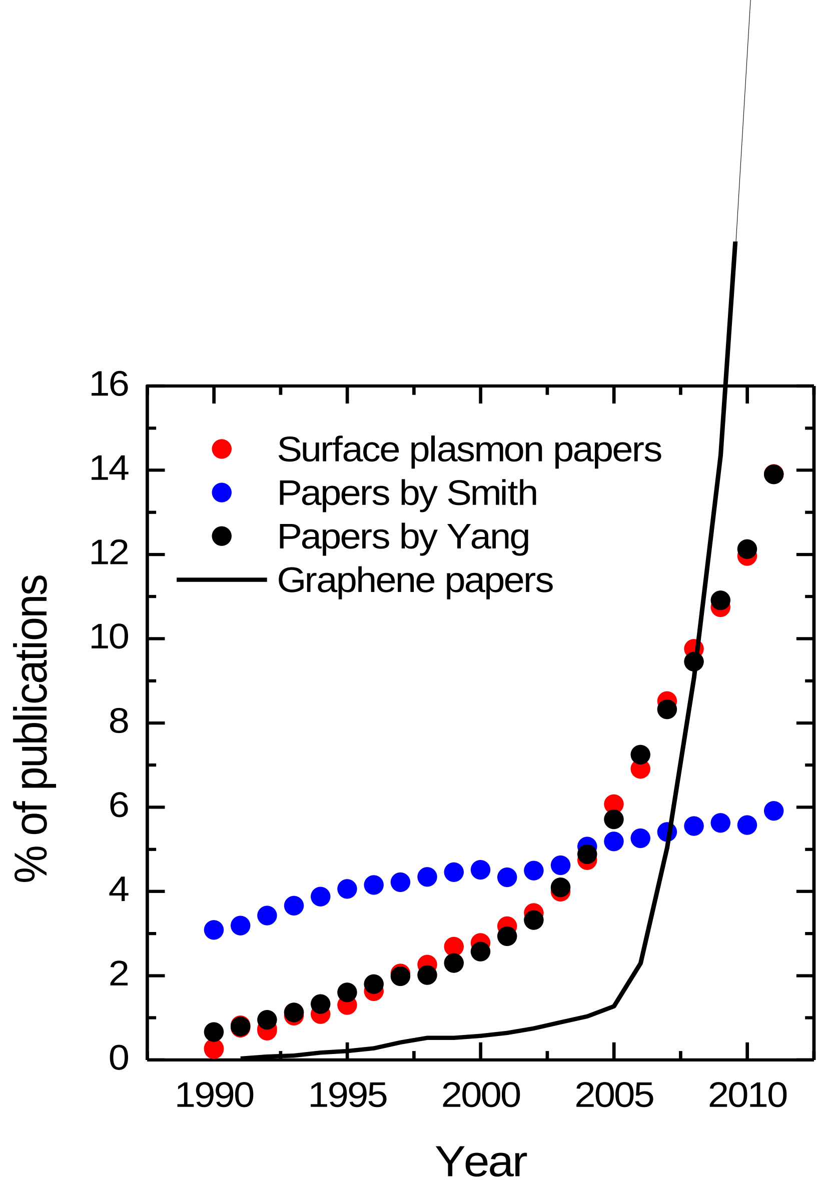
10
12
14
16
1990
1995
2000
2005
2010



http://www.youtube.com/watch?v=9tkDK2mZIOo

1. Brief plasmonics background
2. SPP waveguide devices
3. Biophotonics
4. Prospects

outline

1. Brief plasmonics background
2. SPP waveguide devices
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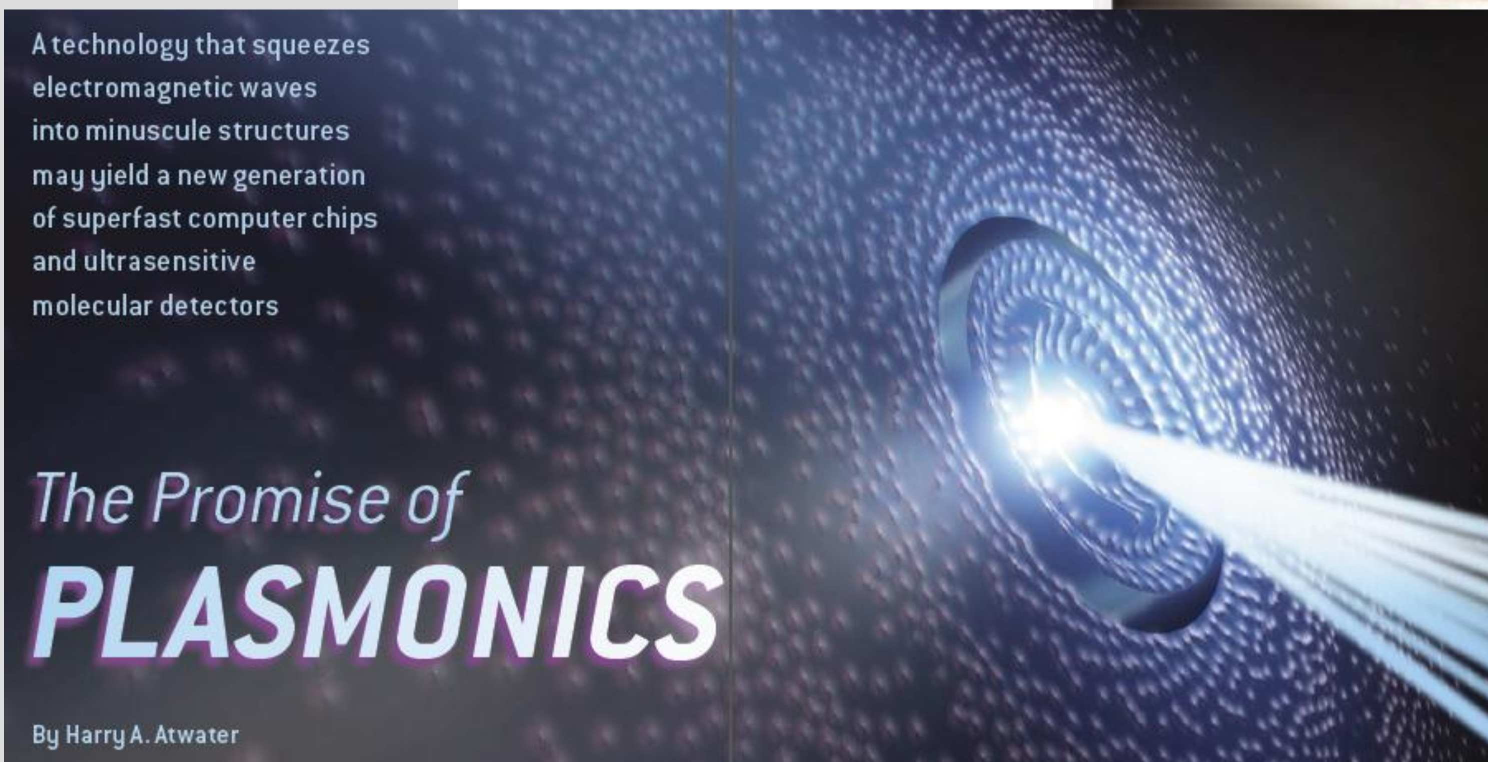
outline

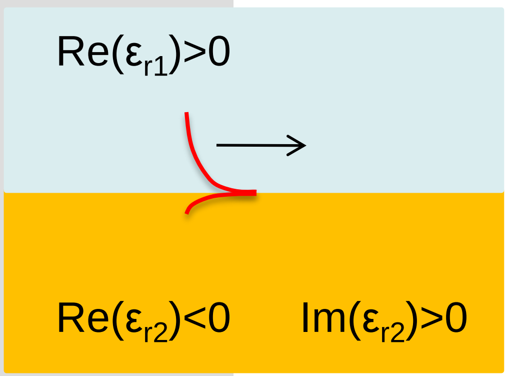

SIGILLUM


CURING RABIES • EYE MOVIES: WHAT THE RETINA SEES
SCIENTIFIC AMERICAN
Cannibal Galaxies: Tearing Apart the Neighbors
THE DAZZLING FUTURE OF
PLASMONICS
New optical technology yields faster computing, brighter LEDs ... oh, and invisibility


A technology that squeezes electromagnetic waves into minuscule structures may yield a new generation of superfast computer chips and ultrasensitive molecular detectors
The Promise of
PLASMONICS
By Harry A. Atwater

$$A(z) = A(0)\exp(i\beta z)$$

$$\beta = \beta' + i\beta''$$



$$\beta' = \frac{\omega}{c}\left(\frac{\epsilon_{r1}\epsilon'_{r2}}{\epsilon_{r1}+\epsilon'_{r2}}\right)^{1/2}$$

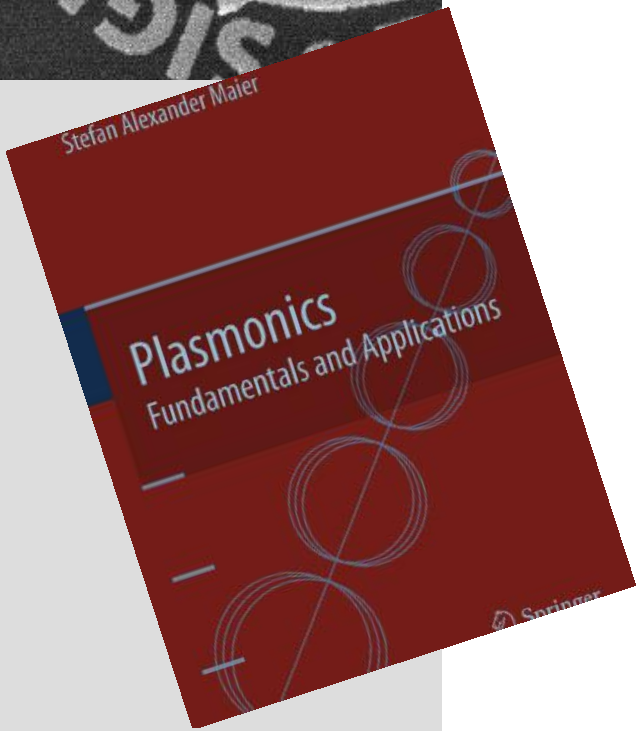
$$\beta'' = \frac{\omega}{c}\left(\frac{\epsilon_{r1}\epsilon'_{r2}}{\epsilon_{r1}+\epsilon'_{r2}}\right)^{3/2}\frac{\epsilon''_{r2}}{2(\epsilon'_{r2})^2}$$

surface plasmon polaritons

$$\varepsilon'(\omega) = 1 - \frac{\omega_{\mathrm{p}}^2 \tau^2}{1 + \omega^2 \tau^2}$$

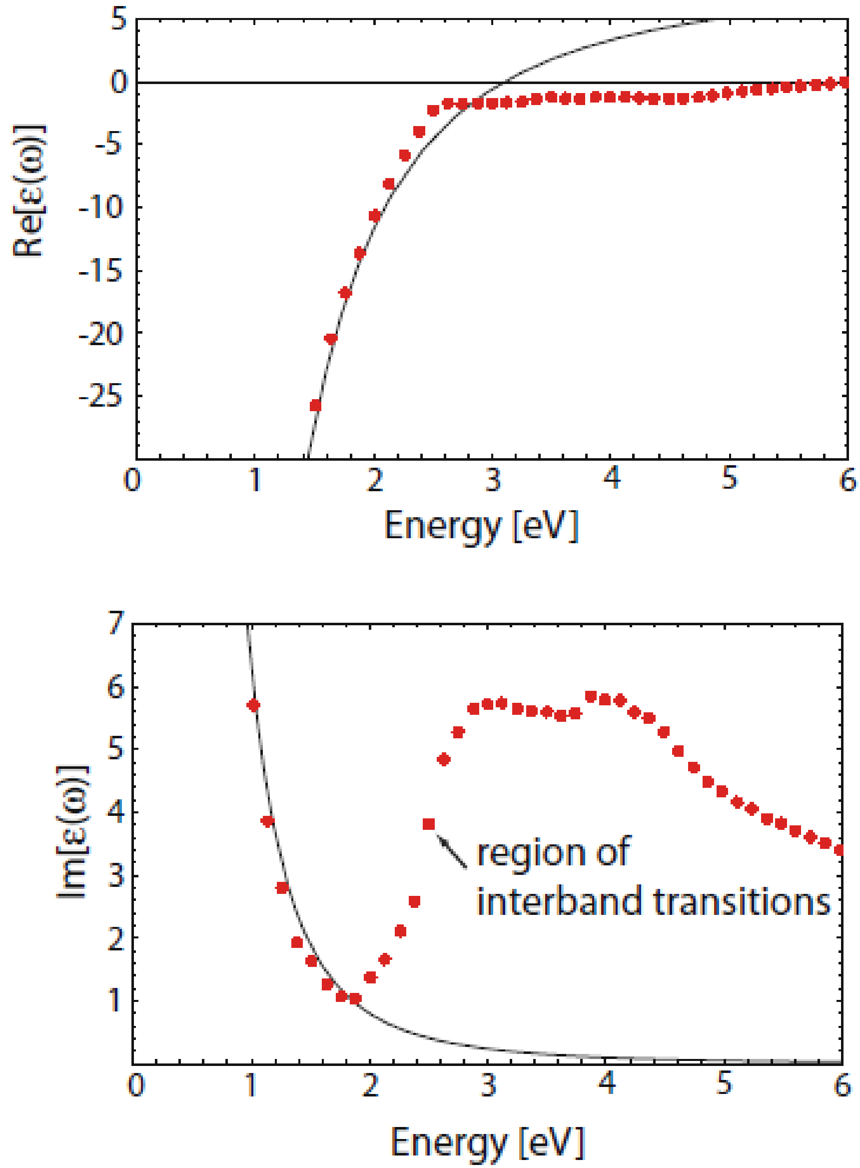
$$\varepsilon''(\omega) = \frac{\omega_{\mathrm{p}}^2 \tau}{\omega(1 + \omega^2 \tau^2)}$$

Drude model



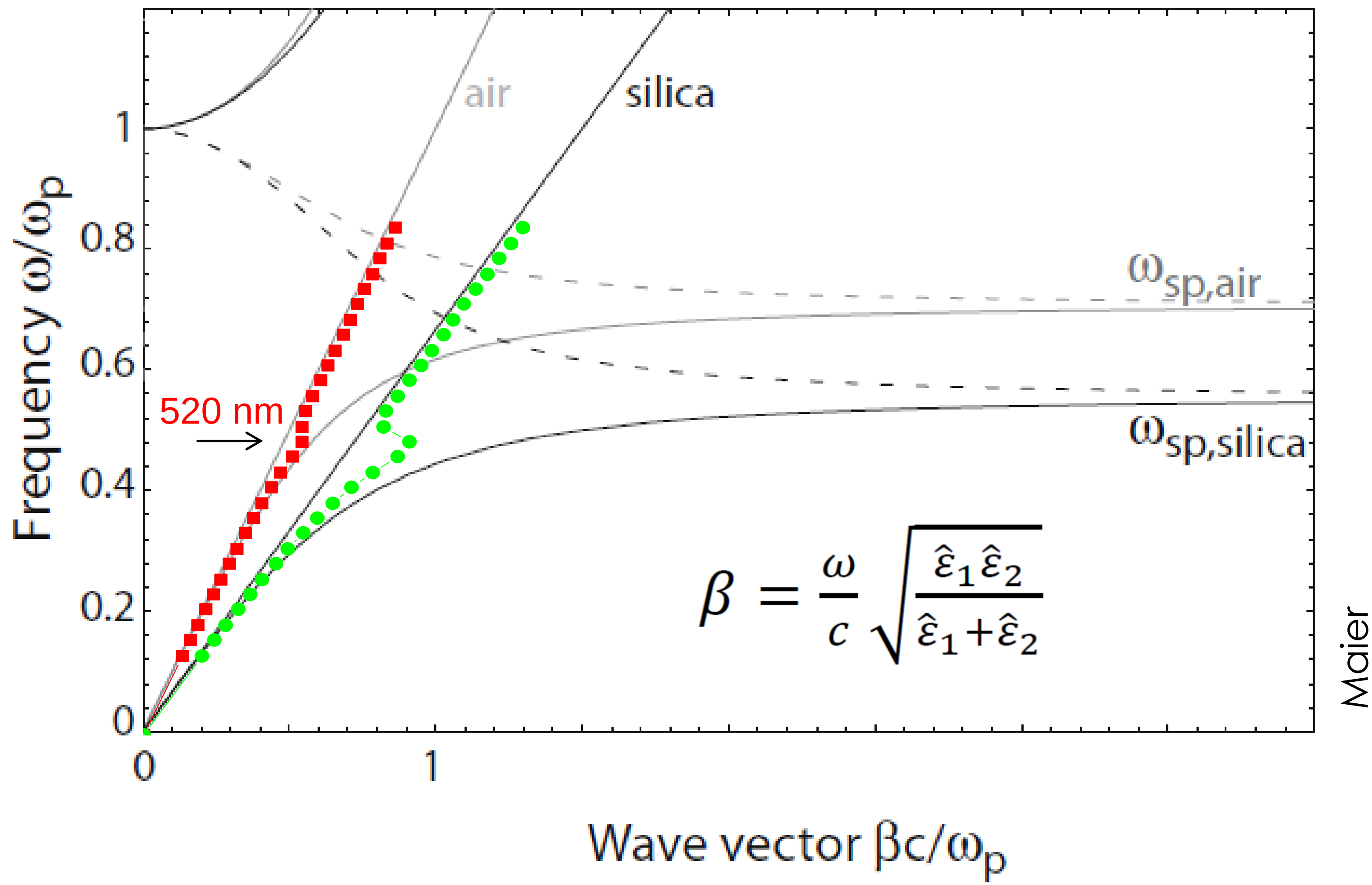
Stefan Alexander Maier
Plasmonics
Fundamentals and Applications
Springer

gold

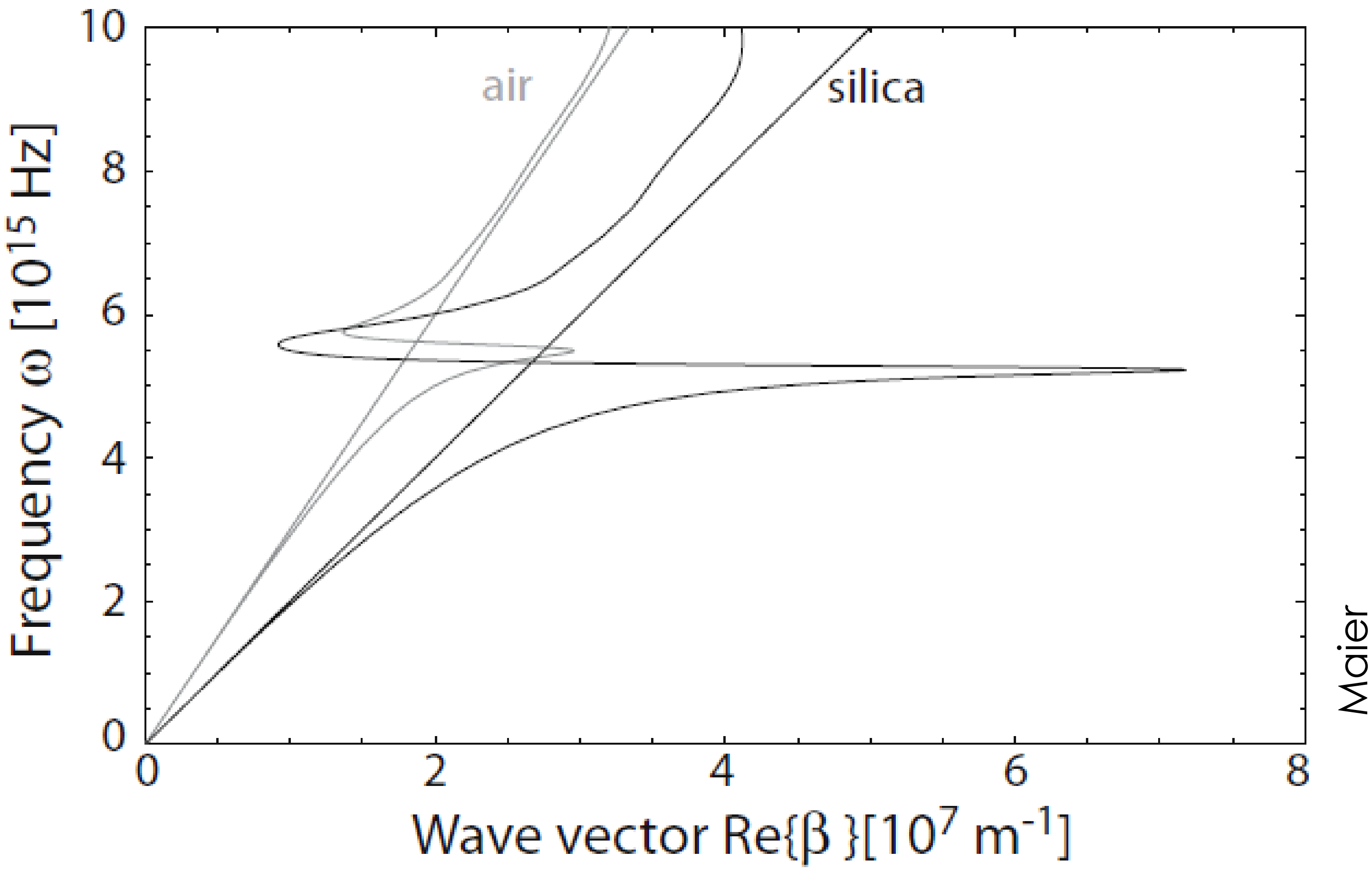


Re[ε(ω)]
Energy [eV]
Im[ε(ω)]
region of
interband transitions
Energy [eV]

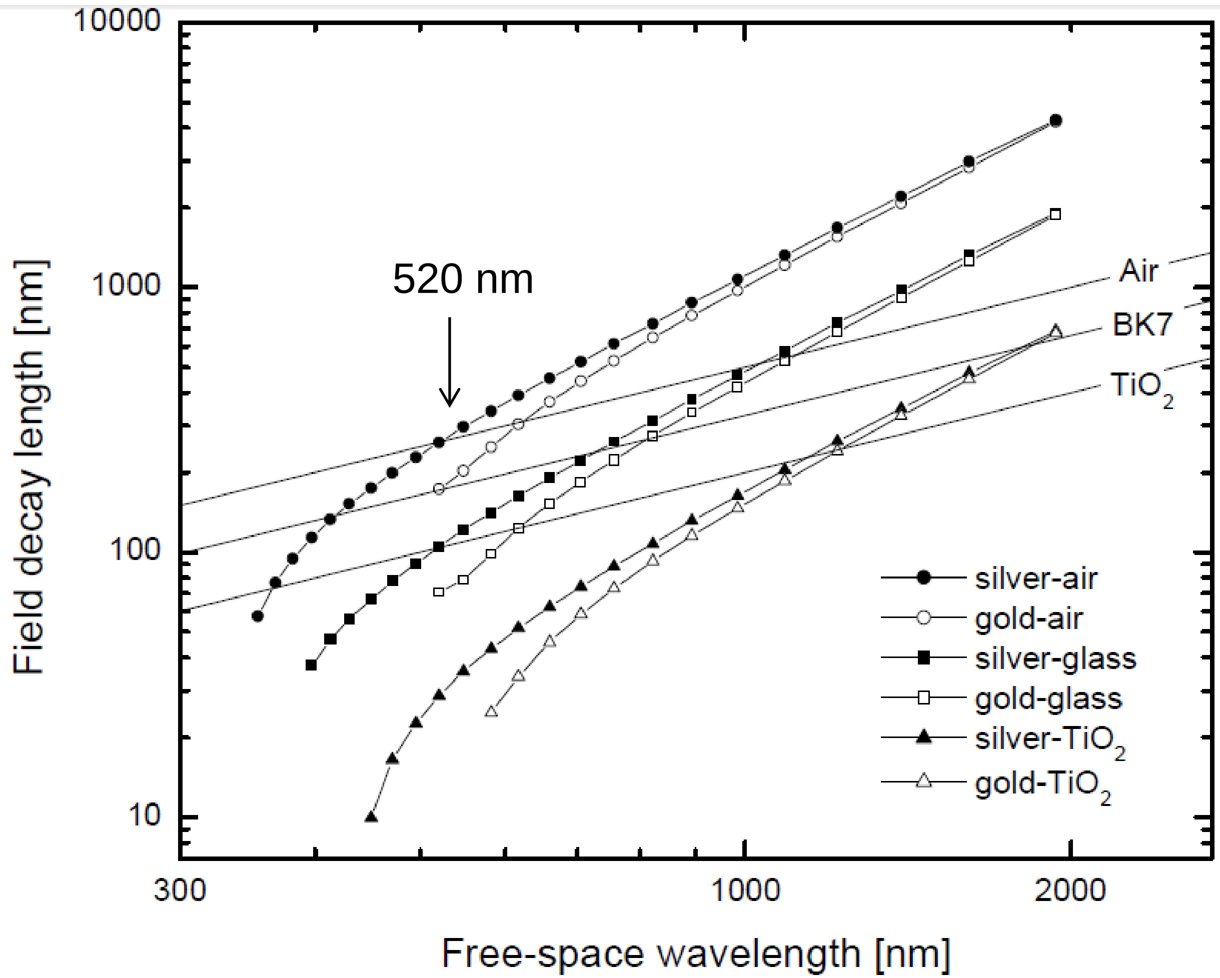
Maier



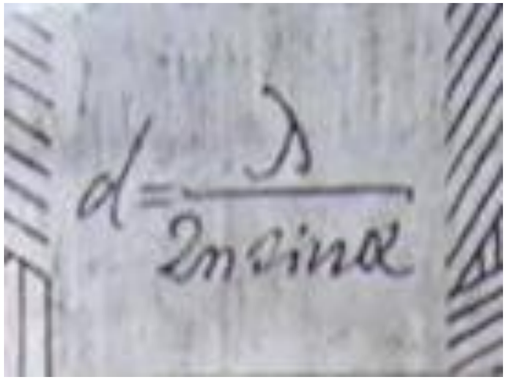
disperison, Drude vs. gold



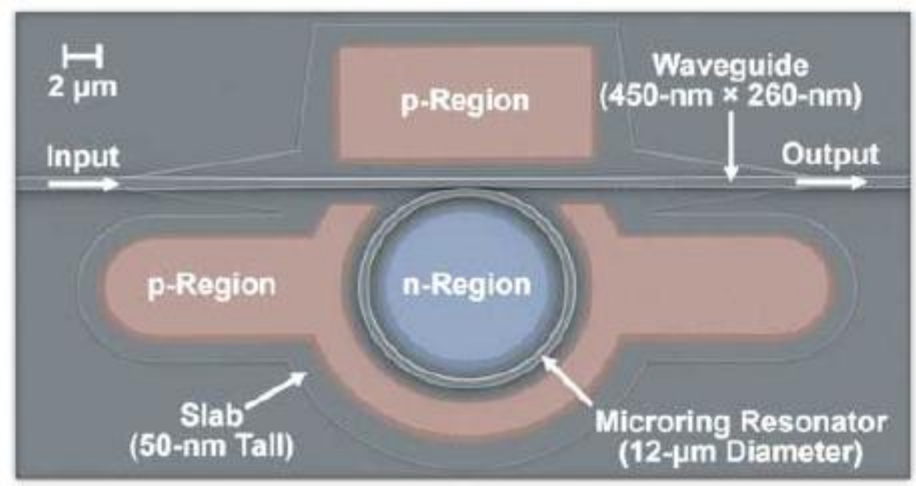
dispersion, silver



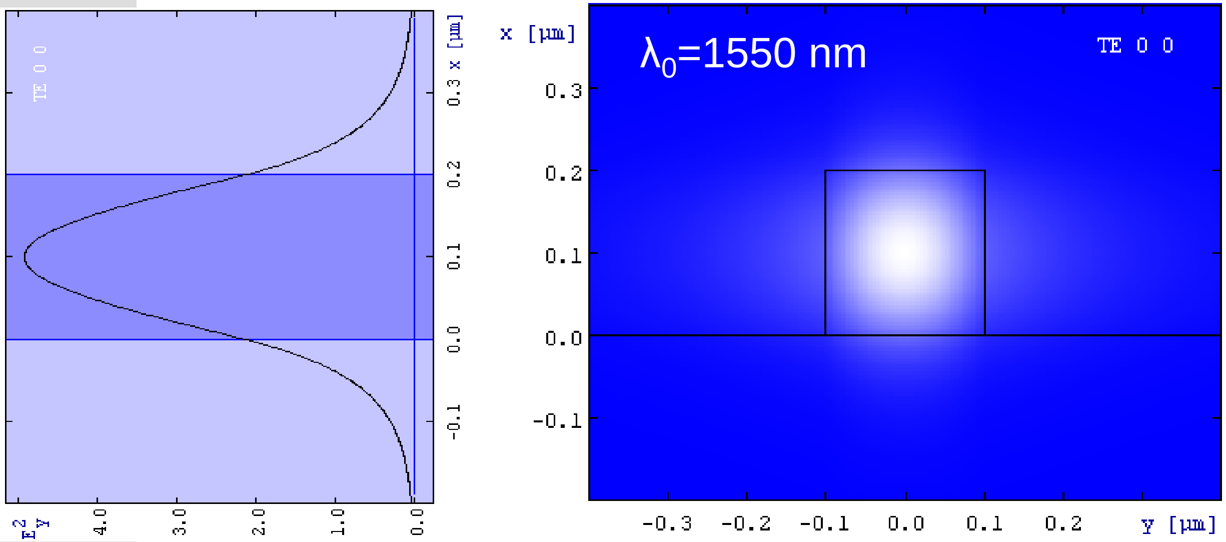
field confinement



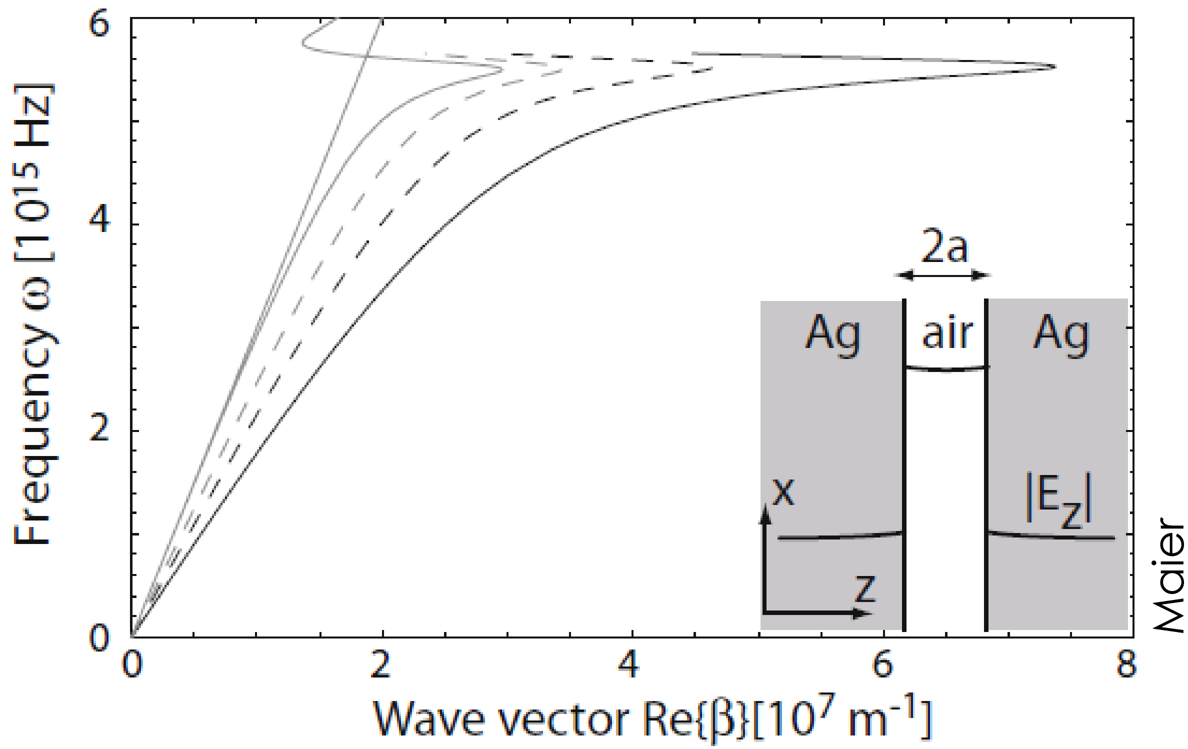
diffraction limit



Biberman et al.
OPTICS EXPRESS 18, 15544 (2010)

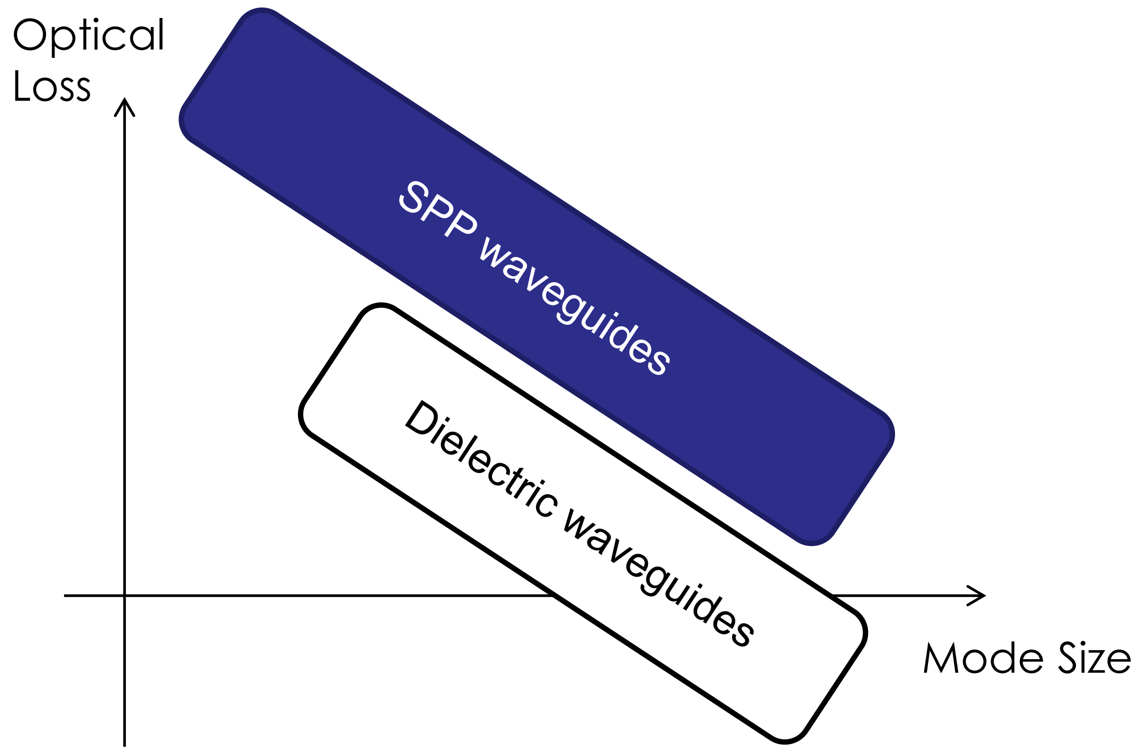


field confinement (Si/SiO_2)



Slots
Ridges
V-grooves
Wedges
Particle chains
DLSPPWGs
LRDLSPPWGs
Other hybrids
...etc.

more complex geometries



overall picture

1. Brief plasmonics background
2. SPP waveguide devices
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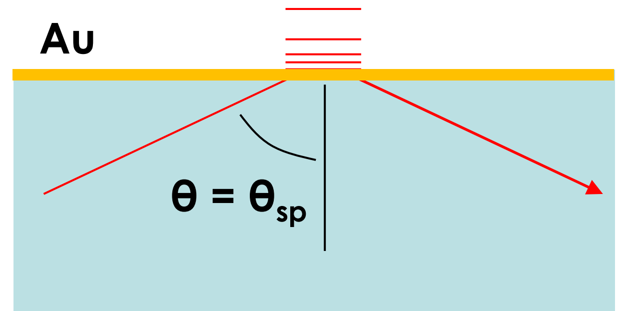
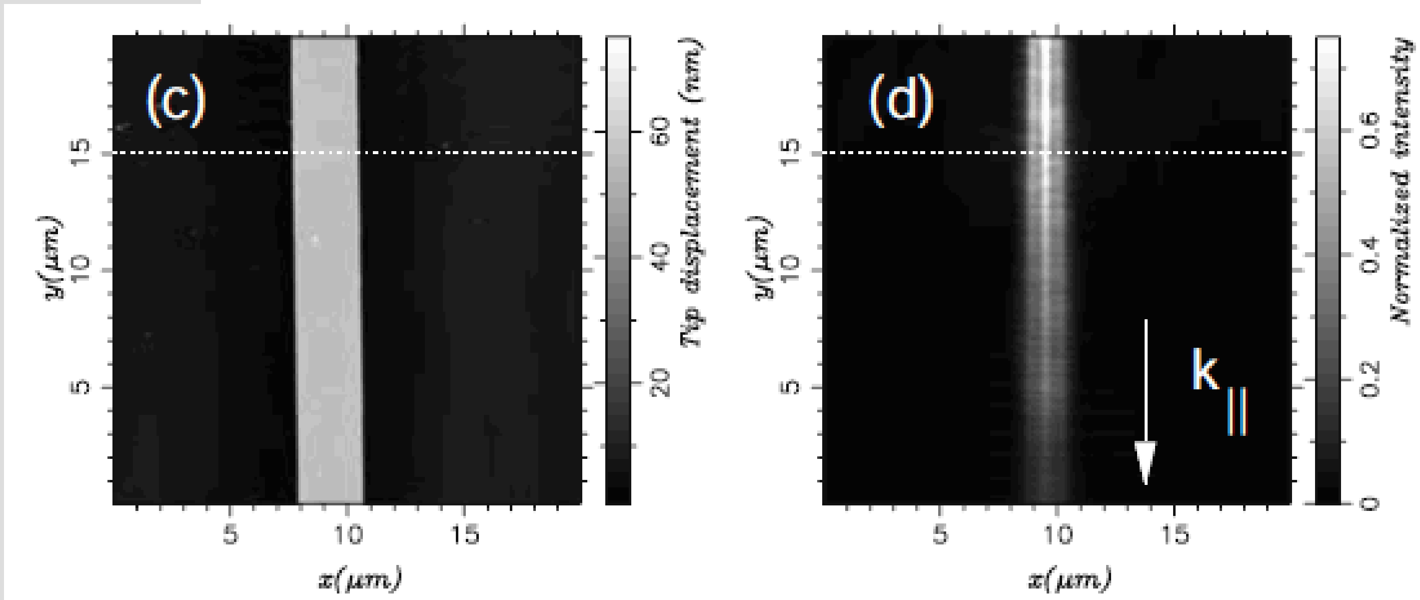
outline



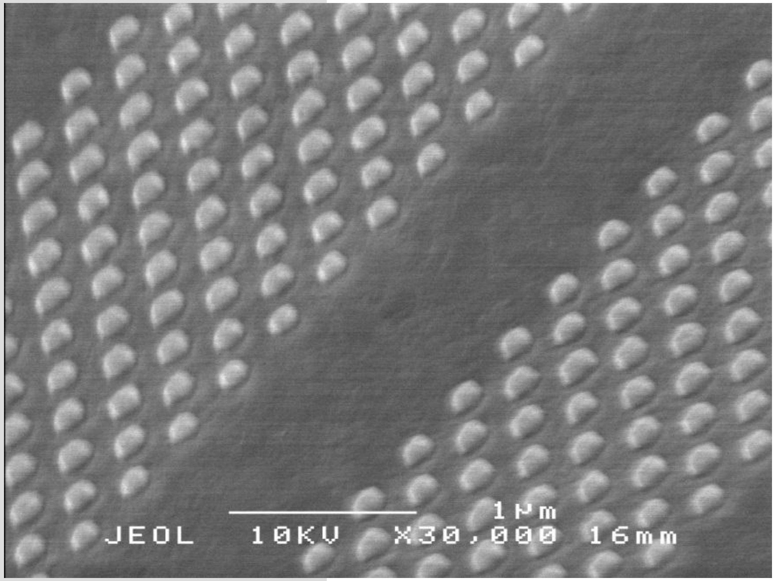
BiaCore

S P R device



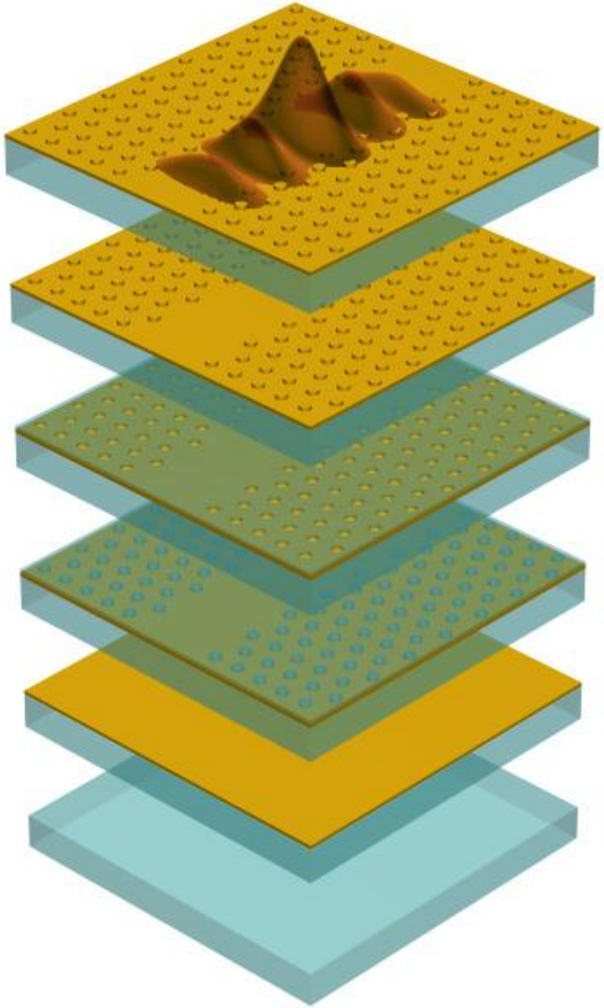
Weeber, Lacroute, Dereux, *Optical near-field distributions of surface plasmon waveguide modes*, PRB 68, 115401 (2003)

metal ridge waveguides

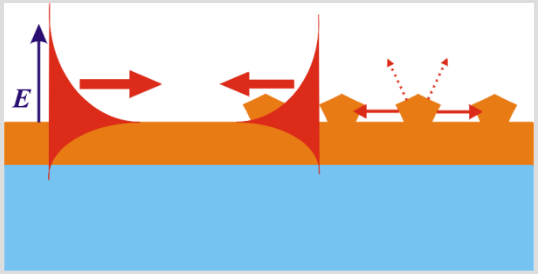


Bozhevolnyi, Erland, Leosson, Skovgaard, Hvam
Waveguiding in surface plasmon polariton band bap structures, PRL 86, 3008 (2001)

Bozhevolnyi, Volkov, Leosson: *Localization and waveguiding of surface plasmon polaritons in random nanostructures*, PRL 89, 186801 (2002)



SPPBG waveguides



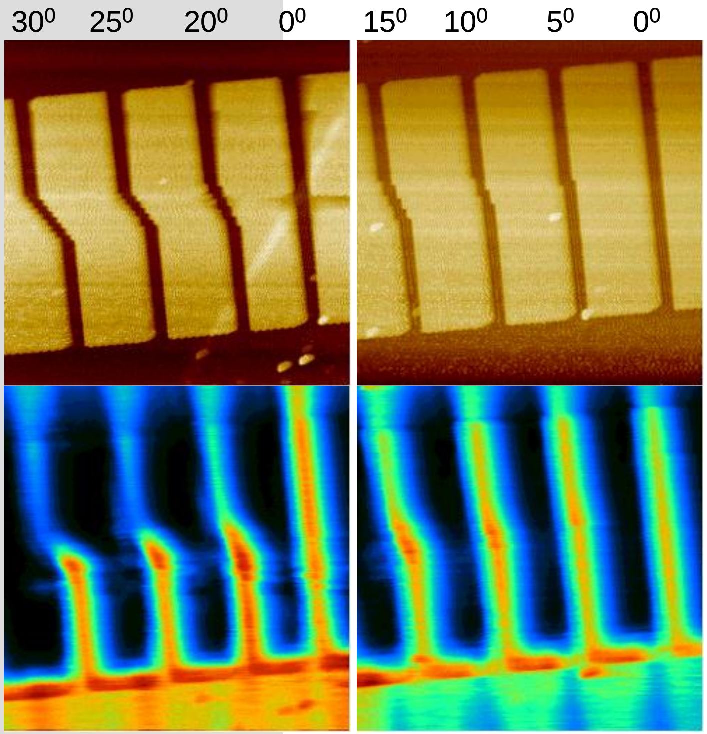


Image size: 32×32μm^2, wavelength 737 nm

min max

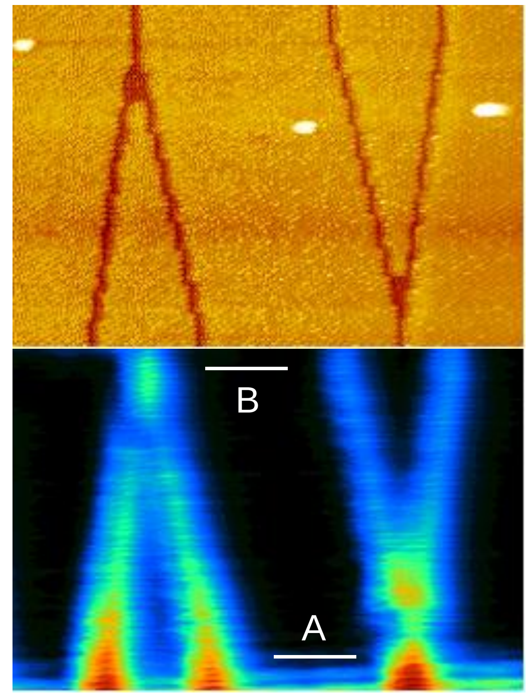
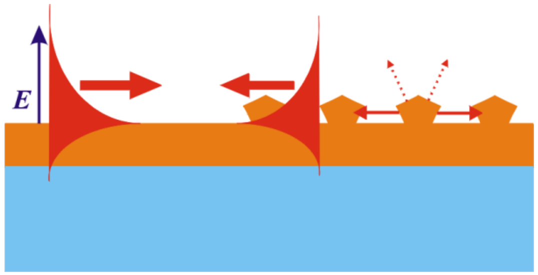


Image size: 32×21μm^2, wavelength 737 nm

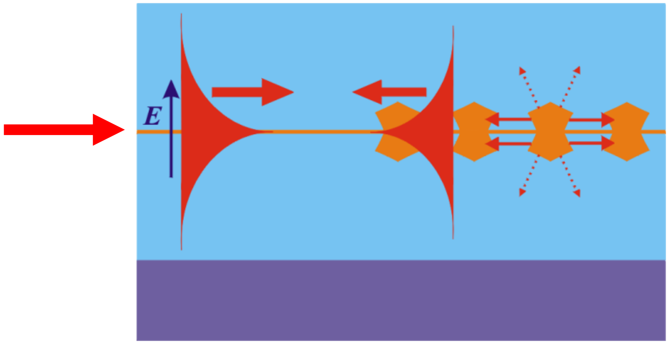
SPPBG waveguides



SPPBG circuits

- High propagation loss >1dB/component
- Coupling issues
- Single-polarization

SPPBG components



LR-SPPBG circuits

+ Lower propagation loss
+ End-fire coupling
- Single-polarization

LR-SPPBG components

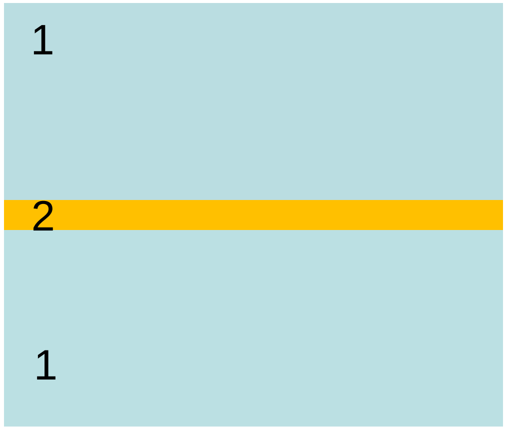
$$e^{-2k_2 d} = \frac{k_2/\hat{\varepsilon}_2 + k_1/\hat{\varepsilon}_1}{k_2/\hat{\varepsilon}_2 - k_1/\hat{\varepsilon}_1} \cdot \frac{k_2/\hat{\varepsilon}_2 + k_3/\hat{\varepsilon}_3}{k_2/\hat{\varepsilon}_2 - k_3/\hat{\varepsilon}_3}$$

$$k_i^2 = \beta^2 - \omega^2 \mu_0 \hat{\varepsilon}_i$$

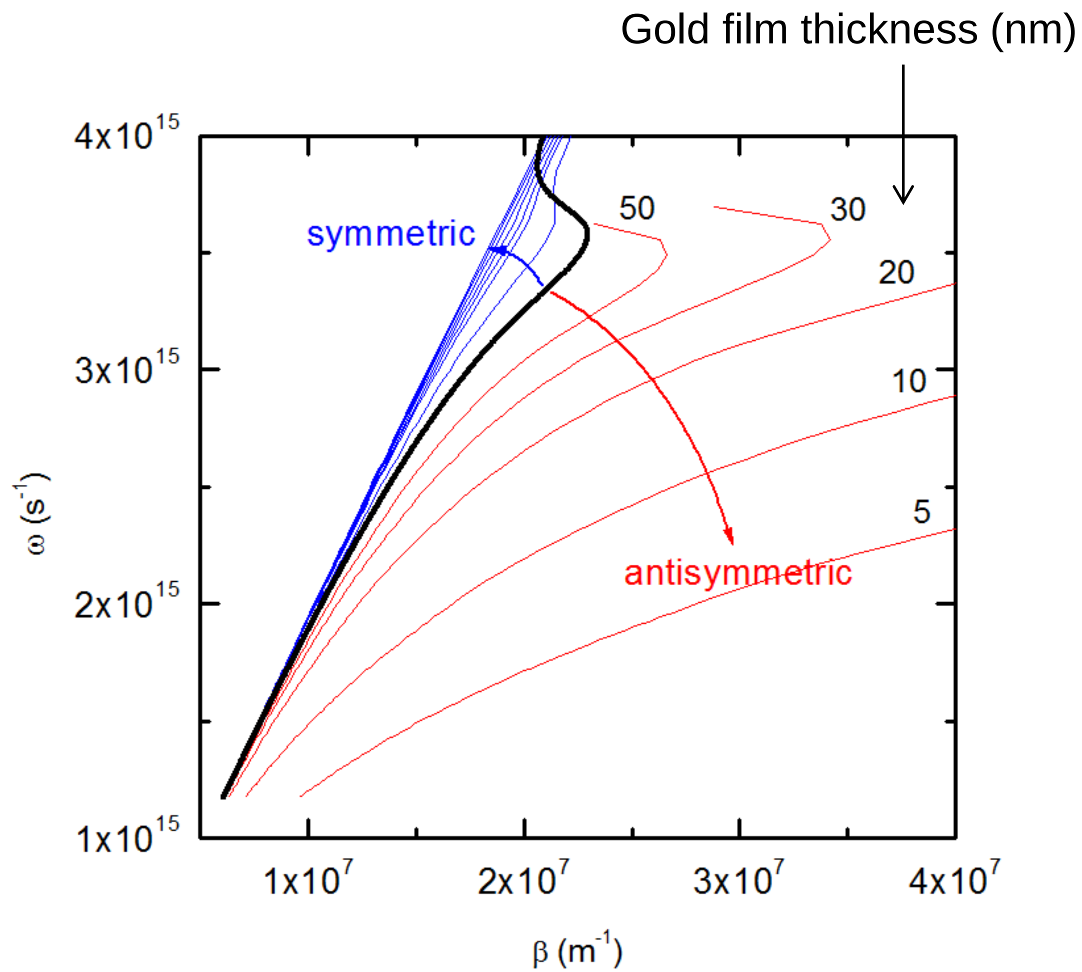
thin metal films

$$e^{-k_2 d} = \pm \frac{k_2/\hat{\varepsilon}_2 + k_1/\hat{\varepsilon}_1}{k_2/\hat{\varepsilon}_2 - k_1/\hat{\varepsilon}_1}$$

$$k_i^2 = \beta^2 - \omega^2 \mu_0 \hat{\varepsilon}_i$$

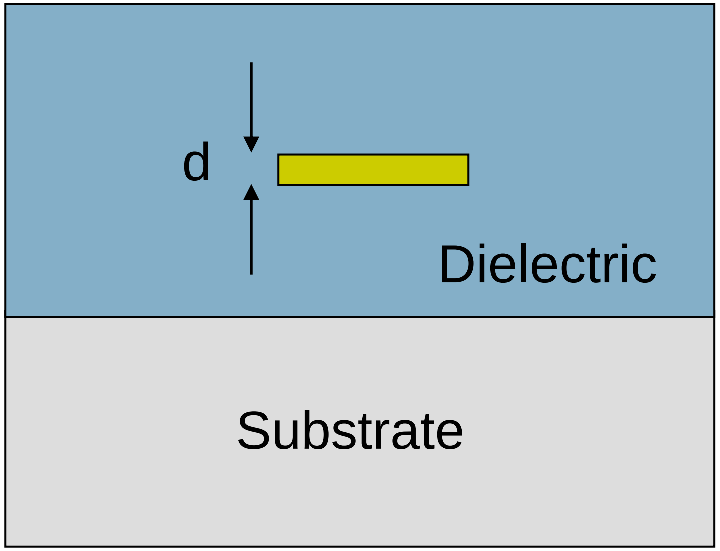


Thin metal films

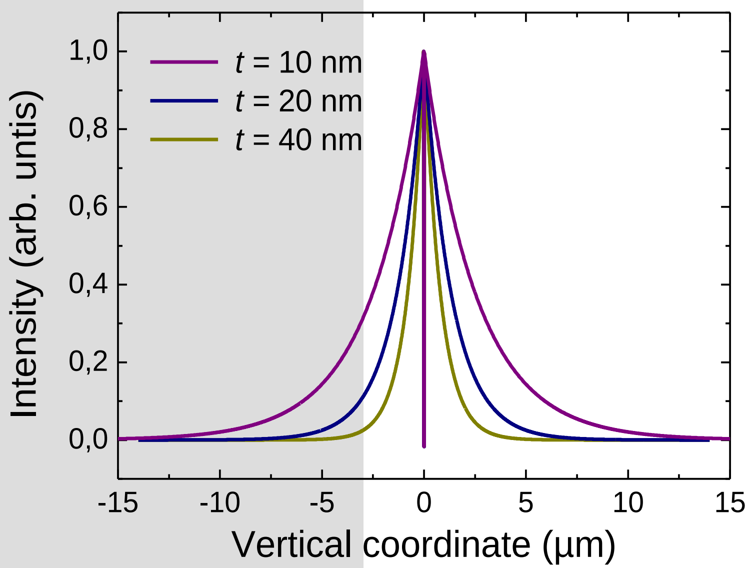


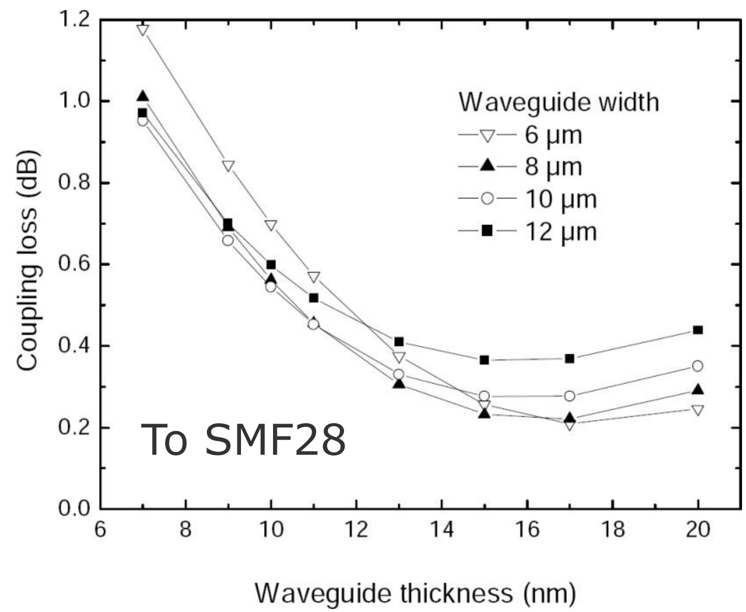
long/short-range SPPs

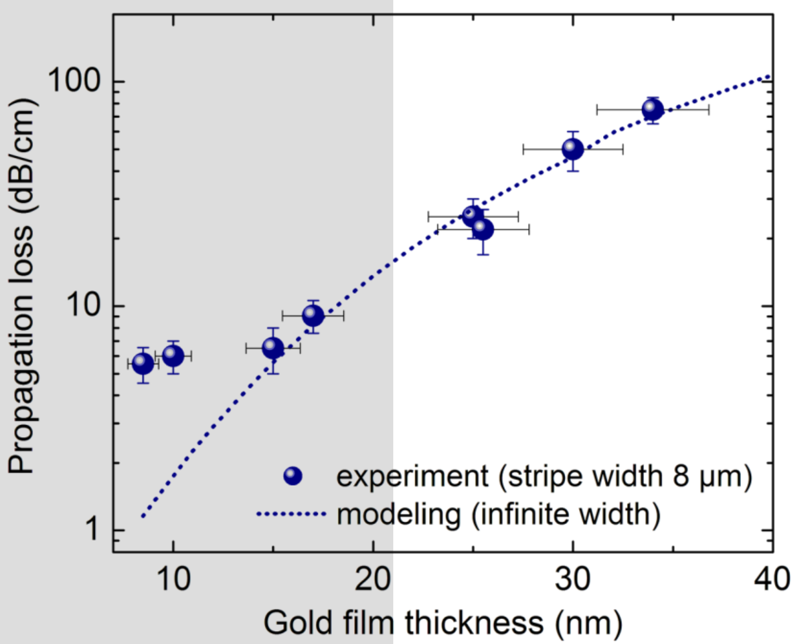
Comprehensive review:
Berini, *Long Range Surface Plasmon Polaritons*,
Advances in Optics and Photonics 1, 484 (2009).

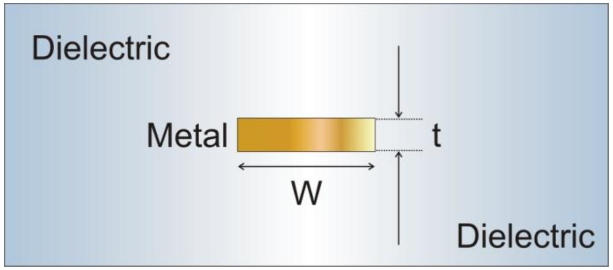


LR-SPPs

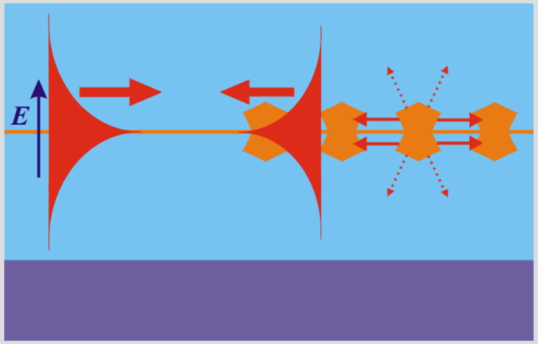




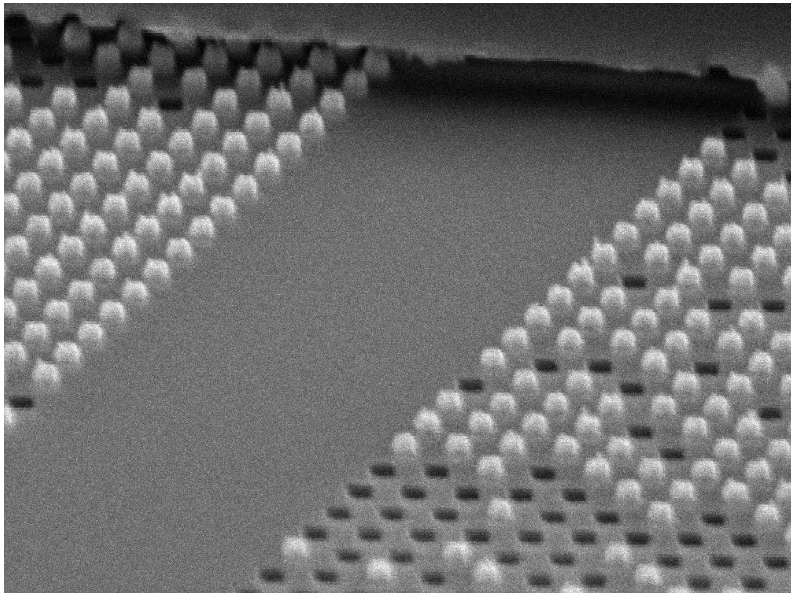


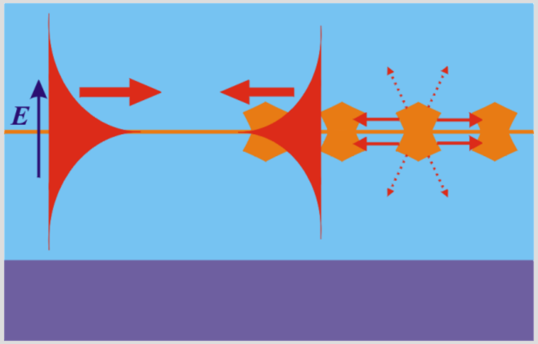


J. J. Burke, et. al., Phys. Rev. B 33, 5186 (1986)
R. Charbonneau, et. al., Optics Letters 25, 844 (2000)
T. Nikolajsen, et.al. Appl. Phys. Lett. 82, 668 (2003)
P.G. Hermannsson, et al., Proc. SPIE 6988-0A (2008)



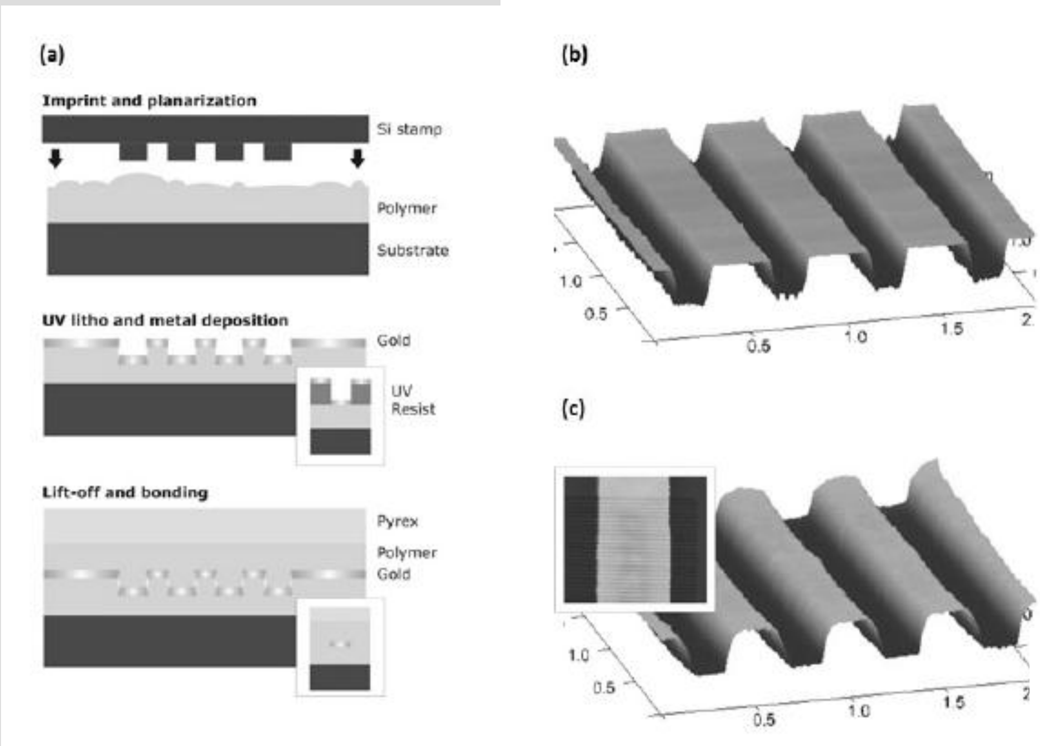
Boltasseva, et al. *Propagation of long-range surface plasmon polaritons in photonic band gap structures*, JOSA B 22, 2027 (2005)

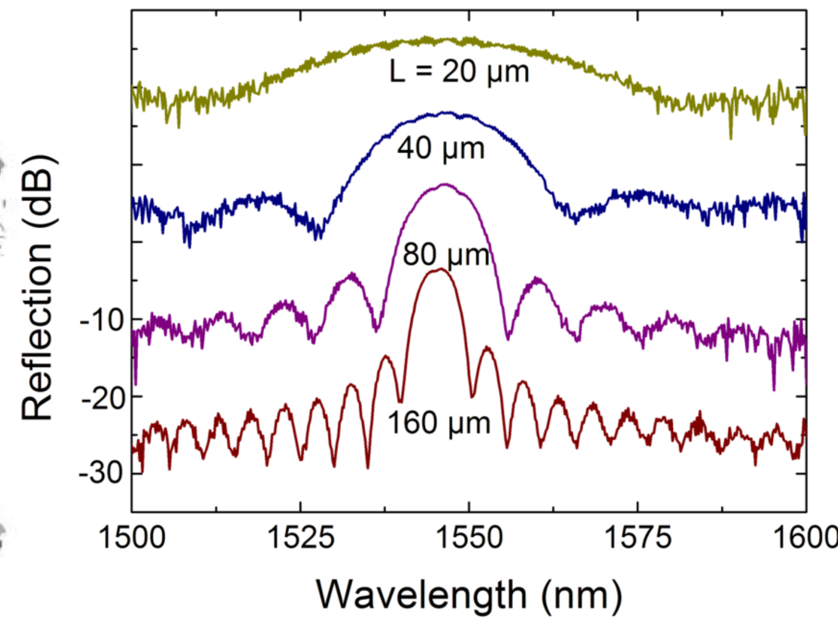


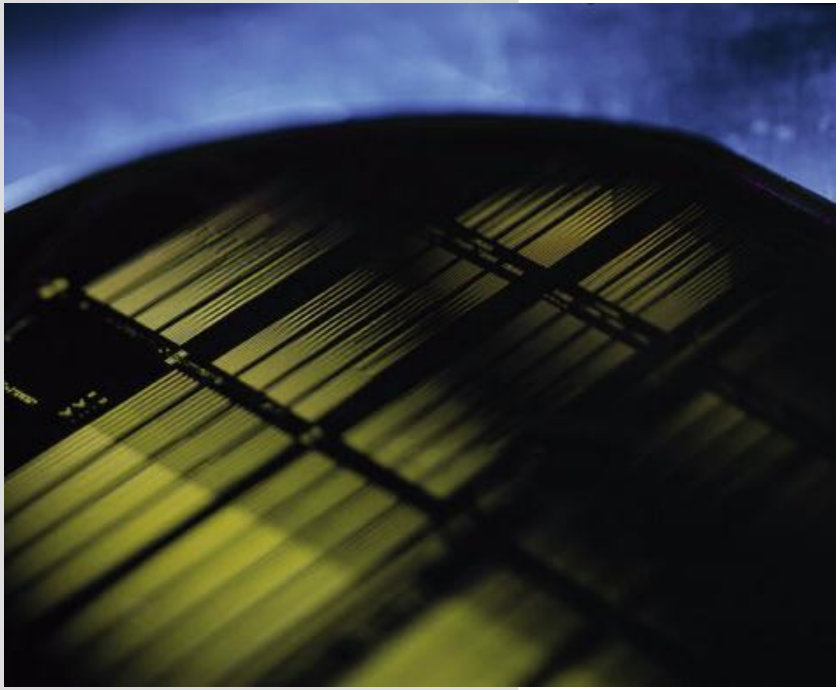


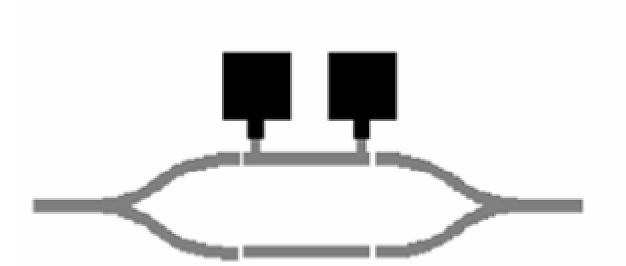
Boltasseva, et al. *Compact Bragg gratings for long-range surface plasmon polaritons*, JLT 24, 912 (2006)

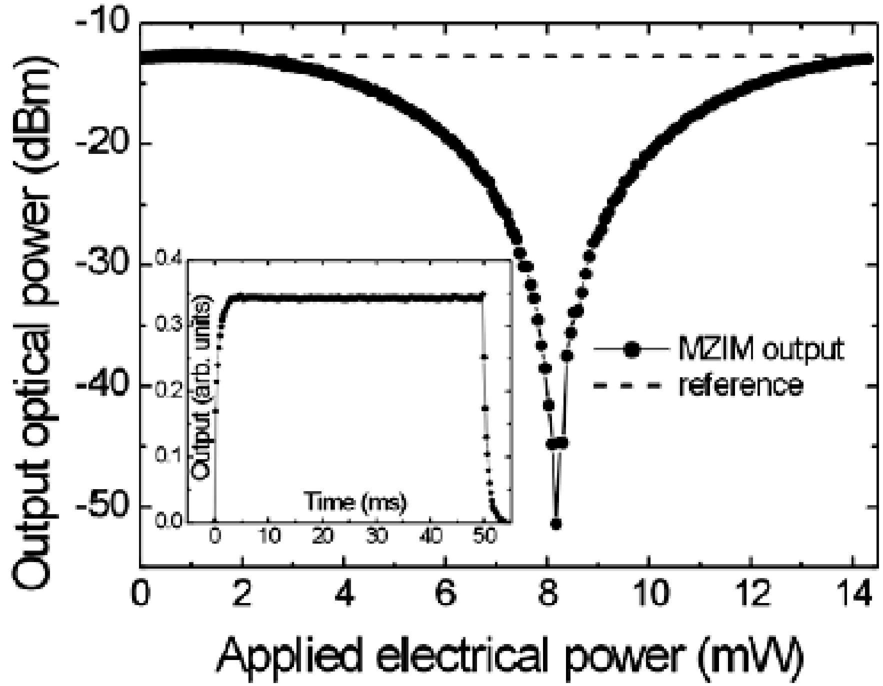
Boltasseva, et al. *Compact Z-add-drop wavelength filters for long-range surface plasmon polaritons*, Opt. Express 13, 4237 (2005)



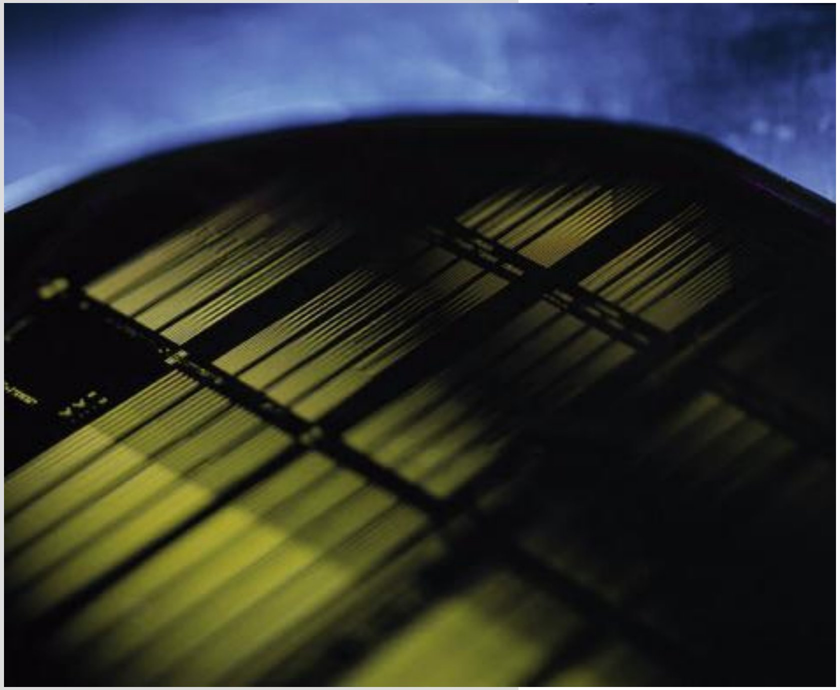


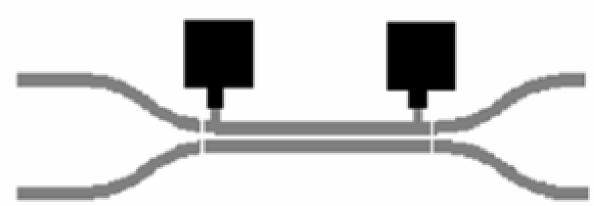


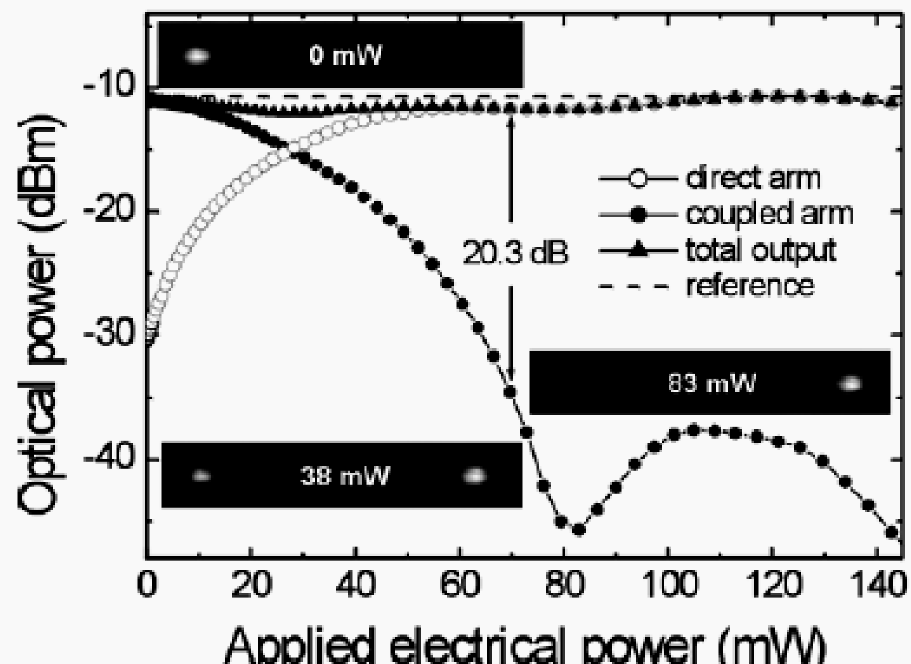




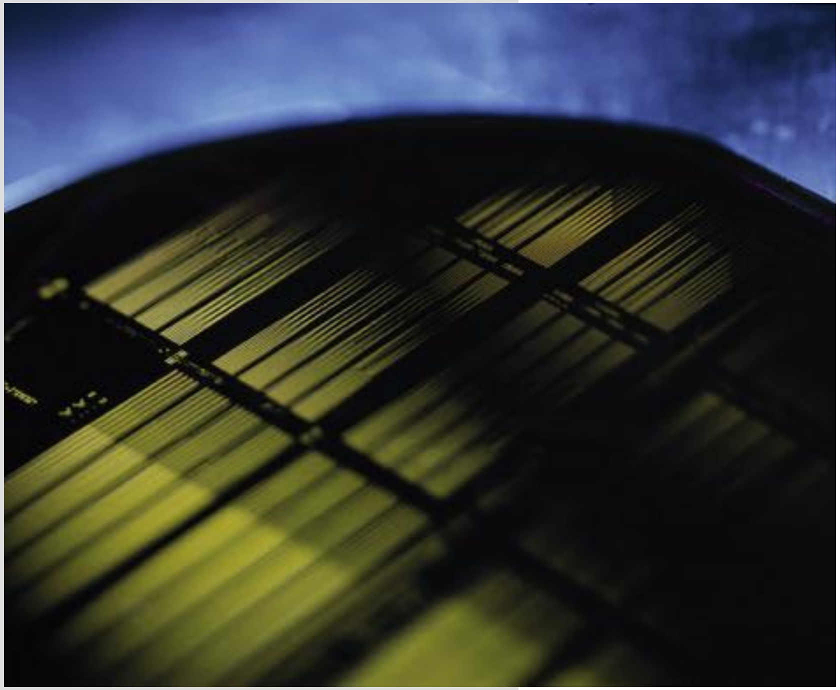
Boltasseva, et al. *Integrated Optical Components Utilizing Long-Range Surface Plasmon Polaritons*, JLT 23, 413 (2005)

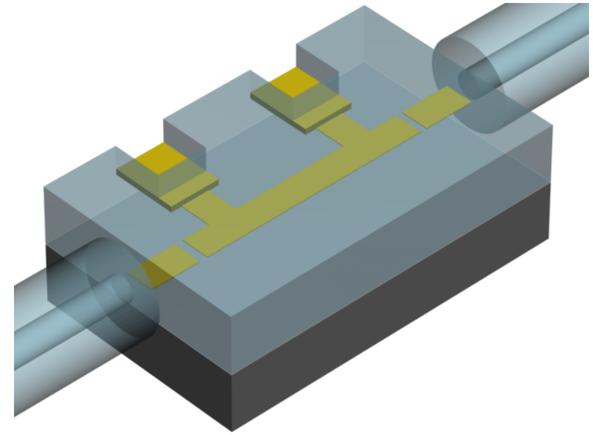






Boltasseva, et al. *Integrated Optical Components Utilizing Long-Range Surface Plasmon Polaritons*, JLT 23, 413 (2005)





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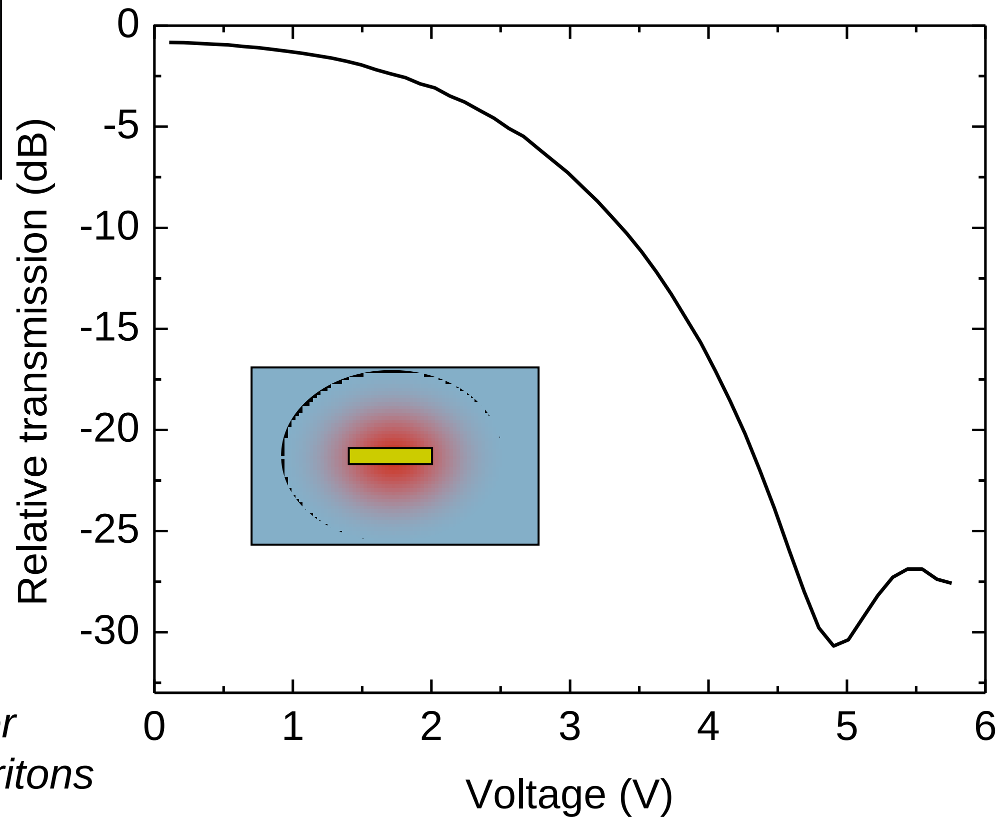
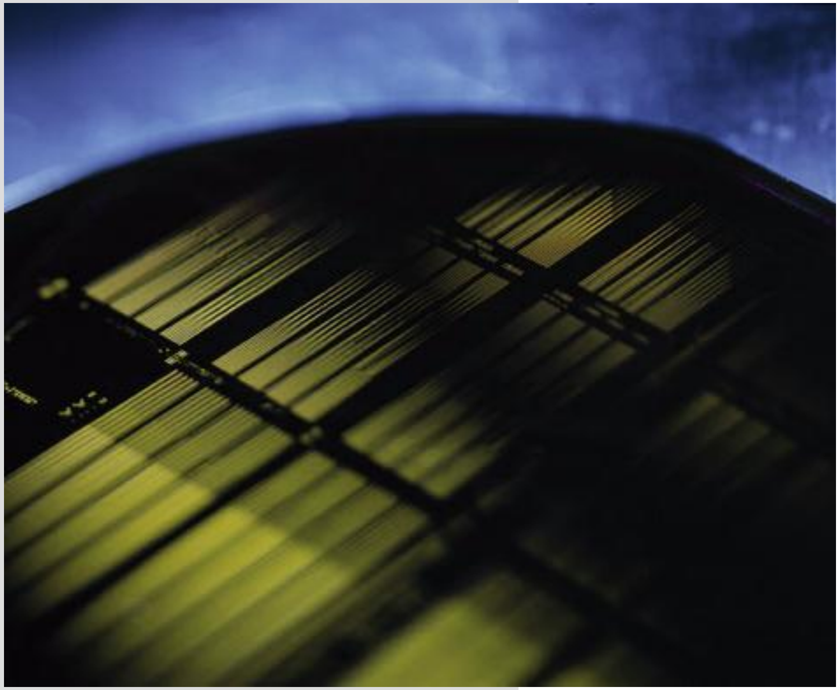
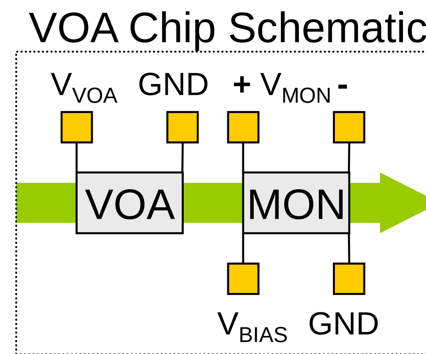
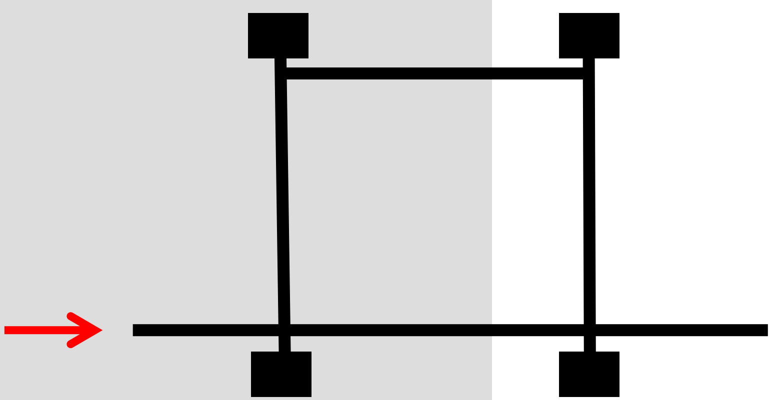
Drive power @ 30 dB: 50 mW
Response time: 0.5 ms
Insertion loss: 1.5 dB
Footprint: 1.5 x 1 mm2

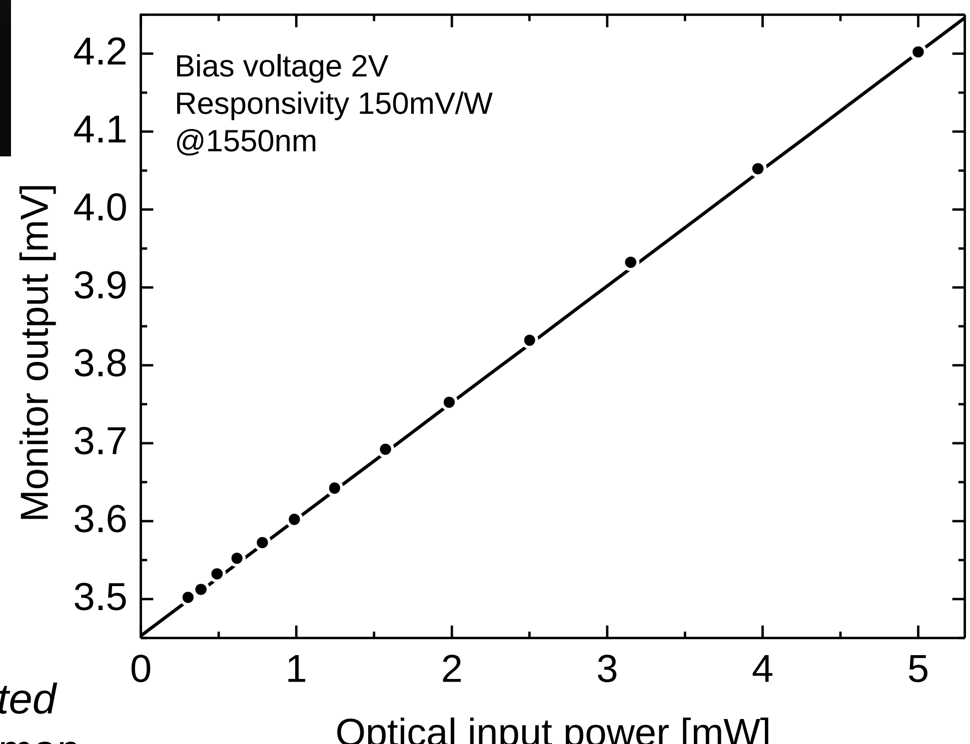


Nikolajsen, et al: *In-line extinction modulator based on long-range surface plasmon polaritons*
Optics Communications 244, 455 (2005)

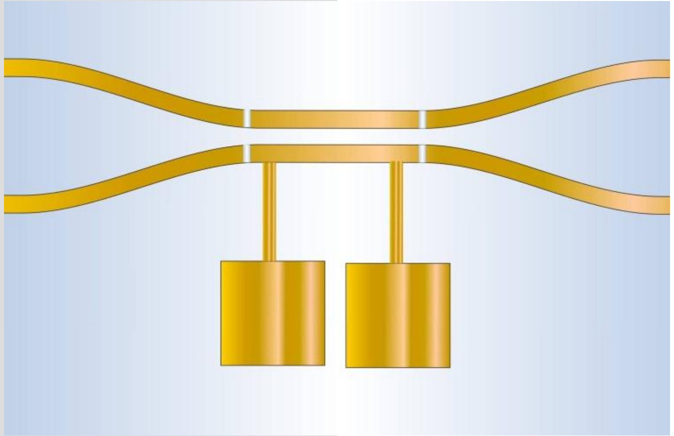








Bozhevolnyi, Nikolajsen, Leosson: *Integrated power monitor for long-range surface plasmon polaritons,* Optics Communications 255, 51 (2005)



LRSPP waveguides are compatible with standard fiber-optics

Efficient thermo-optic devices; heat delivered directly to waveguide core

Properties of two closely spaced waveguides can be controlled independently

Only one dielectric material is needed, no refractive index engineering

Simple fabrication, accurate patterning, low-temperature processing

why LRSPP waveguides?

Already demonstrated:

Waveguides, bends, splitters

Directional couplers (passive/active)

Multimode interferometers (passive/active)

Mach-Zehnder interferometers

Bragg gratings (passive/tunable)

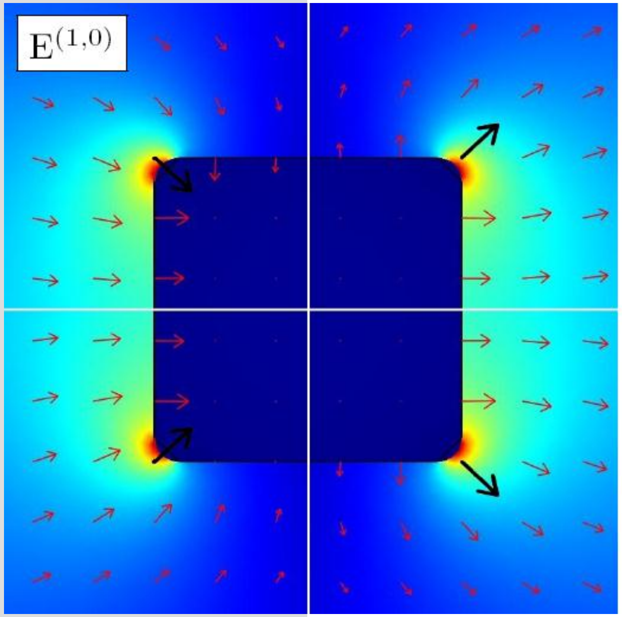
Wavelength add-drop filters

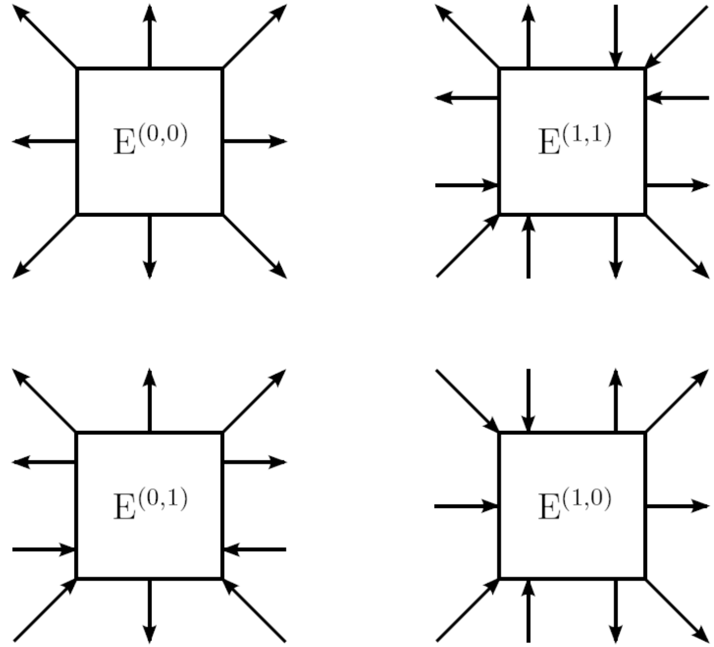
In-line power monitors

In-line extinction modulators

BUT ... all have high insertion loss (several dB) and 100% PDL

LRSPP devices

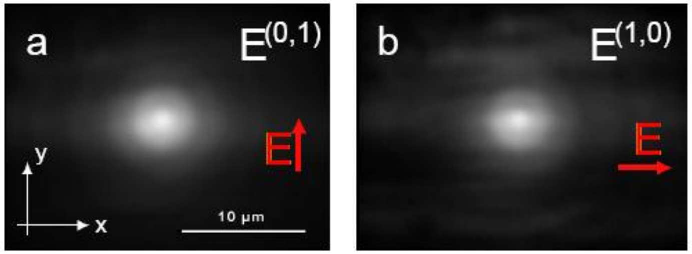


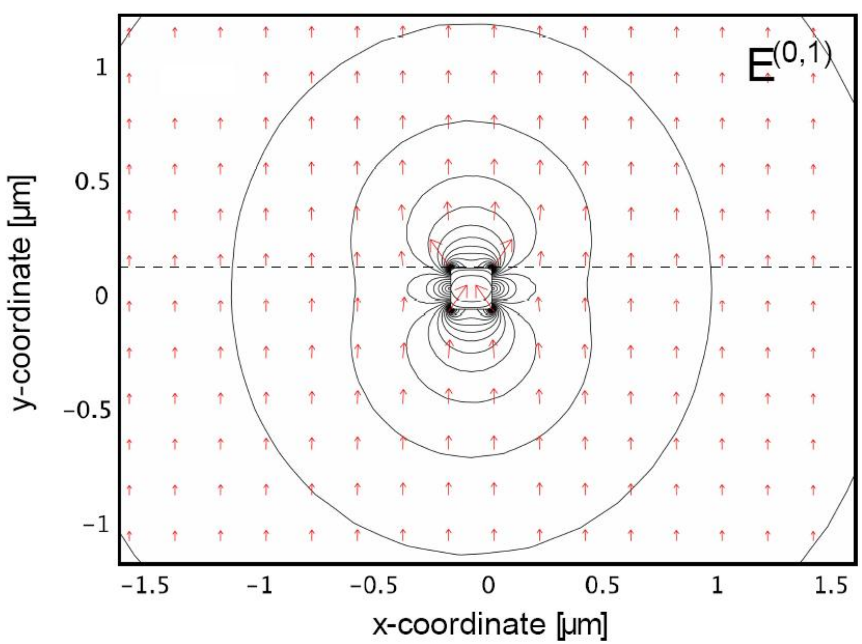


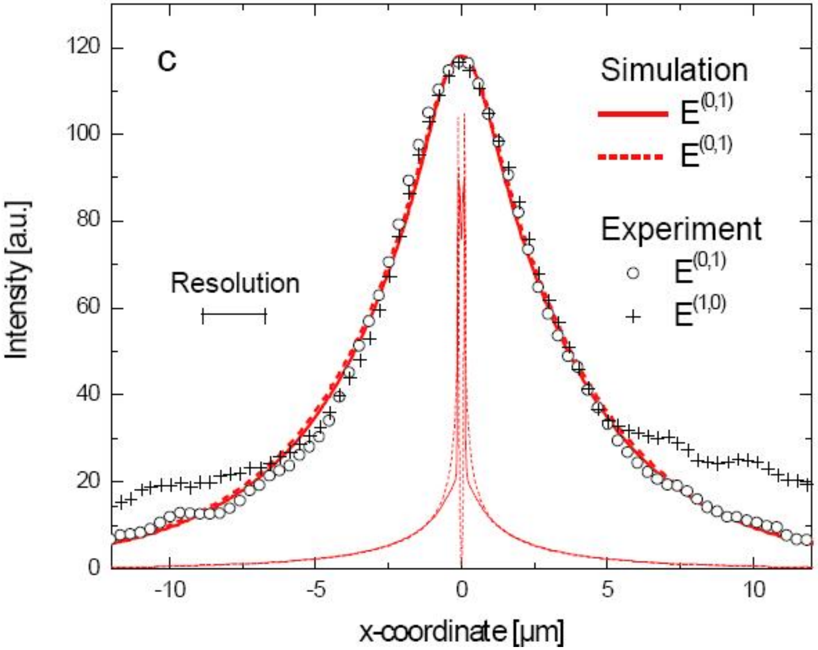
Jung, Søndergaard, Bozhevolnyi
PRB 76, 035434 (2007)

polarization dependence

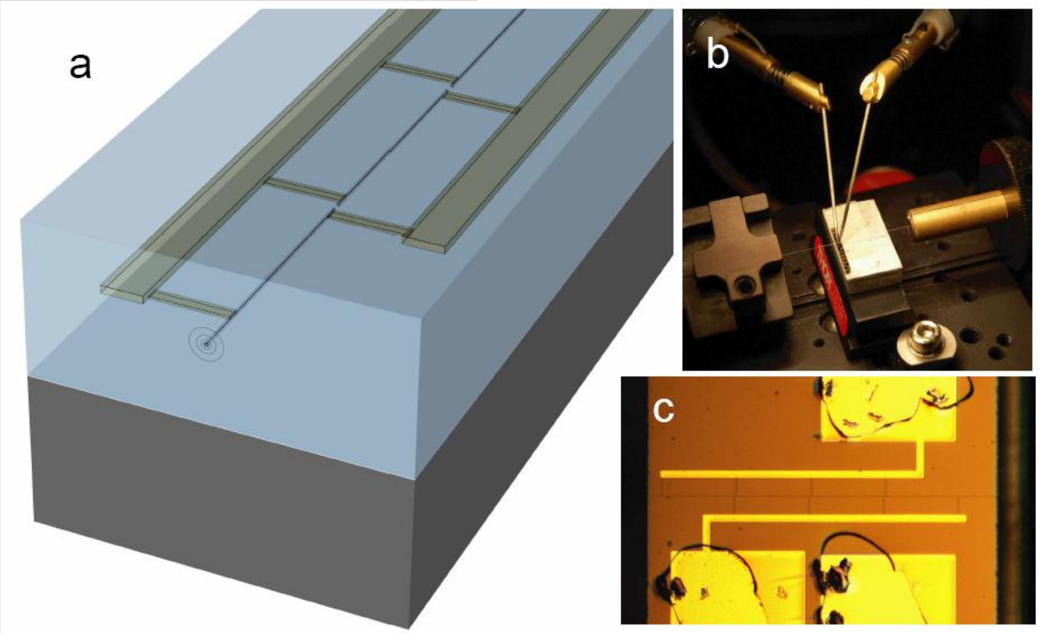
P. Berini, US Patent 6,741,782 (2004)
K. Leosson, et al., Opt. Express 14, 314 (2006)



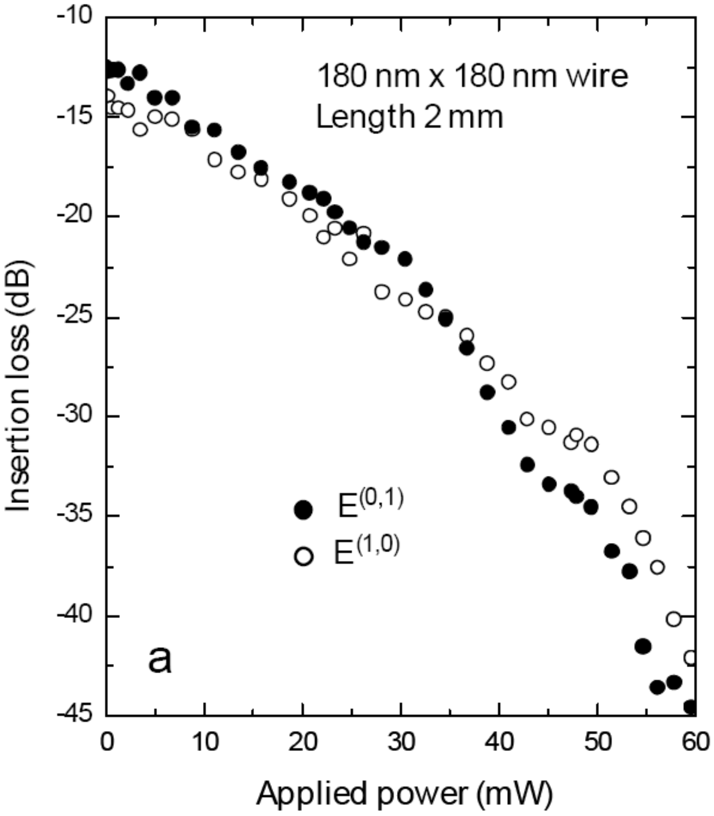




nanowire waveguides



K. Leosson, T. Rosenzveig, A. Boltasseva
Optics Express 16, 15546 (2008)



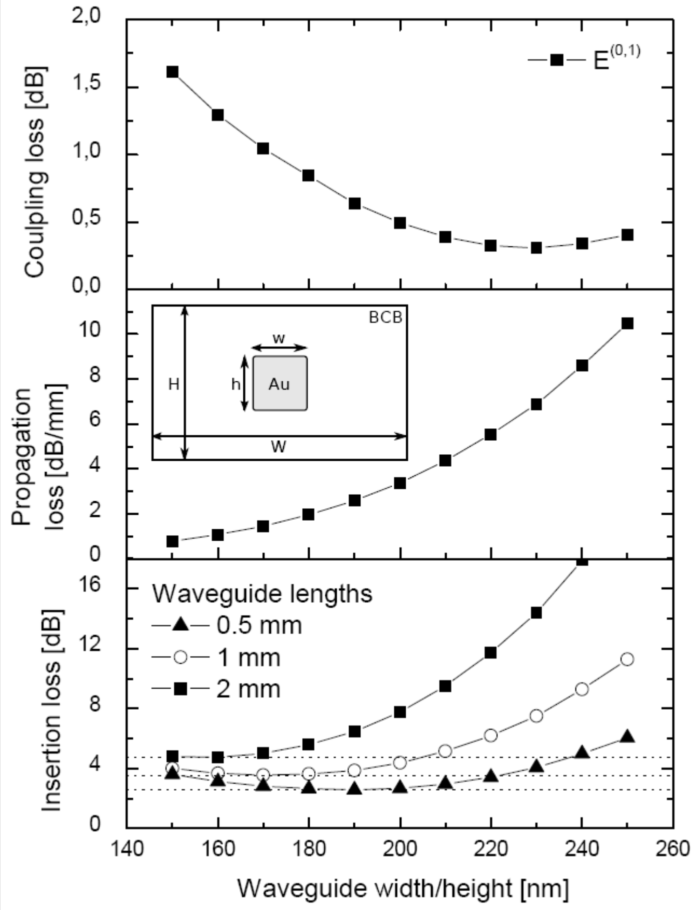
>30 dB extinction ratio

PDL < ± 2.5 dB across attenuation range

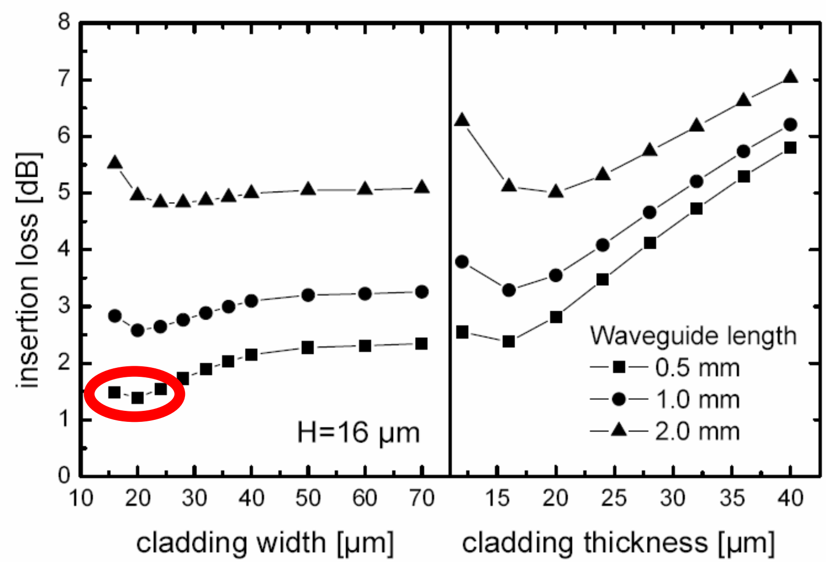
Off-state insertion loss 5-15 dB

Very strict fabrication tolerance (<5nm)

nanowire VOA

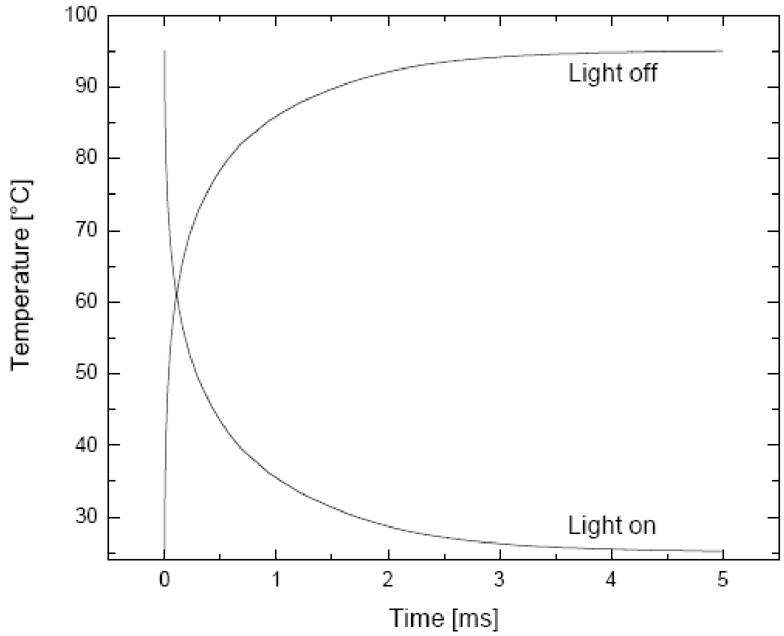


Rosenzveig, Hermansson, Leosson,
Modelling of Polarization-Dependent Loss in Plasmonic Nanowire Waveguides,
Plasmonics 5, 75 (2010)

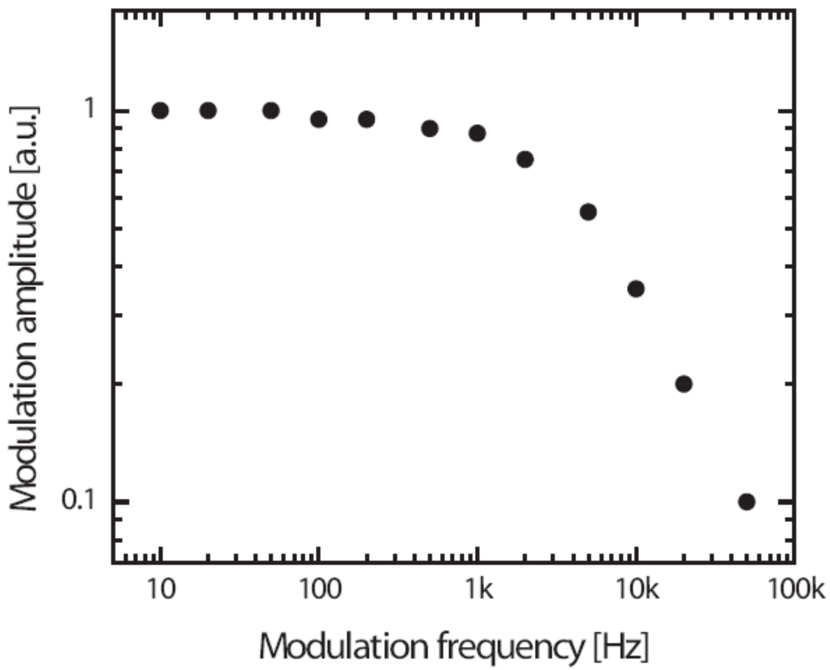


nanowire optimization

FE simulation

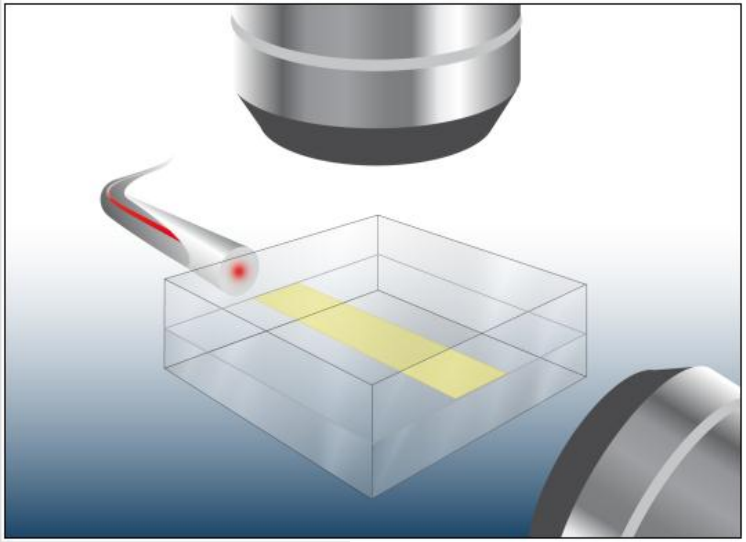


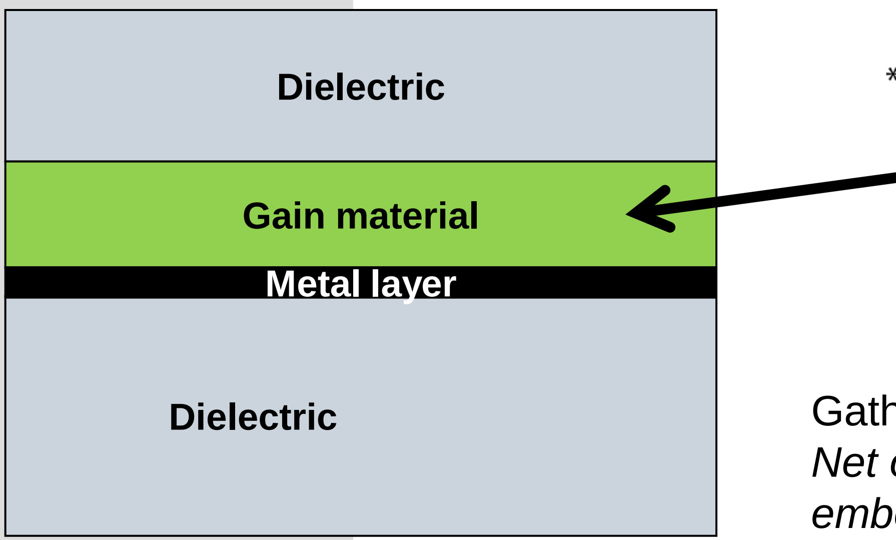
Experiment

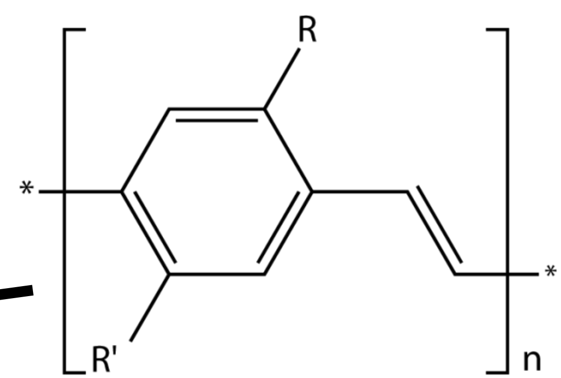


transient response

loss compensation



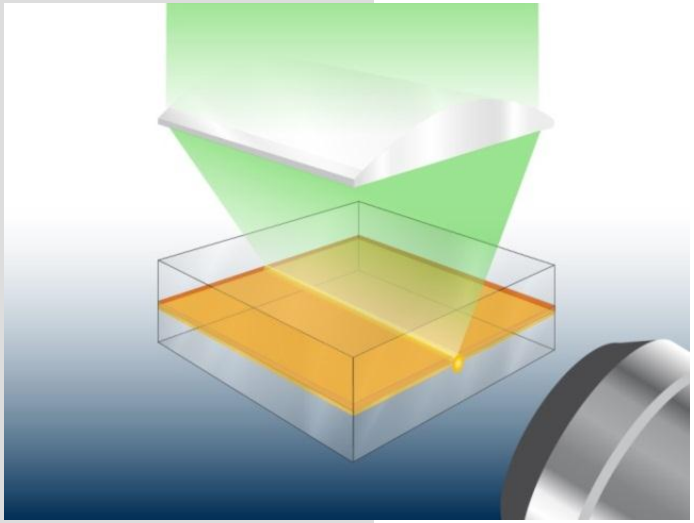


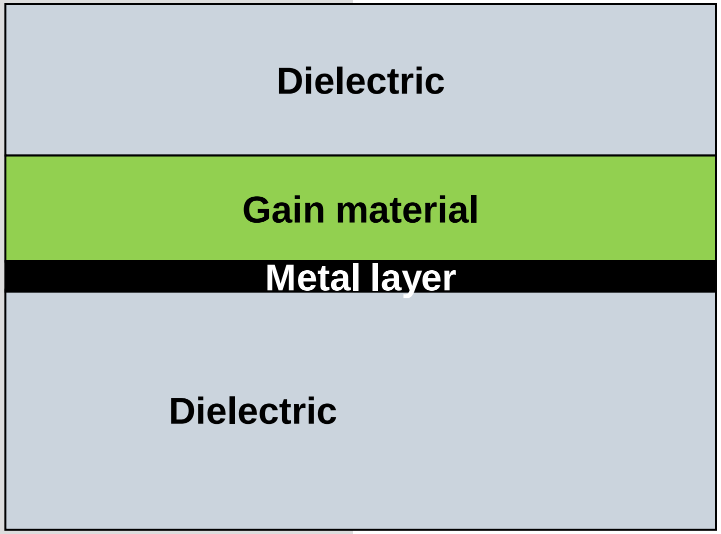


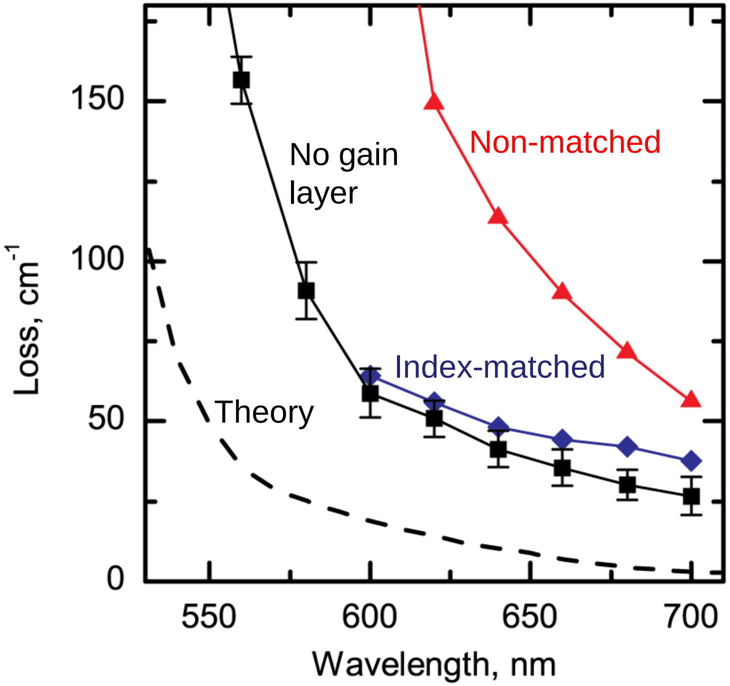
MDMO-PPV

Gather, Meerholz, Danz, Leosson,
Net optical gain in a plasmonic waveguide embedded in a fluorescent polymer,
Nature Photonics, 4, 457 (2010)

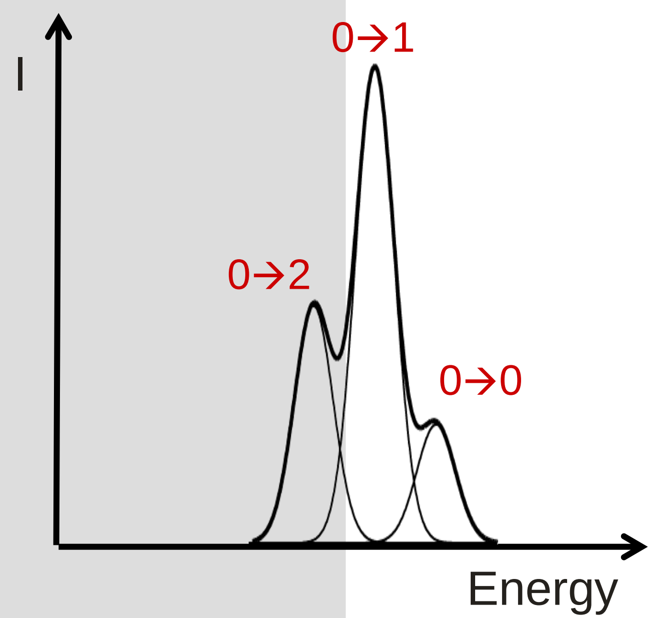
loss compensation

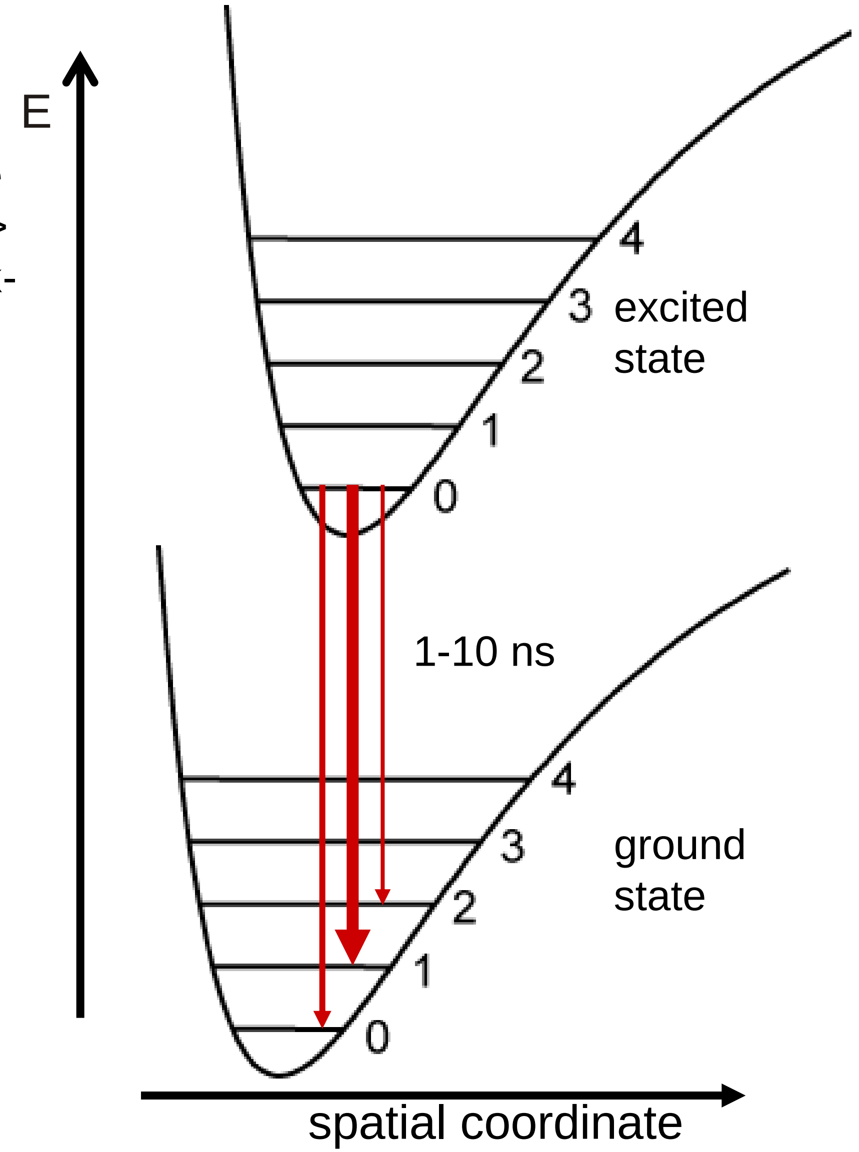






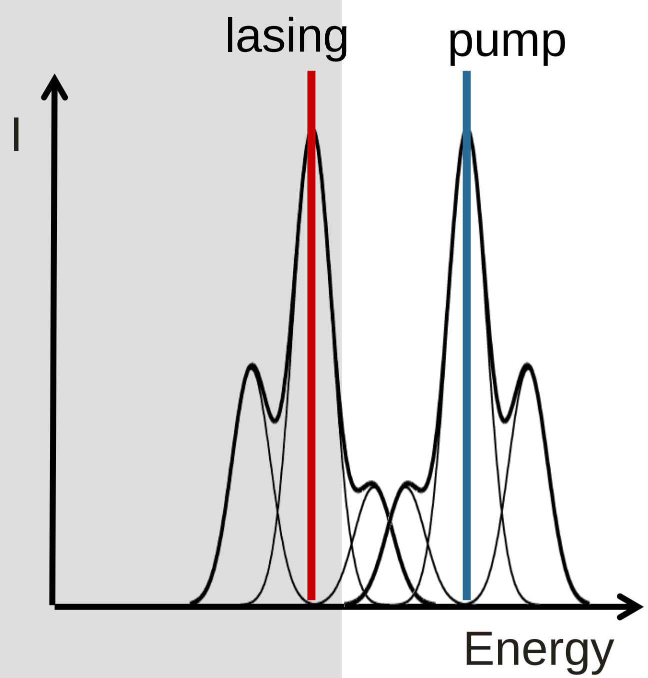
- Localization of exciton allows for strong coupling with phonons
- Vibronic relaxation <1ps
  => all emission from lowest vibronic state
- Excited state conformation is distorted => probability of transitions changes (Franck-Condon Principle)

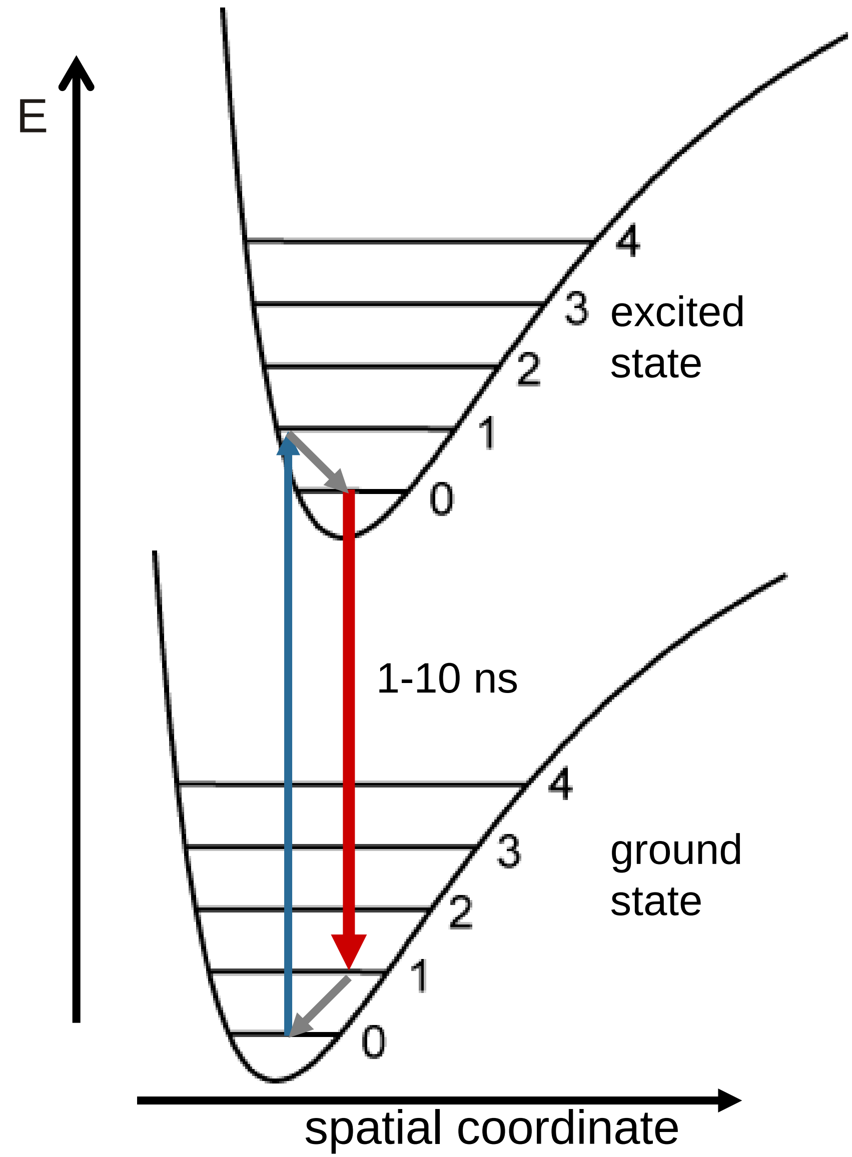




Example:

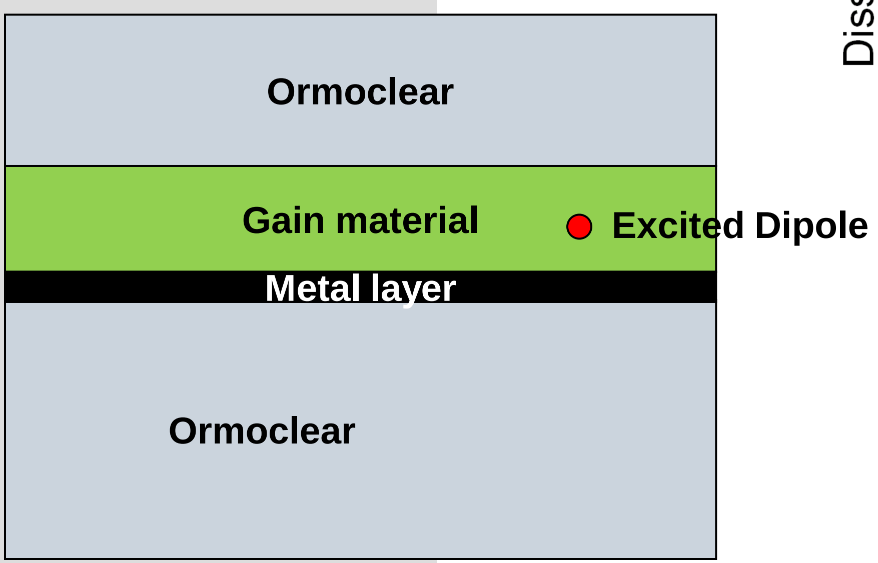
- Pump 0→1
- Vibronic relaxation 1→0
- Radiative relaxation 0→1
- Ground state relaxation 1→0

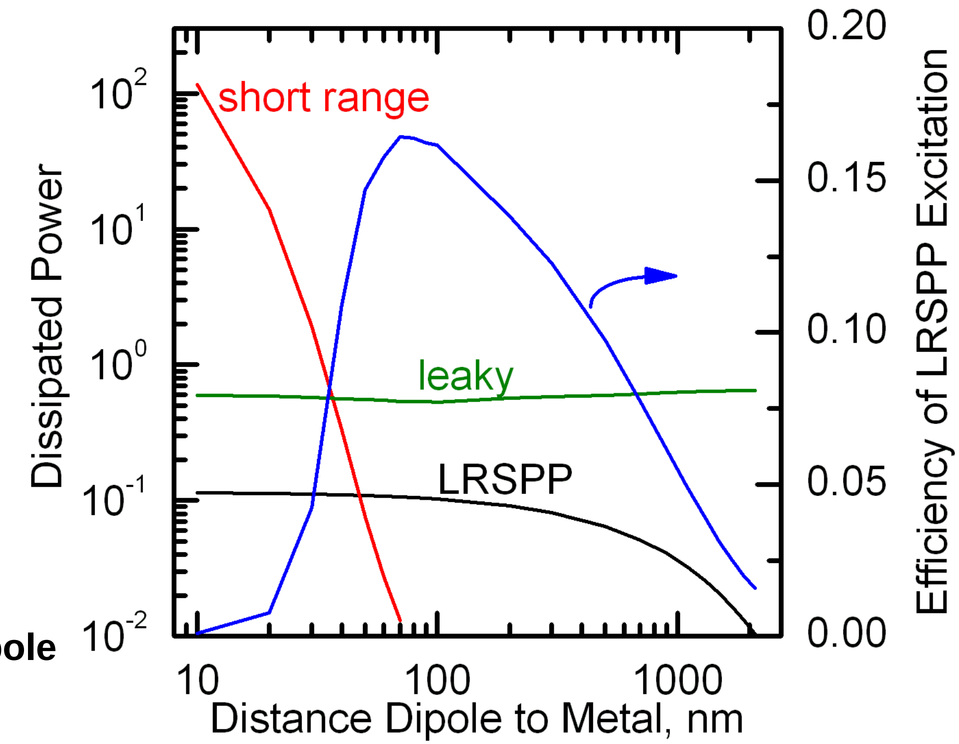


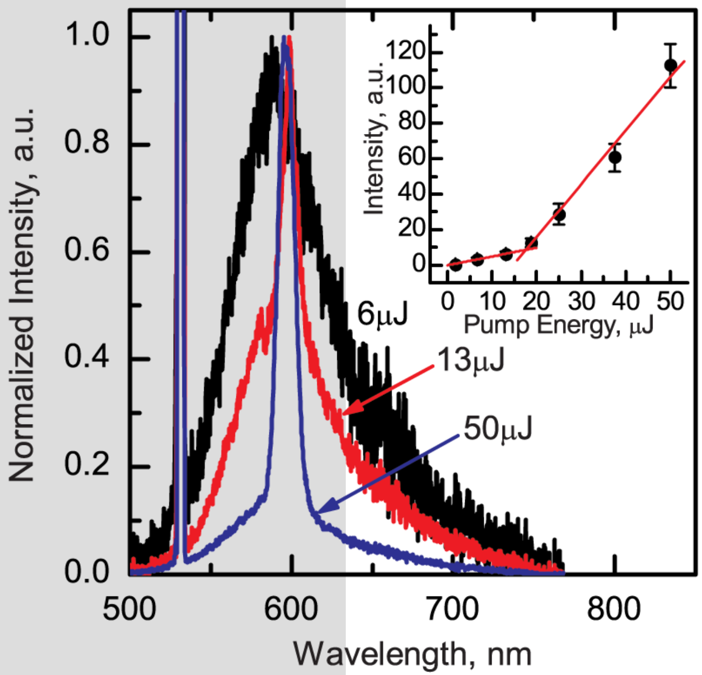


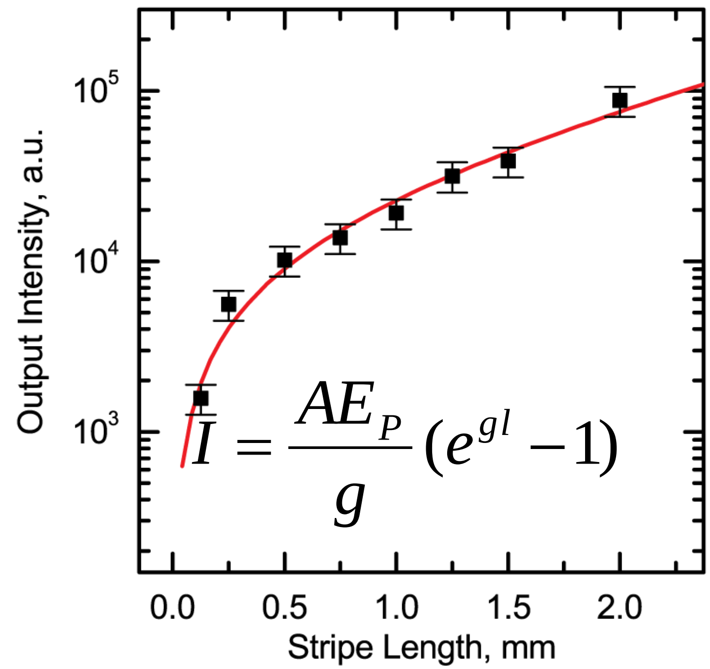
Simulation

- Is the optical energy excited in the conjugated polymer layer transferred to an LRSPP mode?
- Where should the gain material be located?







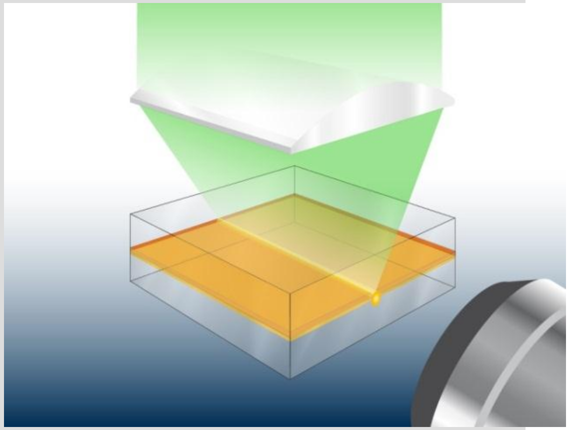


Measured net gain of *g* = 8 ± 2 cm^{-1}

(12.5 mJ/cm^2/pulse, 4-5 nm gold film)

Room temperature, 600nm wavelength

LRSPP gain



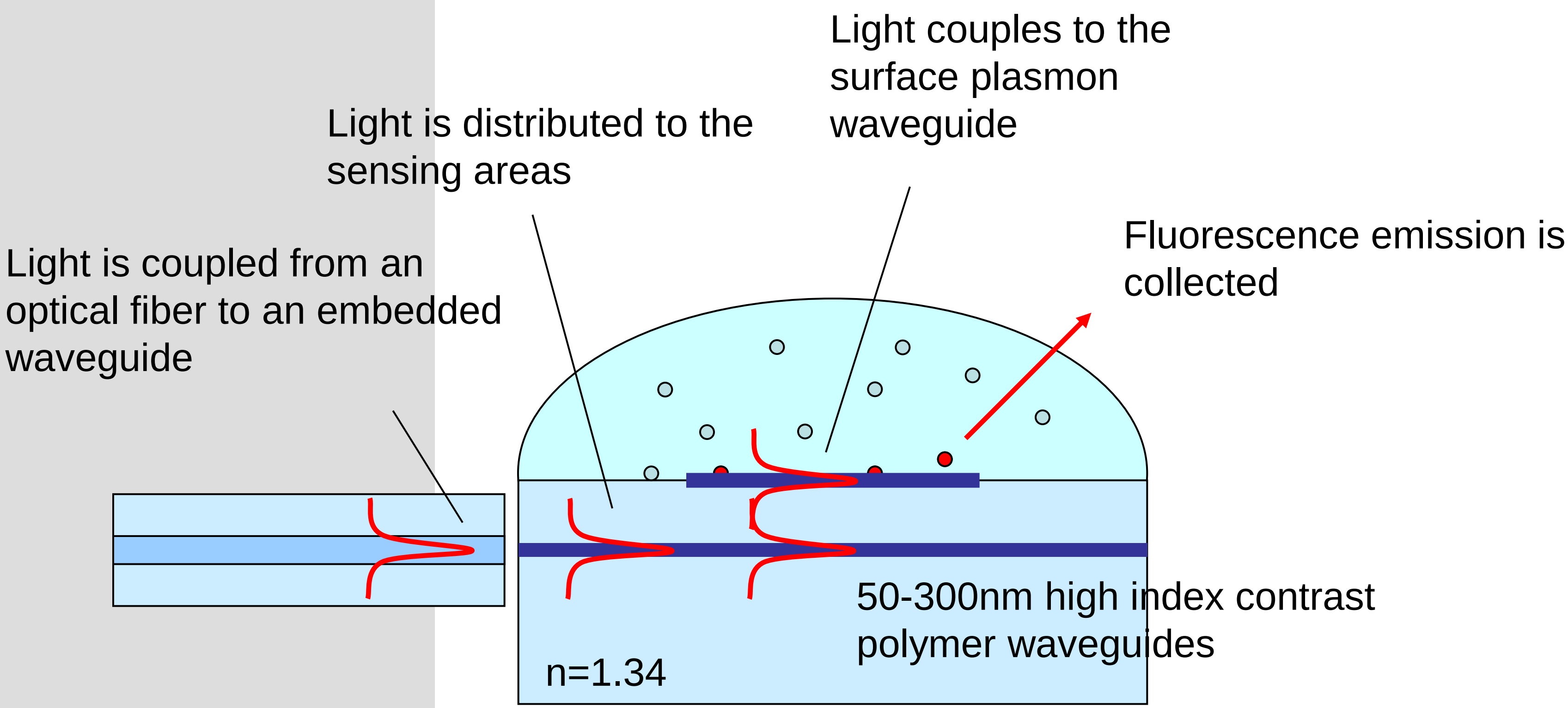
For highly confined SPPs, losses are generally too high to allow for full loss compensation with currently available gain materials and reasonable pump power

see K.Leosson, *Optical amplification of surface plasmon polaritons: a review*, J. Nanophotonics (in press)

1. Brief plasmonics background
2. SPP waveguide devices
3. Biophotonics
4. Prospects

outline

LUMISCENCE



Light couples to the surface plasmon waveguide
Light is distributed to the sensing areas
Fluorescence emission is collected
Light is coupled from an optical fiber to an embedded waveguide
50-300nm high index contrast polymer waveguides
n=1.34

Micromachines **2012**, *3*, 114-125; doi:10.3390/mi3010114

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Article

Integrated Biophotonics with CYTOP

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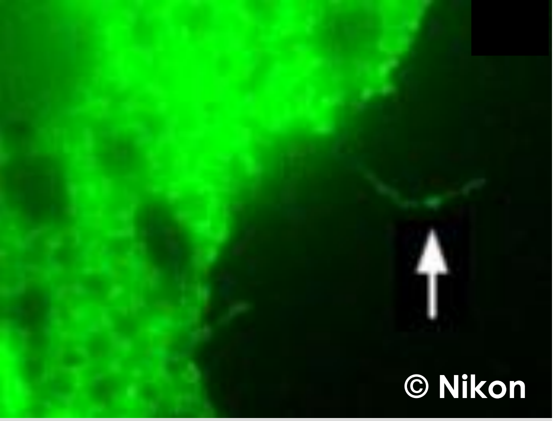
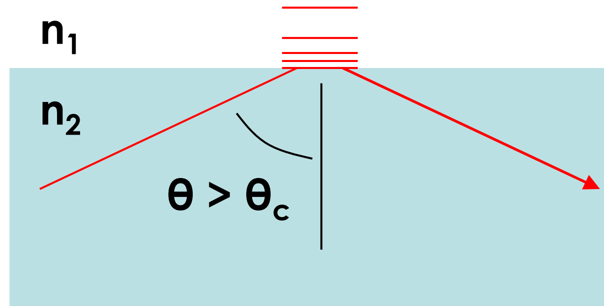
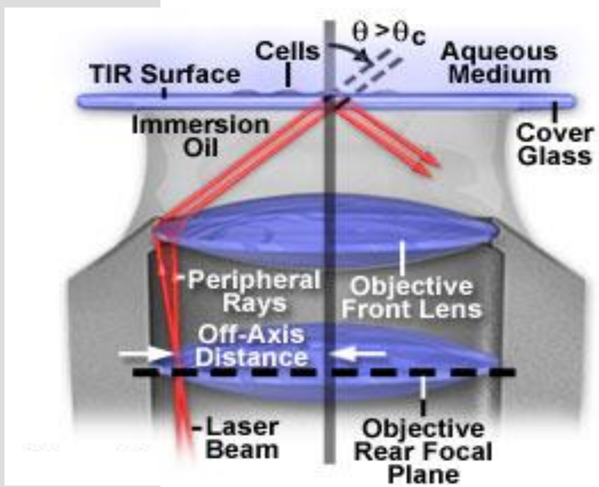
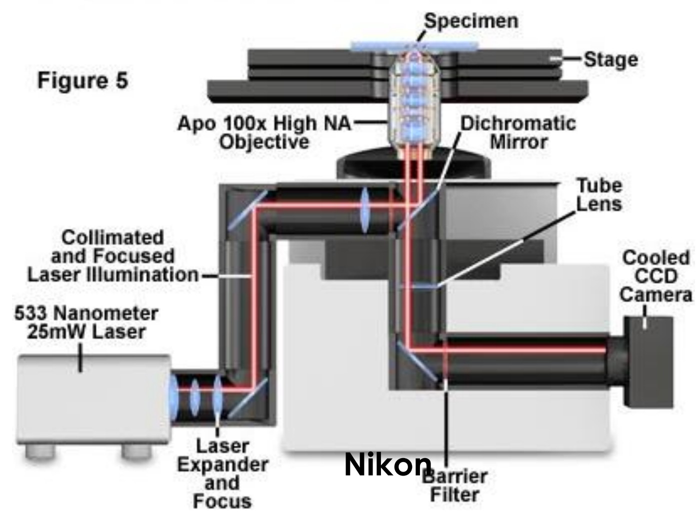
Received: 24 January 2012; in revised form: 16 February 2012 / Accepted: 20 February 2012 / Published: 29 February 2012

Abstract: We describe how the amorphous fluoropolymer CYTOP can be advantageously used as a waveguide cladding material in integrated optical circuits suitable for applications in integrated biophotonics. The unique refractive index of CYTOP ($n = 1.34$) enables the cladding material to be well index-matched to an optically probed sample solution. Furthermore, ultra-high index contrast waveguides can be fabricated, using conventional optical polymers as waveguide core materials, offering a route to large-scale integration of optical functions on a single chip. We discuss applications of this platform to evanescent-wave excitation fluorescence microscopy, passive and/or thermo-electrically-controlled on-chip light manipulation, on-chip light generation, and direct integration with microfluidic circuits through low-temperature bonding.



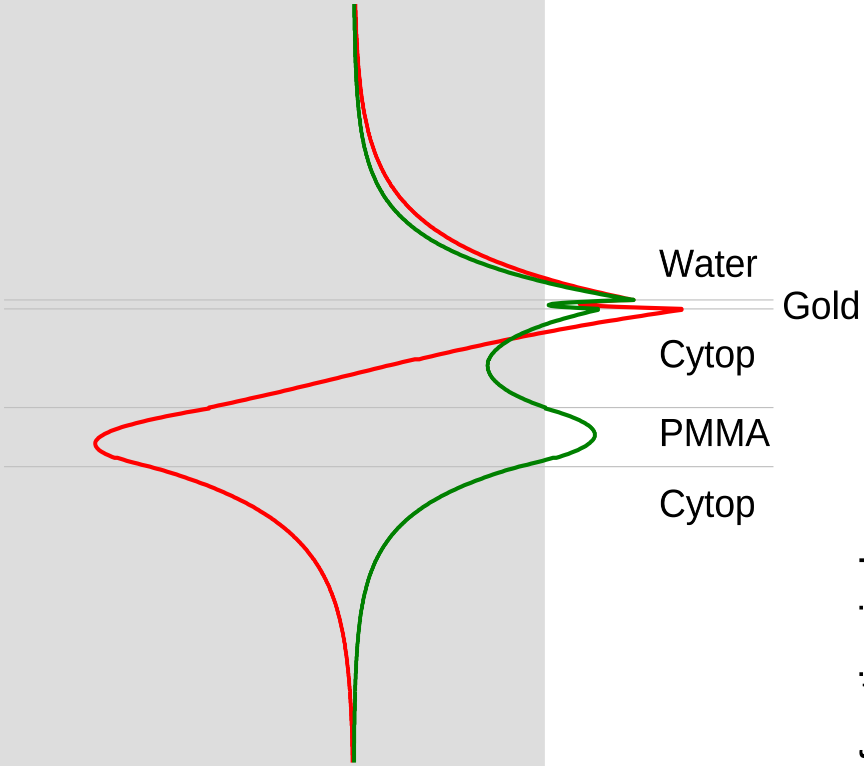


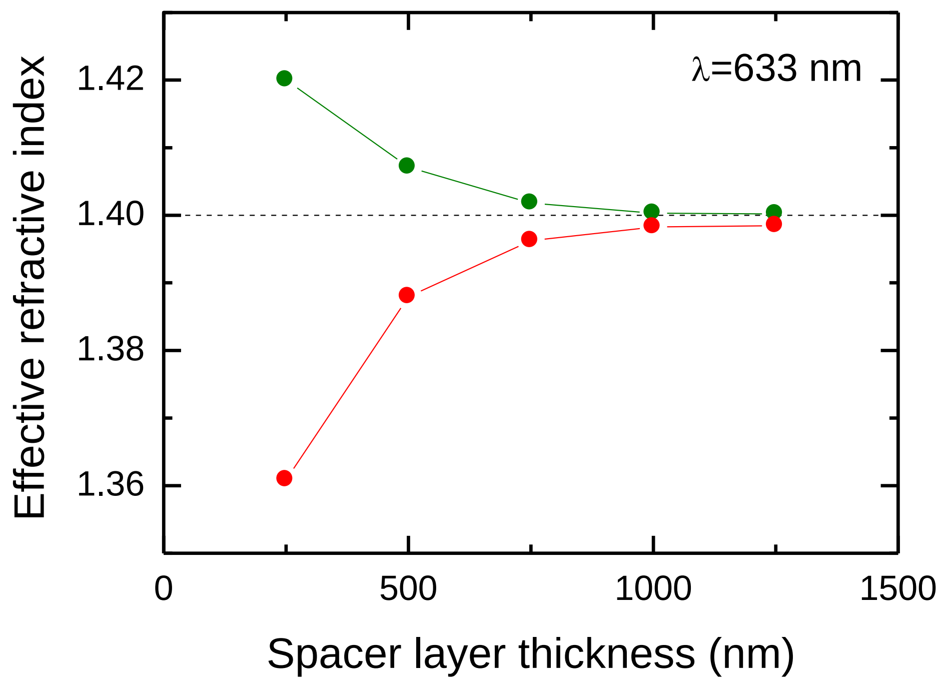




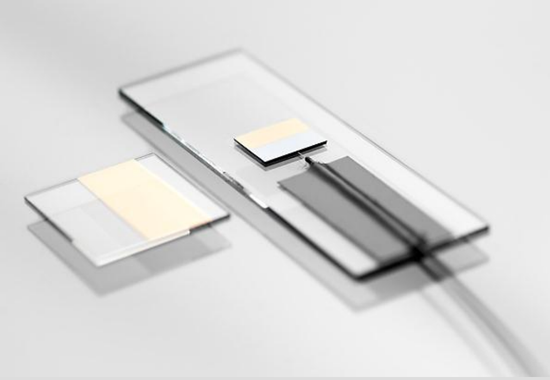
TIRF microscope

5-layer structure (cf. directional coupler)

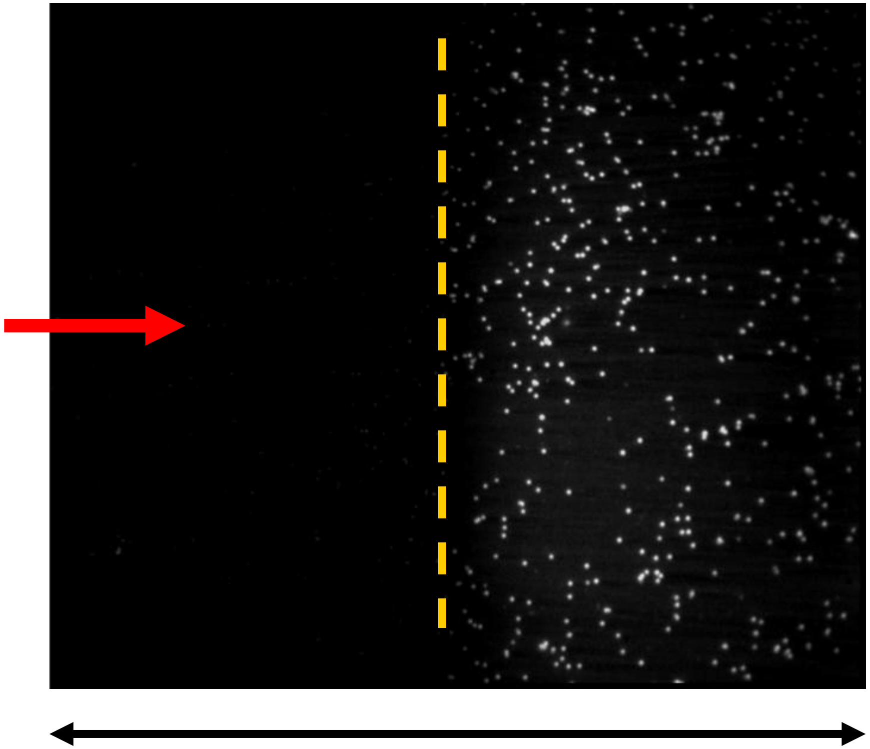




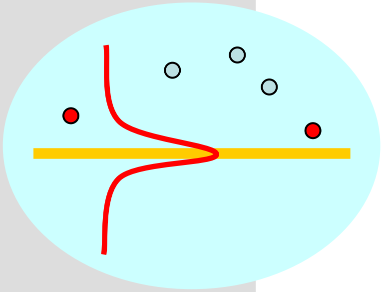
dielectric-plasmon coupling



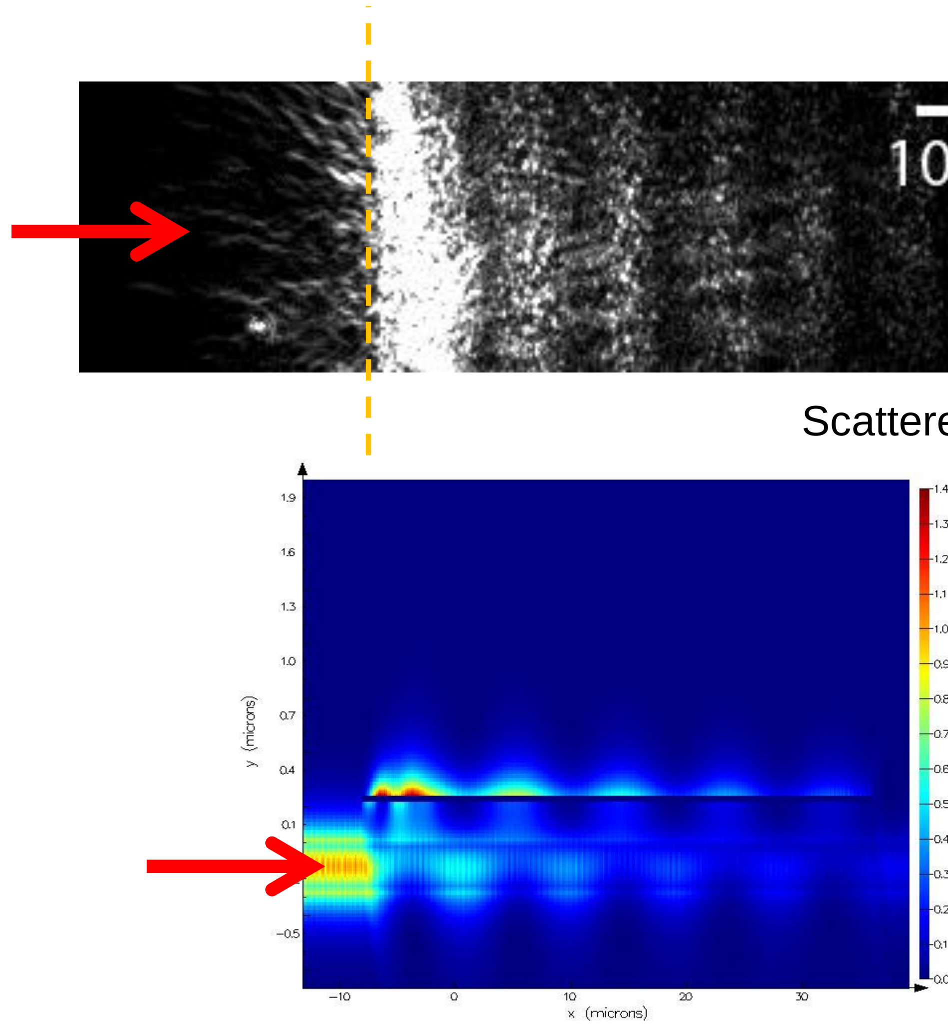
Fluorescent beads in solution



x20
NA 0.4
0.5mm



Penetration depth into liquid
approximately 1.5µm



Scattered light

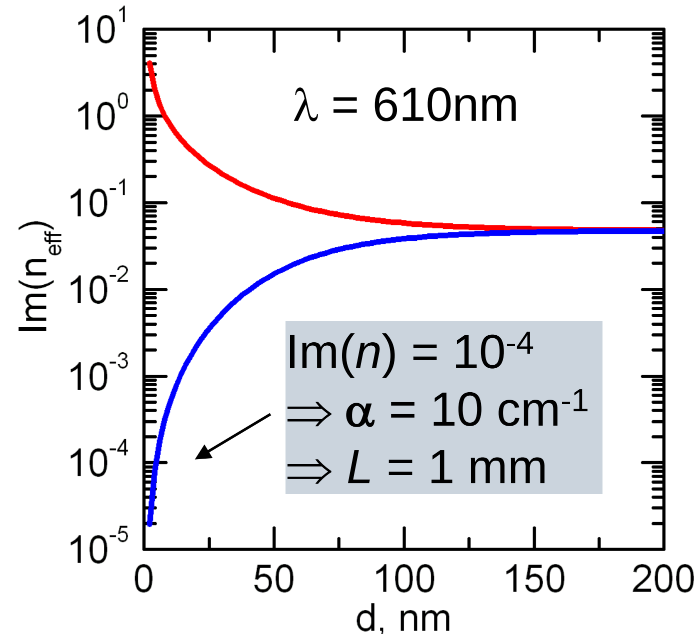
FDTD

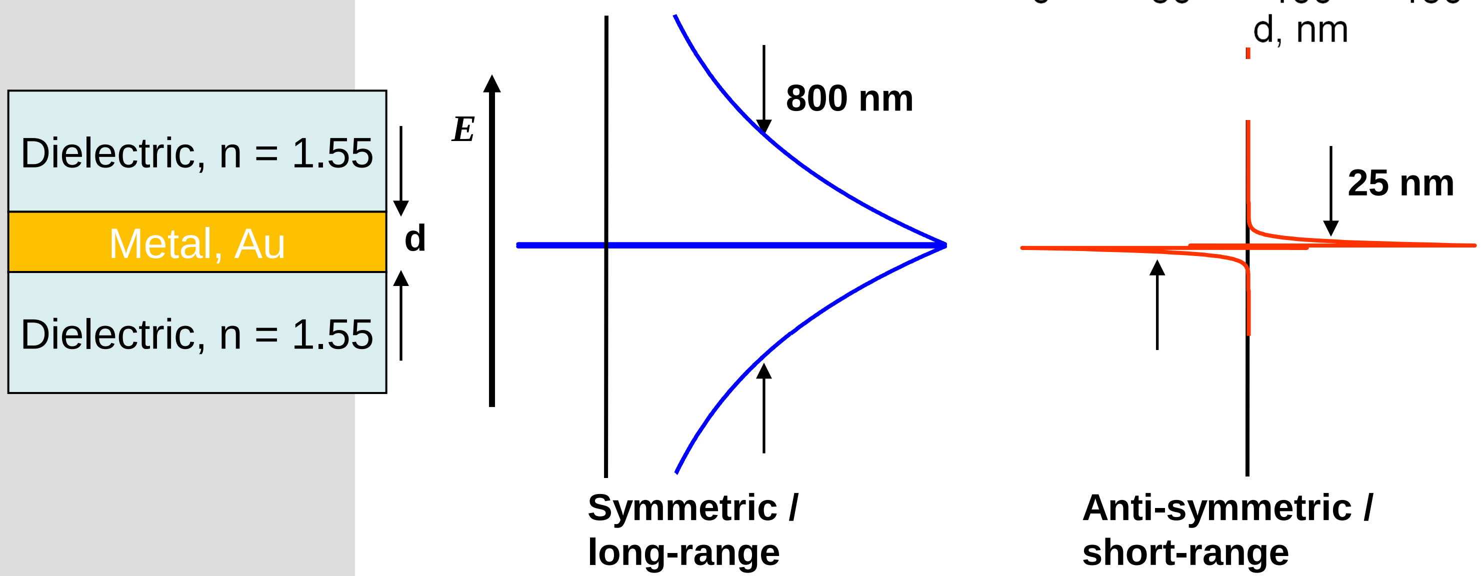
dielectric-plasmon coupling

SPP modes, thin film

$$e^{-k_2 d} = \pm \frac{k_2/\hat{\varepsilon}_2 + k_1/\hat{\varepsilon}_1}{k_2/\hat{\varepsilon}_2 - k_1/\hat{\varepsilon}_1}$$

$$k_i^2 = \beta^2 - \omega^2 \mu_0 \hat{\varepsilon}_i$$





Ultrathin layer sensing based on hybrid coupler with short-range surface plasmon polariton and dielectric waveguide

Ruiyuan Wan,[1] Fang Liu,[1,2] and Yidong Huang[1,3]

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Received August 28, 2009; revised November 16, 2009; accepted November 23, 2009; posted December 18, 2009 (Doc. ID 116389); published January 15, 2010

A highly integrated sensor that is based on a hybrid coupler composed of short-range surface plasmon polariton (SRSPP) and dielectric waveguides was proposed for refractive index detecting of an ultrathin layer. The dependence of the coupling between the SRSPP and dielectric waveguide mode on the refractive index of the detecting layer was analyzed theoretically. For a detecting layer as thin as 1/15 wavelength, the resolution can be as high as 3.3×10^{-6} refractive index units with a sensing length of only tens of micrometers.

OCIS codes: 240.6680, 280.4788.

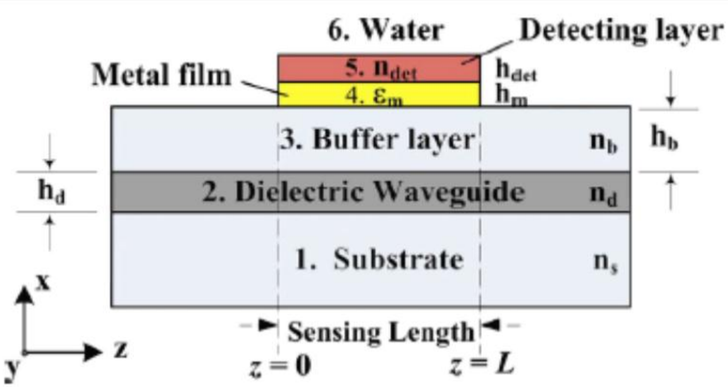
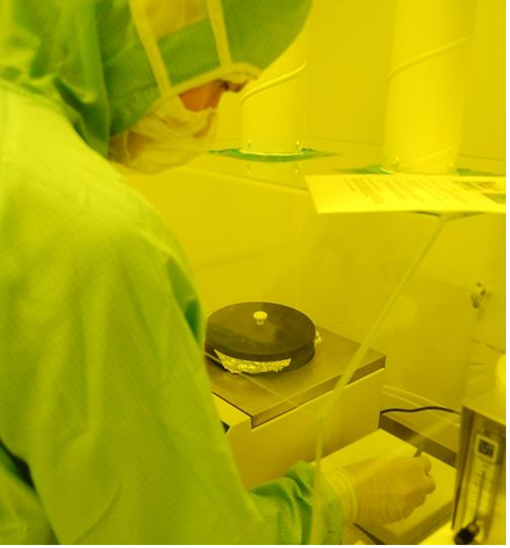
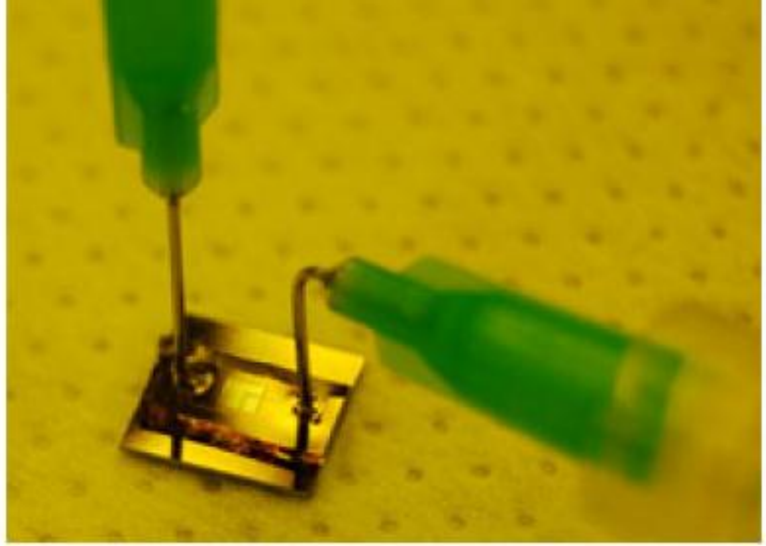
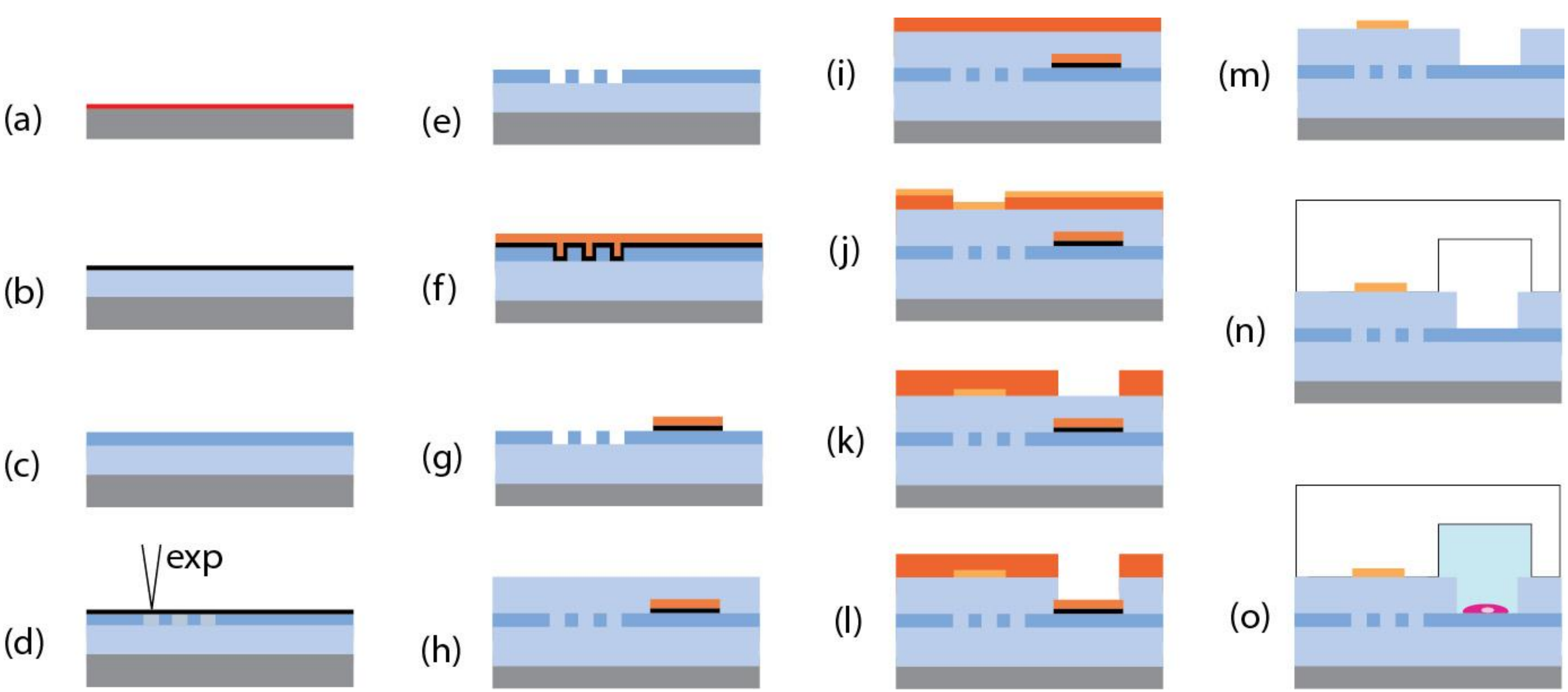


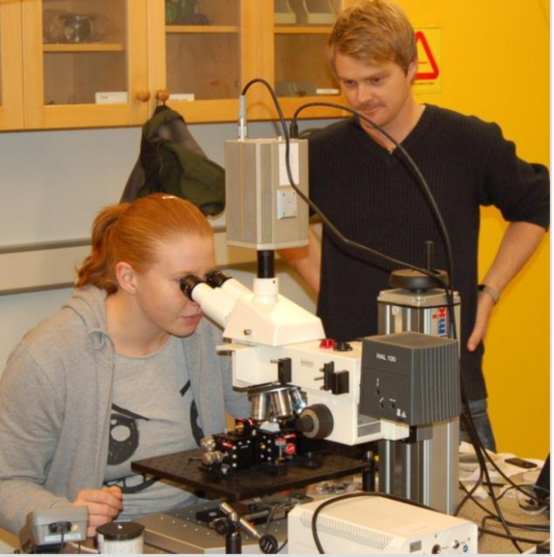
Fig. 1. (Color online) Proposed sensor based on the SRSPP–dielectric hybrid coupling structure.

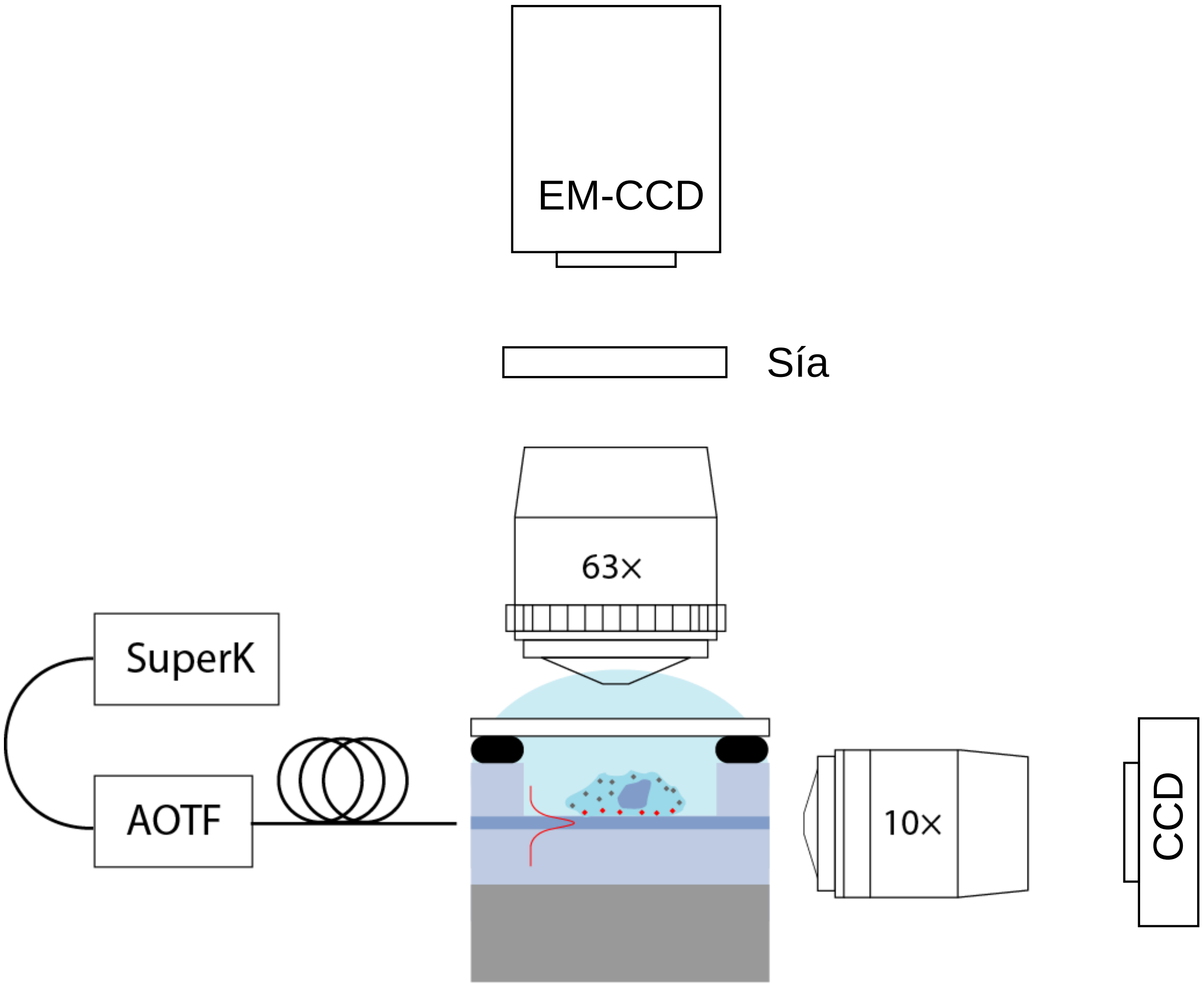




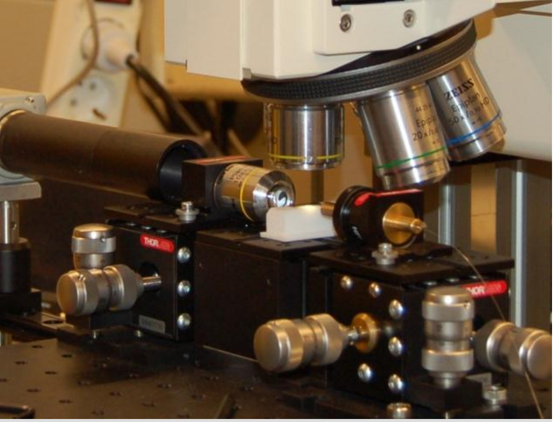
fabrication

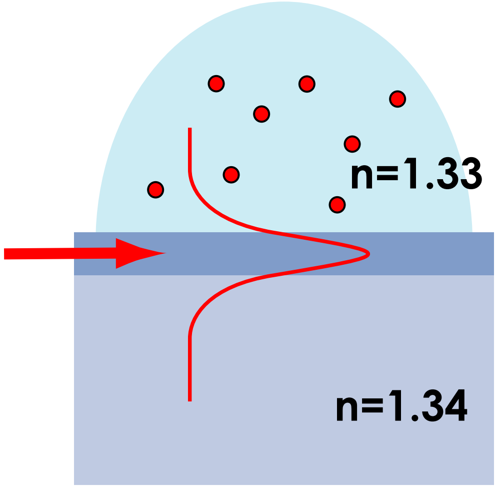


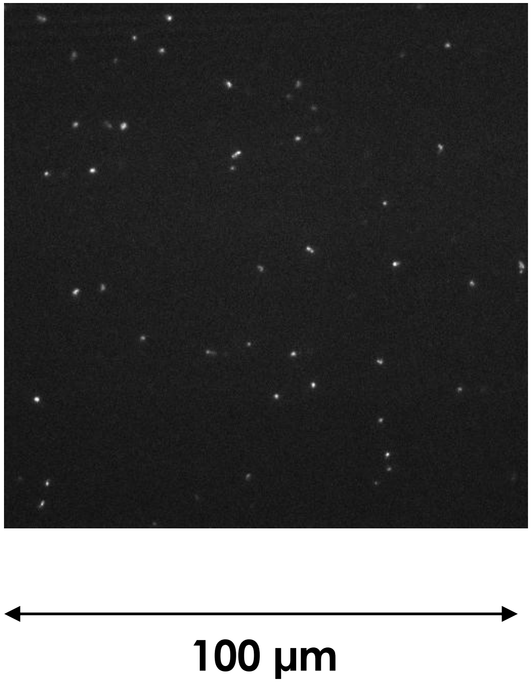




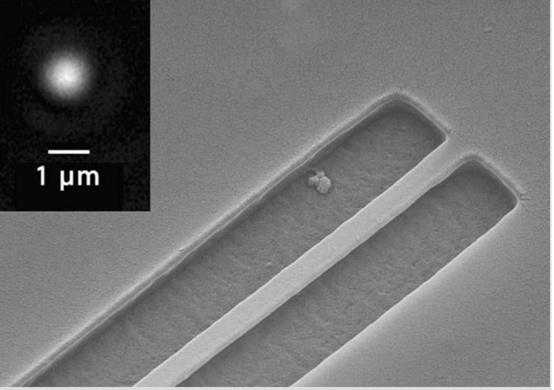
experimental set-up

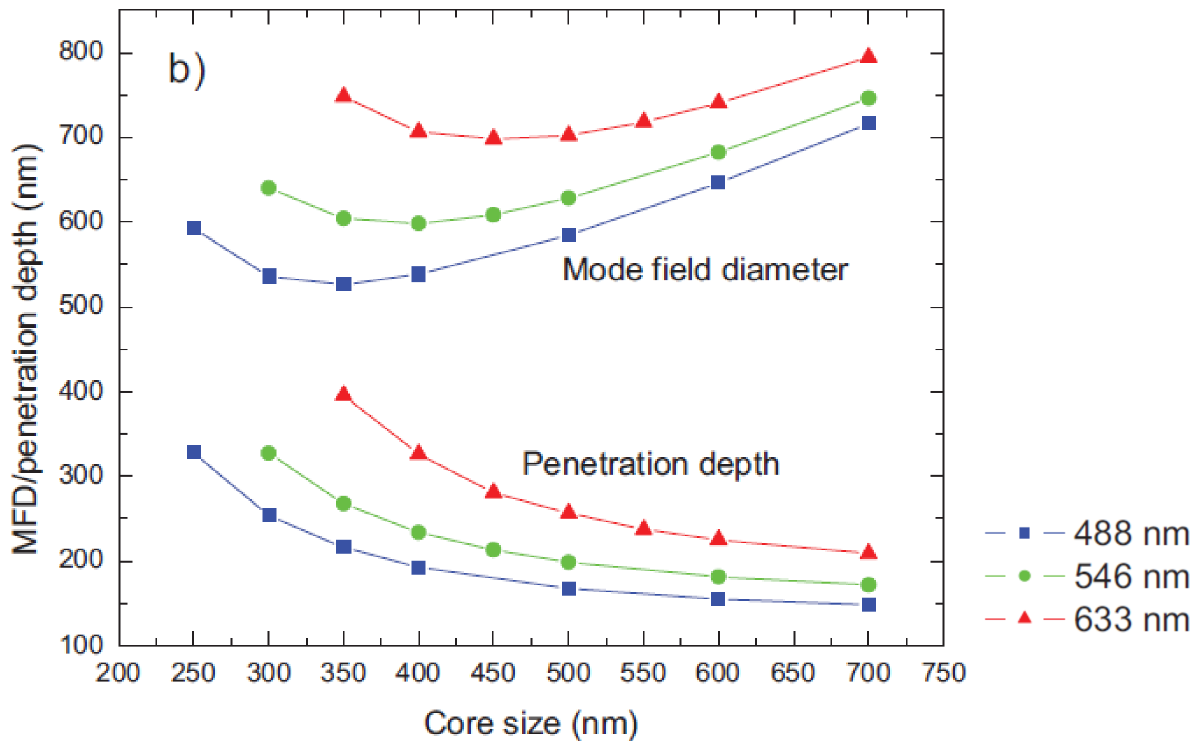




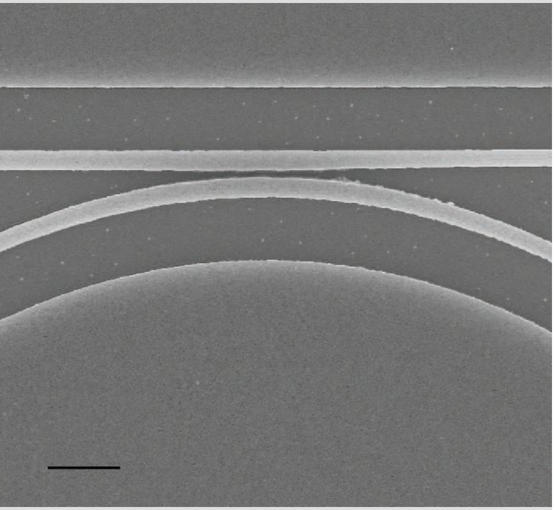


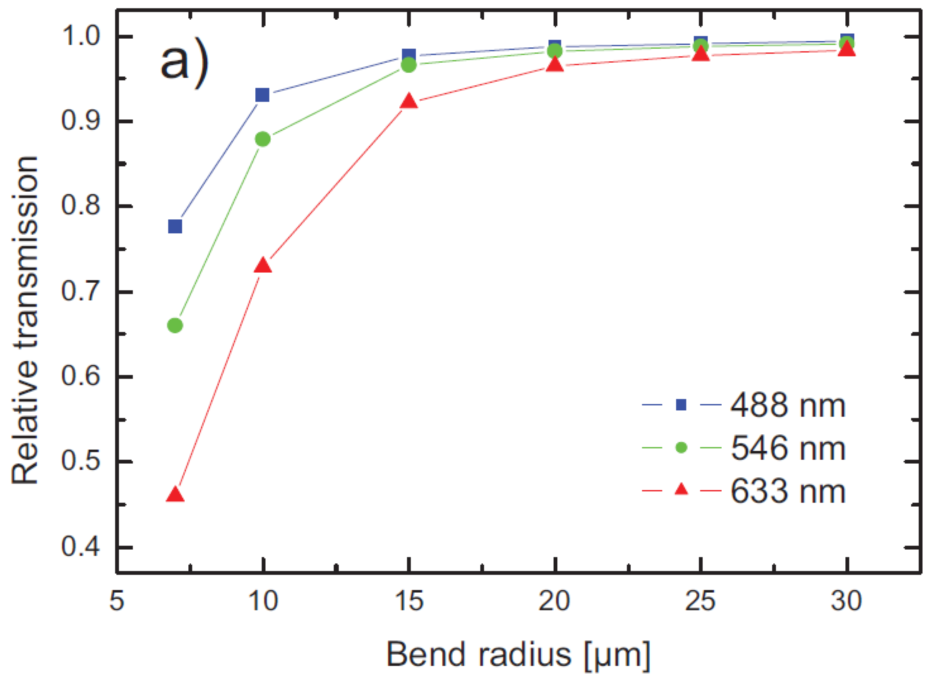
colloidal gold solution





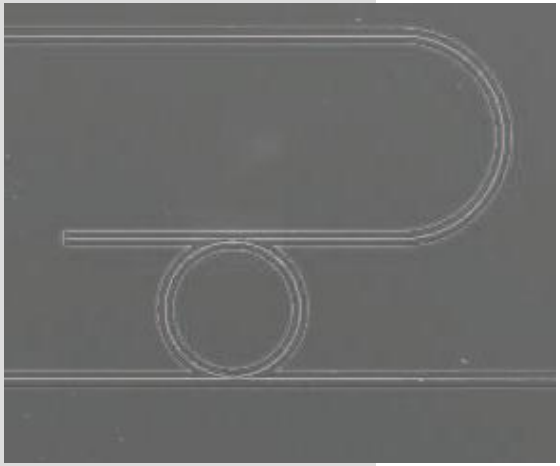
buried channel waveguides

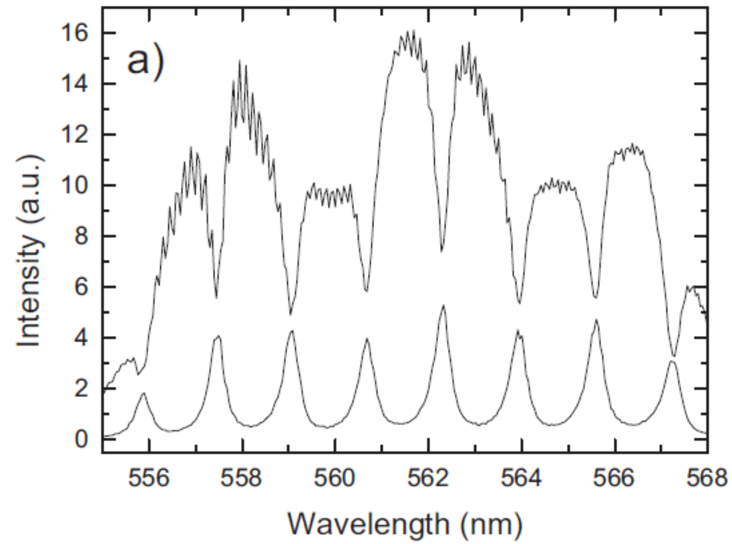




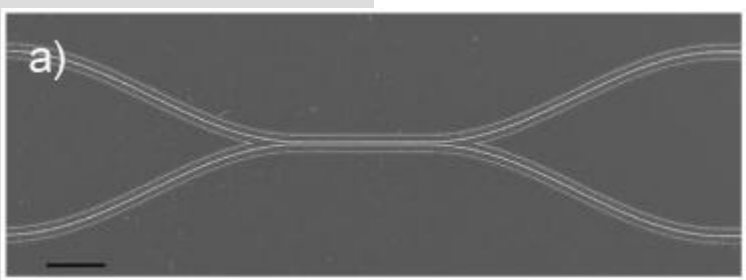
a)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
Relative transmission
5
10
15
20
25
30
Bend radius [μm]
488 nm
546 nm
633 nm

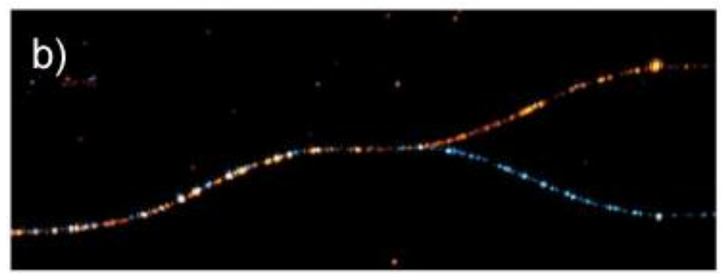
b e n d   l o s s





Q≈1000





f i l t e r s

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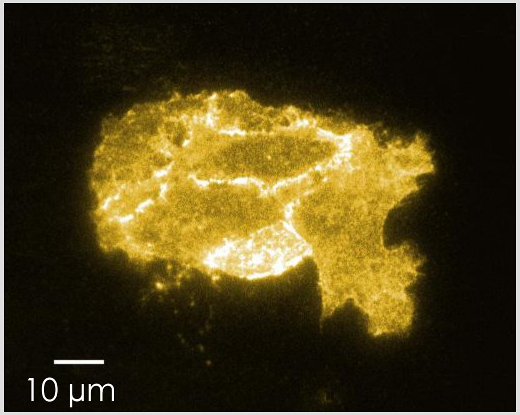

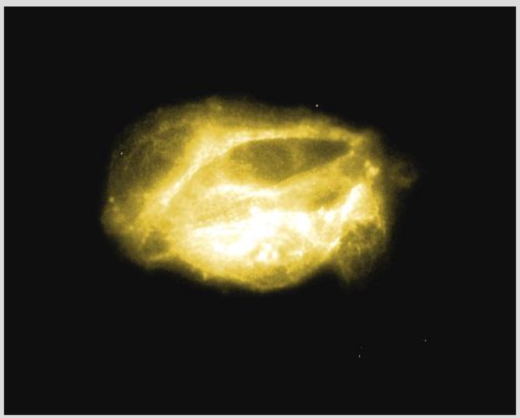

Evanescent-wave fluorescence microscopy using symmetric planar waveguides

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[2]Stem Cell Biology Unit, Department of Anatomy, Biomedical Center, University of Iceland and Department of Laboratory Hematology, Landspitali-University Hospital (K-building), IS-101, Reykjavik, Iceland
[*]Corresponding author: kleos@hi.is

Abstract: We describe a new evanescent-wave fluorescence excitation method, ideally suited for imaging of biological samples. The excitation light propagates in a planar optical waveguide, consisting of a thin waveguide core sandwiched between a sample in an aqueous solution and a polymer with a matching refractive index, forming a symmetric cladding environment. This configuration offers clear advantages over other waveguide-excitation methods, such as superior image quality, wide tunability of the evanescent field penetration depth and compatibility with optical fibers. The method is well suited for cell membrane imaging on cells in culture, including cell-cell and cell-matrix interaction, monitoring of surface binding events and similar applications involving aqueous solutions.

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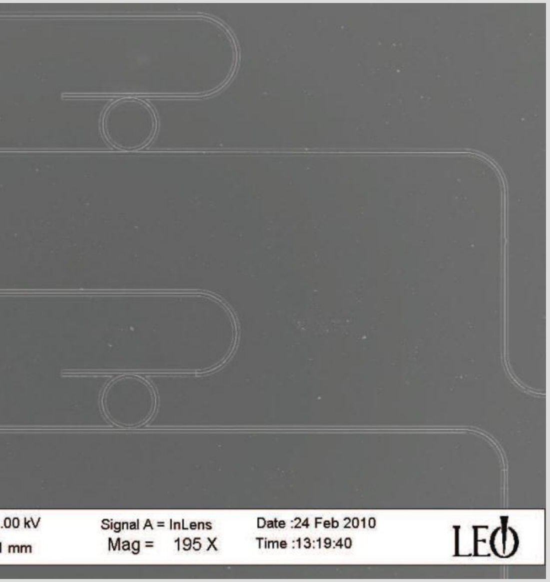

High index contrast polymer waveguide platform for integrated biophotonics

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[2]*Cancer Research Laboratory, Faculty of Medicine, University of Iceland, Vatnsmyrarvegi 16, 101 Reykjavik, Iceland*
[3]*Currently with the Department of Oncology and The Medical Research Council Cancer Cell Unit, Hutchinson/MRC Research Centre, Hills Road, Cambridge, CB2 0XZ, UK*
**kleos@hi.is*

Abstract: We present detailed characterization of a unique high-index-contrast integrated optical polymer waveguide platform where the index of the cladding material is closely matched to that of water. Single-mode waveguides designed to operate across a large part of the visible spectrum have been fabricated and waveguide properties, including mode size, bend loss and evanescent coupling have been modeled using effective-index approximation, finite-element and finite-difference time domain methods. Integrated components such as directional couplers for wavelength splitting and ring resonators for refractive-index or temperature sensing have been modeled, fabricated and characterized. The waveguide platform described here is applicable to a wide range of biophotonic applications relying on evanescent-wave sensing or excitation, offering a high level of integration and functionality. The technology is biocompatible and suitable for wafer-level mass production.

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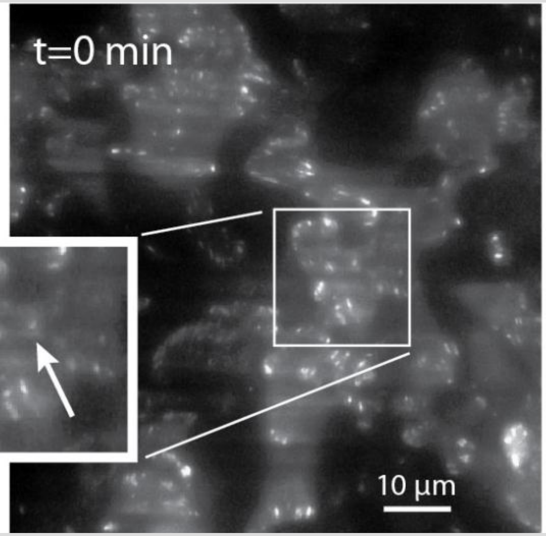

On-chip modulation of evanescent illumination and live-cell imaging with polymer waveguides

Björn Agnarsson,[1,2] Asta B. Jonsdottir,[3,4] Nina B. Arnfinnsdottir[1,5] and Kristjan Leosson[1,*]

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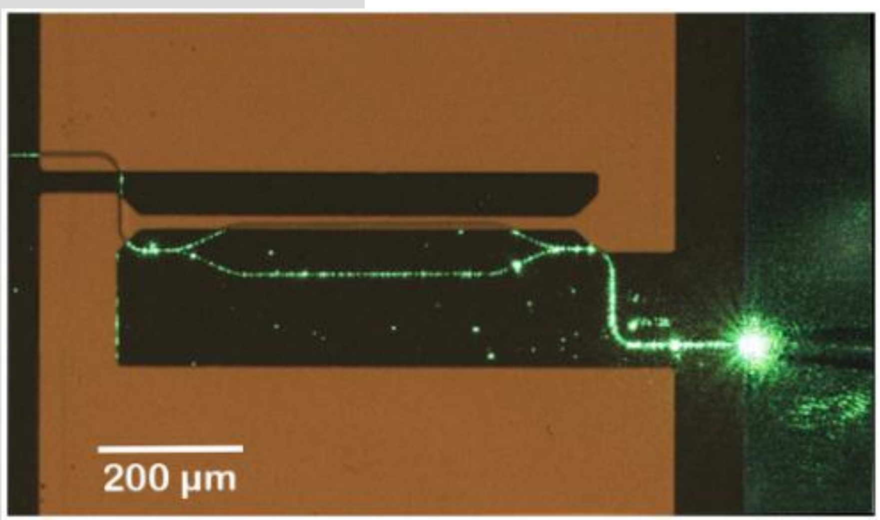
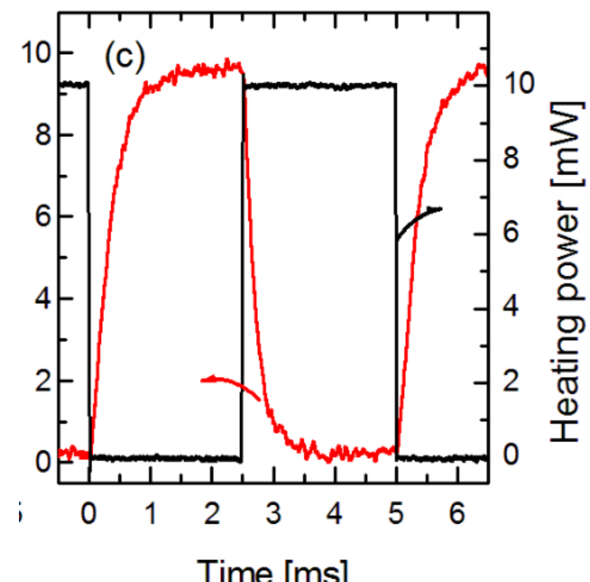




Fredrik Höök receives Sweden's biggest national prize in physics

Published Tue 03 Apr 2012

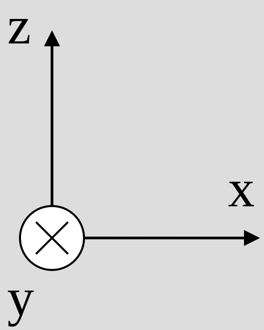
Fredrik Höök, Professor in Biological Physics at Chalmers, receives this year's Göran Gustafsson Prize in physics from The Royal Swedish Academy of Sciences. He is awarded the prize for his outstanding research on the cell membrane. He now receives SEK 4.5 million for new research projects that he selects entirely as he sees fit.

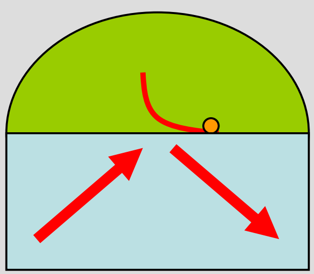
Professor Fredrik Höök studies cell membranes using cell-membrane mimics – artificial variants of membrane that coat all cells. He and his research team are currently working on two particularly promising research projects. One focuses on separating membrane proteins for identification of drug targets. The other focuses on viral infection – how virus particles and cell membranes interact when a virus crosses the membrane.

The motivation for the prize reads: *"For very successful research within the area of biophysics. It applies, above all, to the development of experimental bioanalytical methods. The aim is to increase the understanding of how biomolecular interactions form the activities in living cells."*

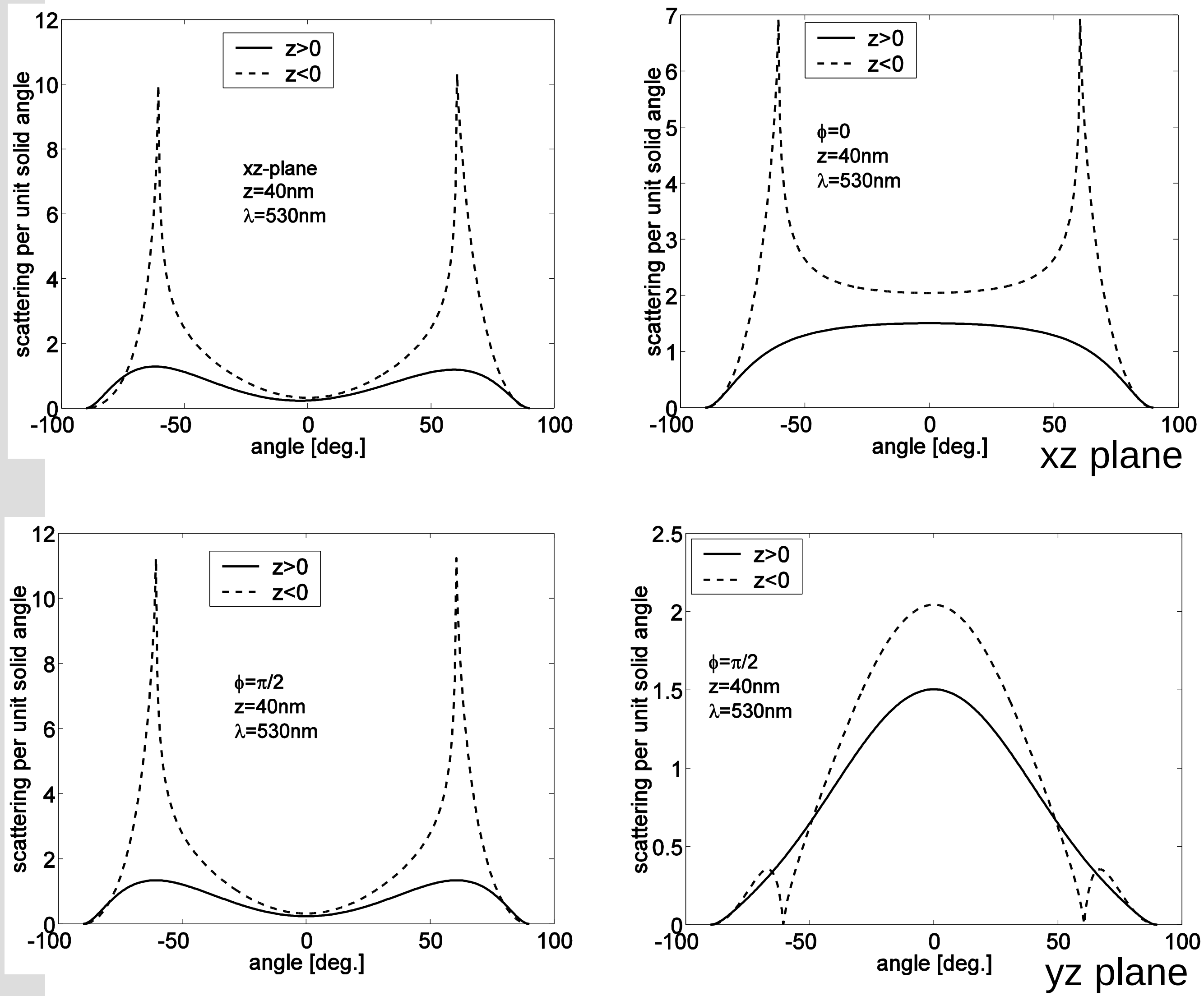
Fredrik Höök explains that he primarily sees the Göran Gustafsson Prize as a reward for a collective effort.

Blood diagnostics platform (Lumiscence/IMI Inc.)





p-polarized (TM) | s-polarized (TE)



WO 2007/077218 A1

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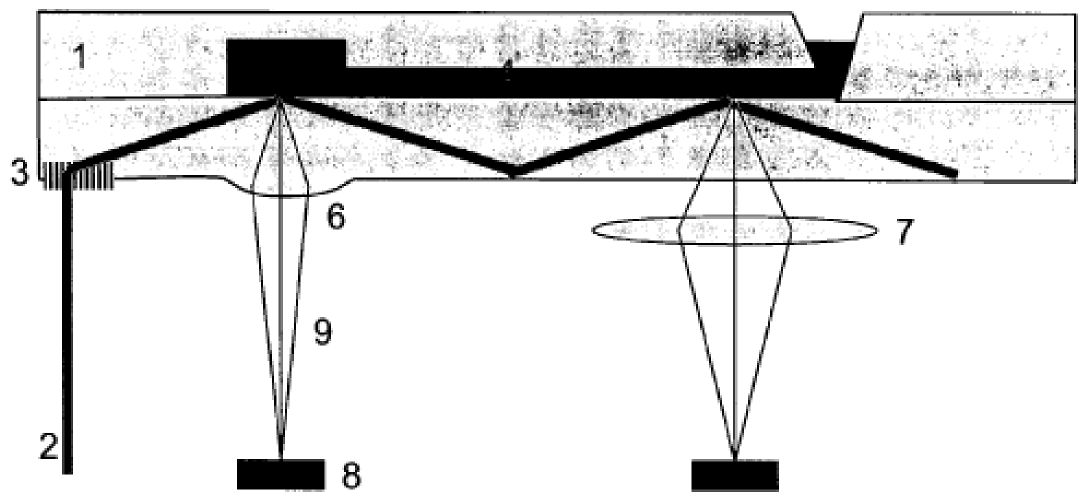
European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

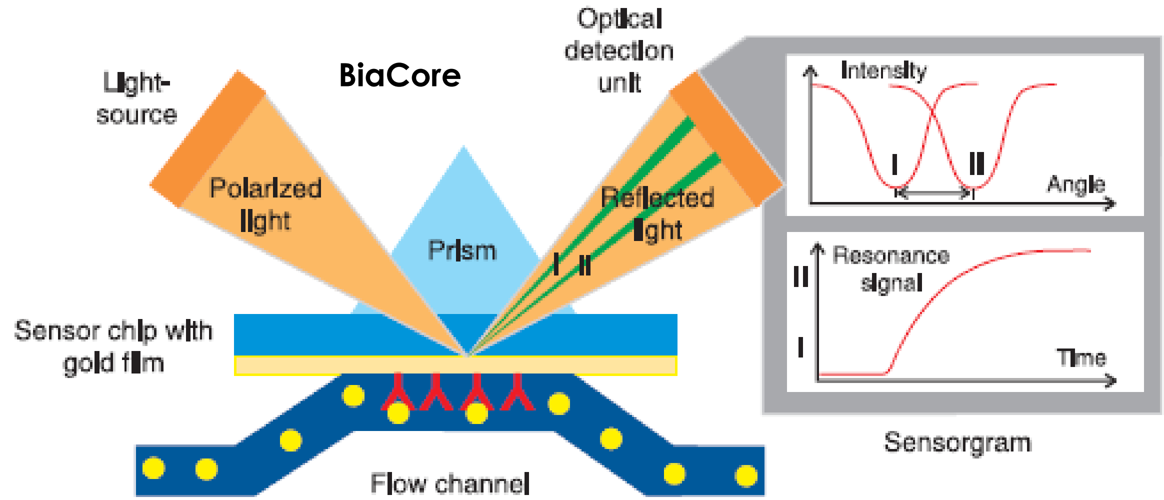
(54) **Title:** AN OPTICAL SYSTEM; AN OPTICAL CHIP FOR AN OPTICAL SYSTEM AND A METHOD OF USING AN OPTICAL CHIP FOR AN ANALYTICAL OPERATION

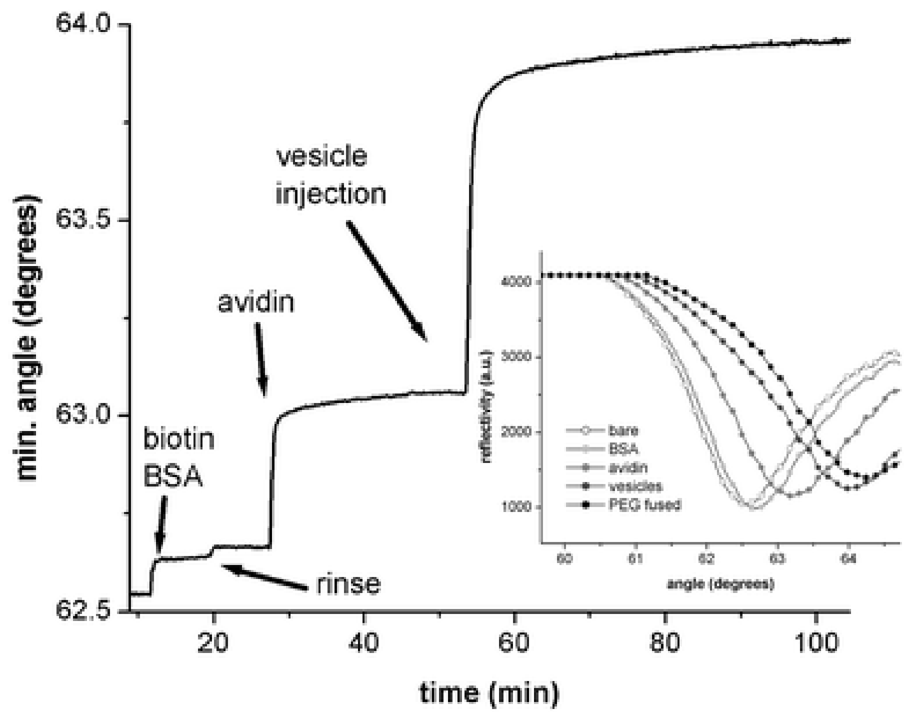


(57) **Abstract:** The present invention provides an optical system for use in analytical operations. The system comprises an optical chip with a chamber for a sample with a lower refractive index than the material of at least a part of the optical chip defining a transparent window into the chamber. The system also comprises at least one lens, a light source and a detector. The light source is arranged to direct a light beam into the chip- sample interface to generate an evanescent field, and the detector is arranged to collect light (such as fluorescence or scattered light) from objects in the sample induced by the evanescent field via the lens, which is either incorporated into the optical chip or is placed between the optical chip and the detector to collect and direct light to the detector. Also provided are a method of using the optical system and an optical chip.

1. Brief plasmonics background
2. SPP waveguide devices
3. Biophotonics
4. Prospects

outline

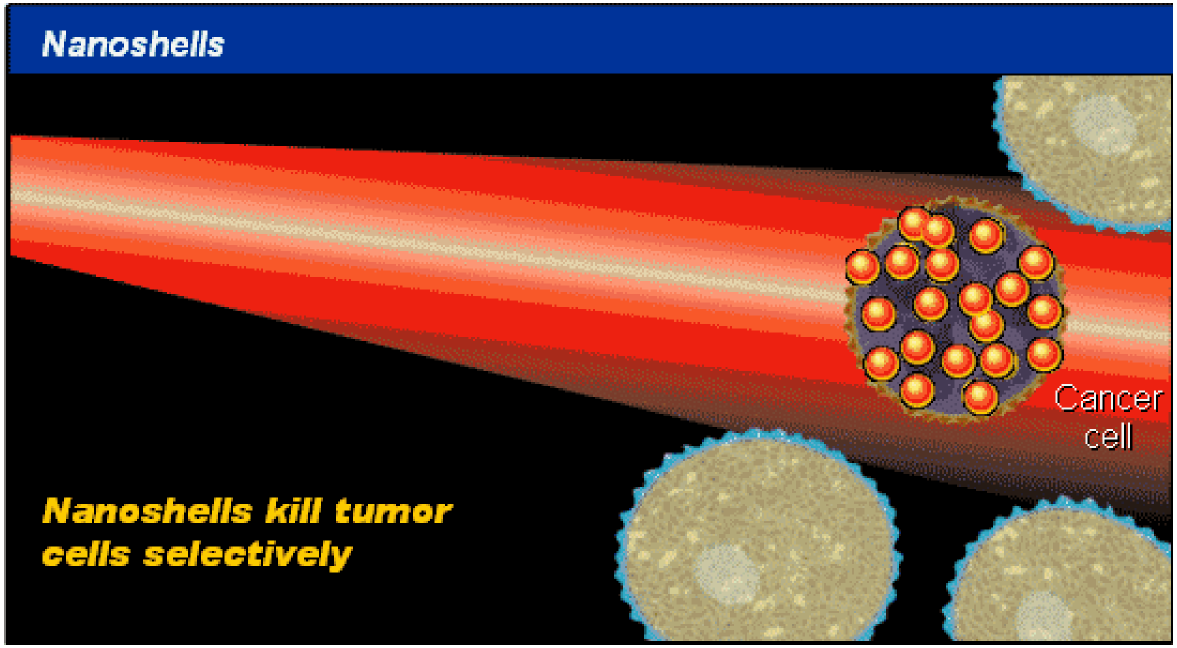

BiaCore
Light-source
Polarized light
Prism
Optical detection unit
Reflected light
I II
Sensor chip with gold film
Flow channel
Intensity
Angle
I
II
Resonance signal
Time
Sensorgram


min. angle (degrees)
64.0
63.5
63.0
62.5
time (min)
20
40
60
80
100
biotin BSA
avidin
vesicle injection
rinse
reflectivity (a.u.)
4000
3000
2000
1000
bare
BSA
avidin
vesicles
PEG fused
angle (degrees)
60
61
62
63
64

SPR device

- Overview
- Understanding Nanotechnology
  - Video Journey Into Nanotechnology
  - Nanowires
  - Cantilevers
  - Nanoshells
  - Nanoparticles
  - Image Library
  - Tools for Education
  - Cancer Nanotechnology FAQ
  - Glossary
- Impacts on Cancer
- Where It Stands Now

Nanotechnology Animations: Nanoshells



Reference: Jennifer West, Rice University

Innovations in optical microfluidic technologies for point-of-care diagnostics†

Frank B. Myers and Luke P. Lee*

Received 18th July 2008, Accepted 1st October 2008
First published as an Advance Article on the web 30th October 2008
DOI: 10.1039/b812343h

Despite a growing focus from the academic community, the field of microfluidics has yet to produce many commercial devices for point-of-care (POC) diagnostics. One of the main reasons for this is the difficulty in producing low-cost, sensitive, and portable optical detection systems. Although electrochemical methods work well for certain applications, optical detection is generally regarded as superior and is the method most widely employed in laboratory clinical chemistry. Conventional optical systems, however, are costly, require careful alignment, and do not translate well to POC devices. Furthermore, many optical detection paradigms such as absorbance and fluorescence suffer at smaller geometries because the optical path length through the sample is shortened. This review examines the innovative techniques which have recently been developed to address these issues. We highlight microfluidic diagnostic systems which demonstrate practical integration of sample preparation, analyte enrichment, and optical detection. We also examine several emerging detection paradigms involving nanoengineered materials which do not suffer from the same miniaturization disadvantages as conventional measurements.

TABLE 1. Imaging and Therapeutic Capabilities of Nanoparticles[a]

	modality	nanoparticle/agent
imaging	optical scattering/OCT	gold nanoshells, nanorods, nanocages, nanoparticles
	fluorescence	quantum dots, dye-doped silica, carbon nanotubes, organic fluorophores, phosphors
	MRI	manganese-based, iron oxide, gadolinium agents, perfluorocarbon
	PET, SPECT	radioisotopes (^{64}Cu, ^{18}F, ^{124}I, ^{11}In)
	CT	gold nanoparticles, iodine
	ultrasound	polymeric nanoparticles, perfluoropentane
therapeutic actuation	photothermal	gold nanoshells, nanorods, nanocages, nanoparticles
	brachytherapy	^{198}Au, ^{125}I, ^{103}Pd (X-rays)
	photoacoustic	carbon nanotubes
	chemotherapy	anticancer drugs (doxorubicin, paclitaxel, etc.)
	photodynamic	photosensitizer
	gene therapy	siRNA, DNA
	magnetic hyperthermia	iron oxide based nanoparticles
	radiotherapy	^{64}Cu radionucleotide
	neutron capture therapy	gadolinium, boron

Rizia Bardhan†, Surbhi Lal⊥, Amit Joshi§, and Naomi J. Halas*†⊥||

Acc. Chem. Res., 2011, 44 (10), pp 936-946

nature methods
Techniques for life scientists and chemists

BRIEF COMMUNICATION

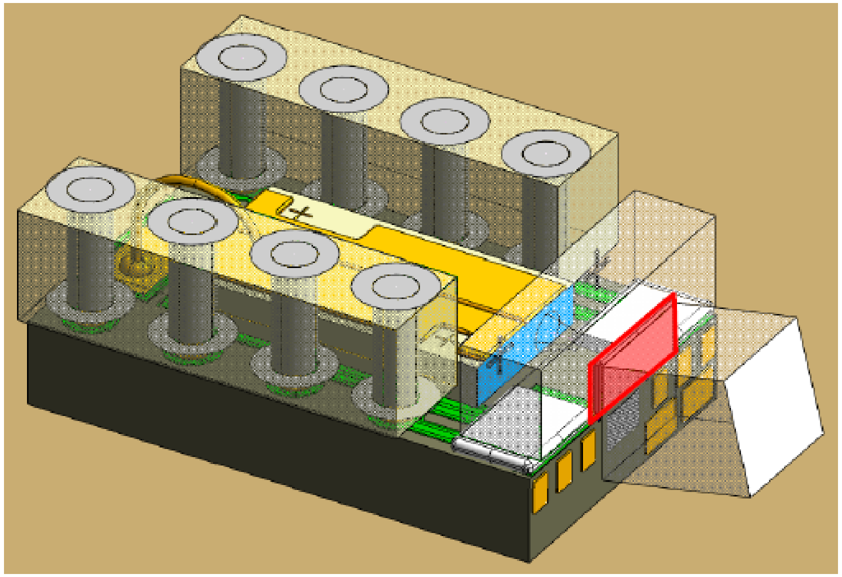
Nature Methods **4**, 1015 - 1017 (2007)
Published online: 18 November 2007 | doi:10.1038/nmeth1133

Quantized plasmon quenching dips nanospectroscopy via plasmon resonance energy transfer

Gang Logan Liu[4], Yi-Tao Long[1,4], Yeonho Choi[1], Taewook Kang[1] & Luke P Lee[1,2]

We observed quantized plasmon quenching dips in resonant Rayleigh scattering spectra by plasmon resonance energy transfer (PRET) from a single nanoplasmonic particle to adsorbed biomolecules. This label-free biomolecular absorption nanospectroscopic method has ultrahigh molecular sensitivity.

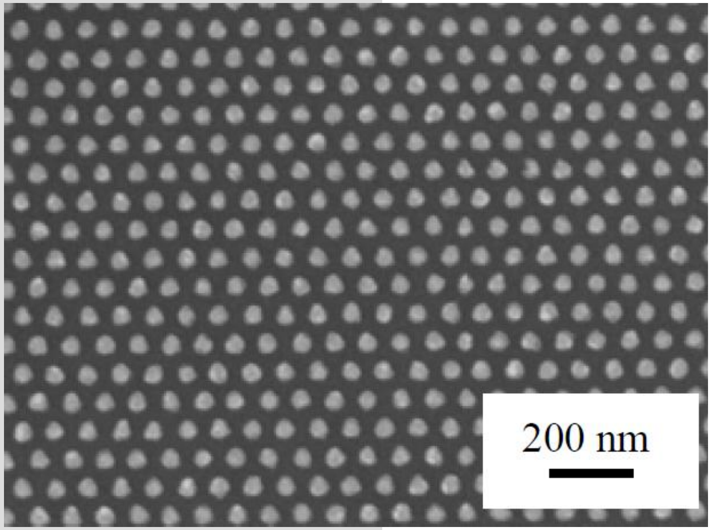
Mike Seigler
Seagate

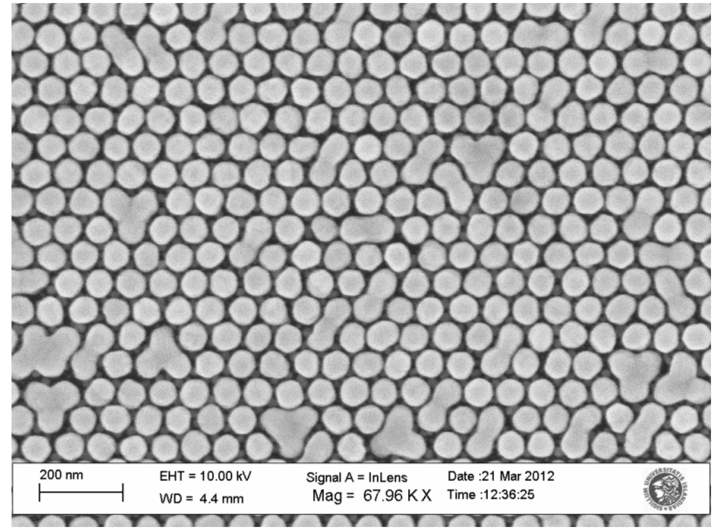


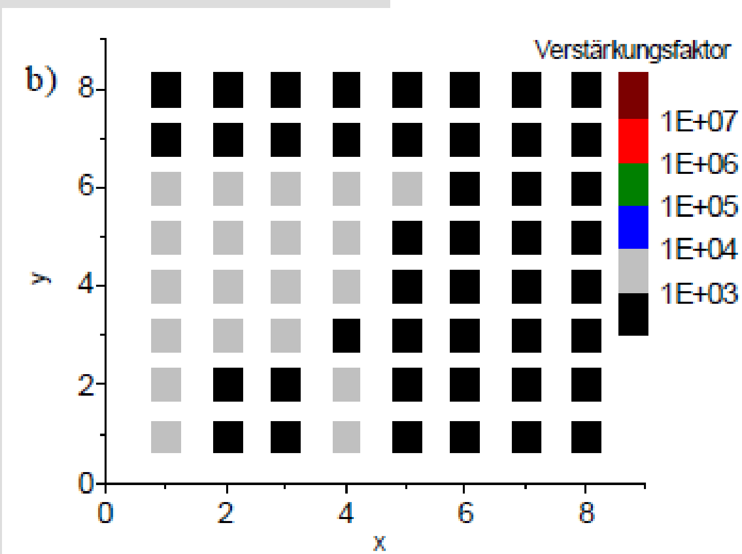
plasmon-assisted magnetic recording

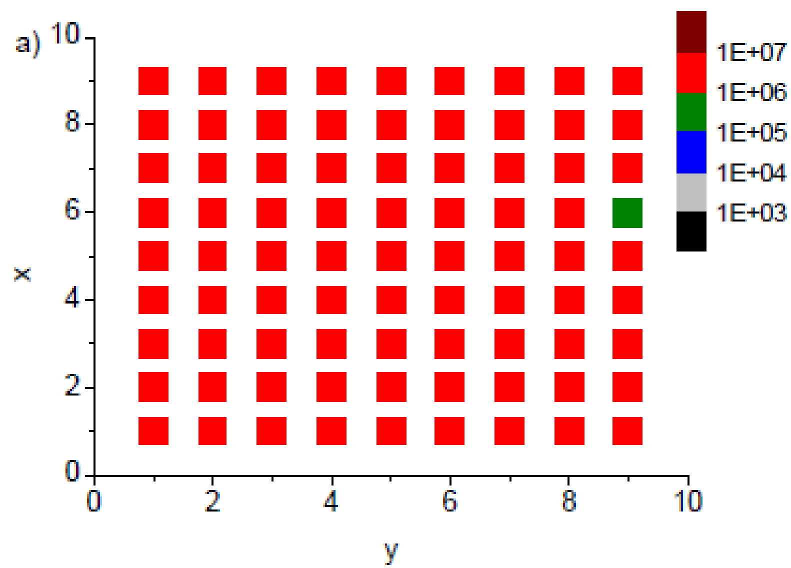
SERS, particle growth

Virginia Joseph: *Nanopartikel auf Oberflächen – Charakterisierung und Anwendung in der oberflächenverstärkten Raman-Streuung*,
PhD Thesis, Humboldt Universität Berlin (2012)

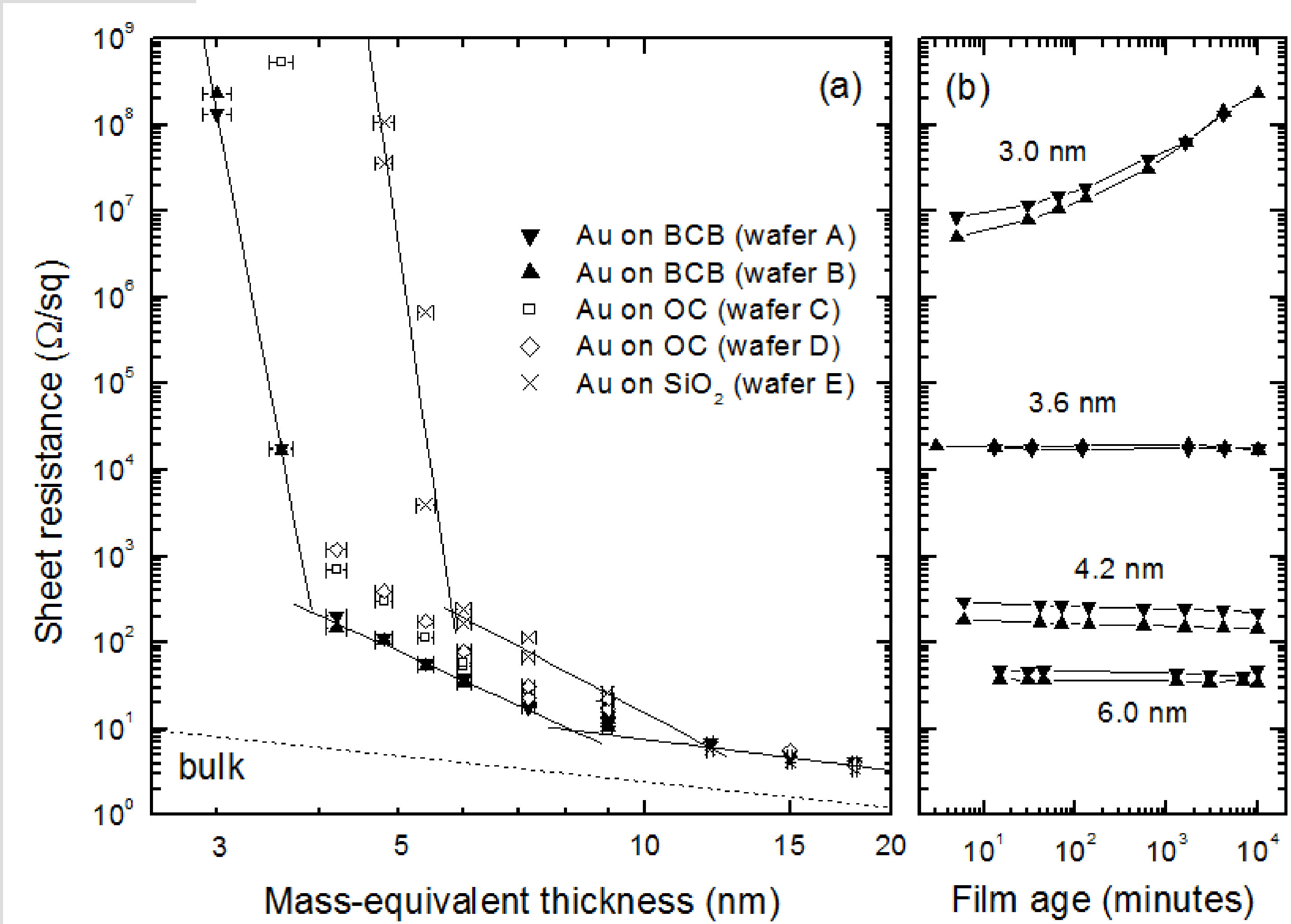


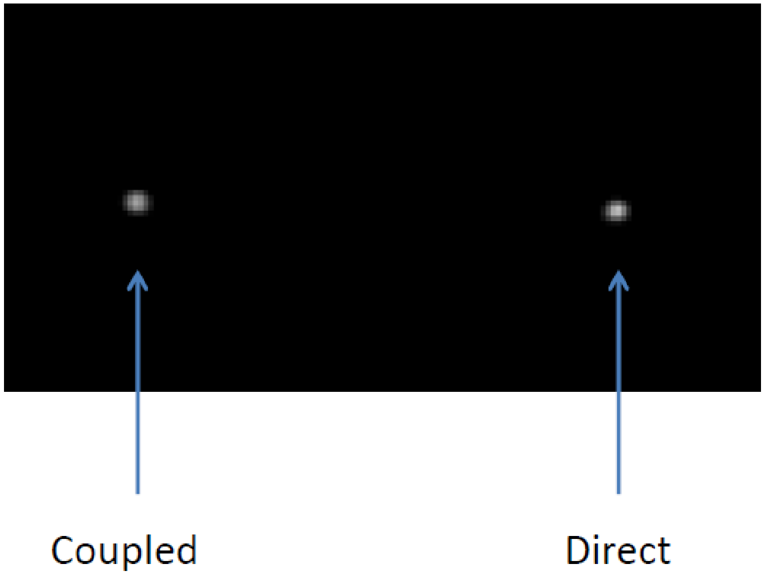


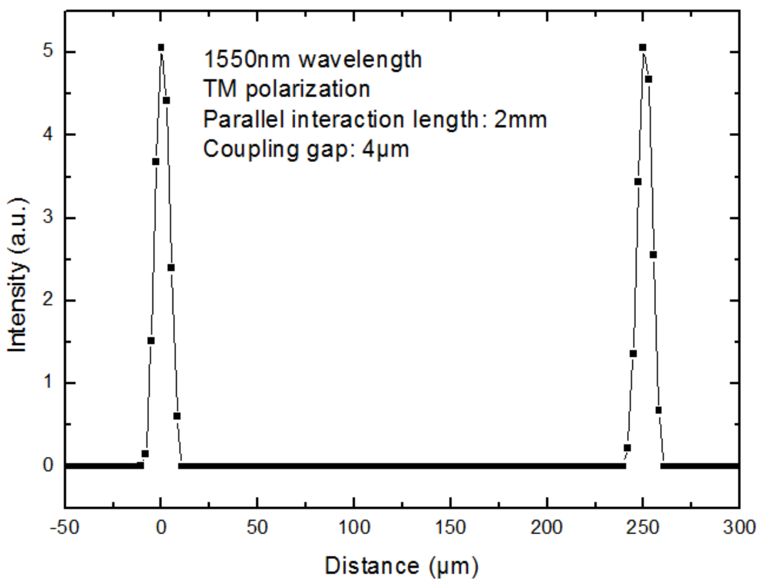


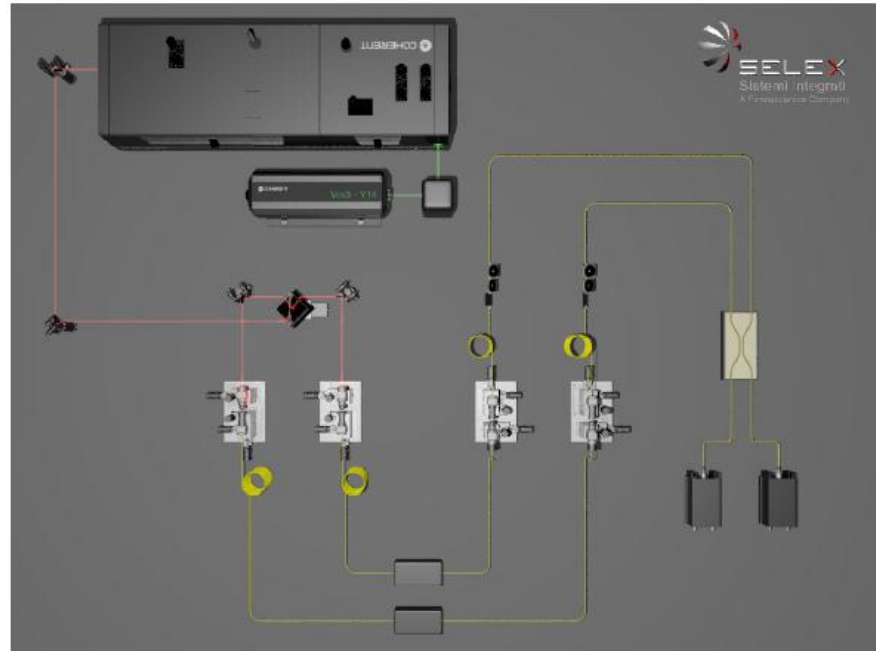


Sheet resistance









Quantum Interference on Plasmonic Circuits

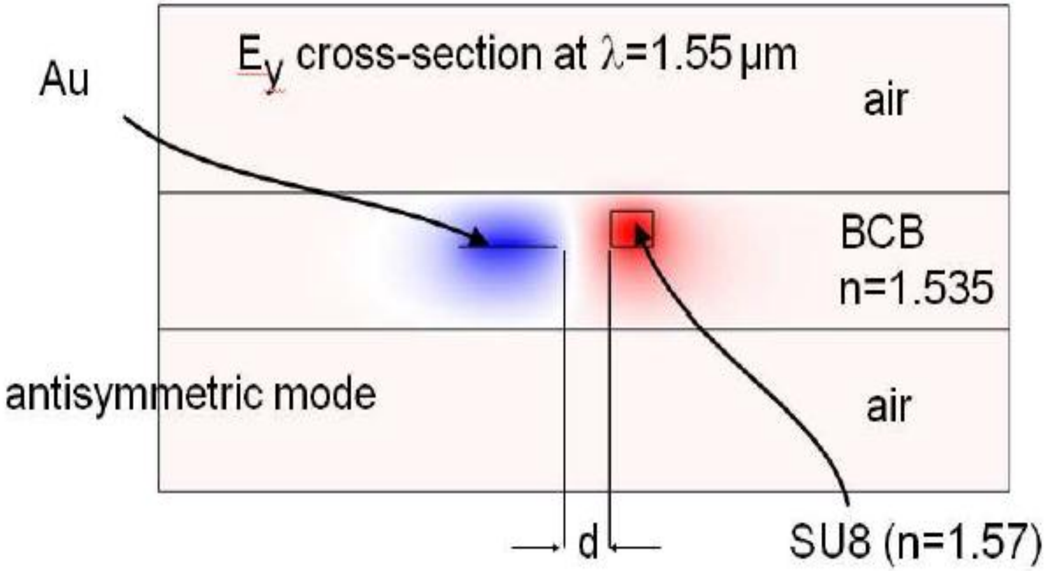
F.A. Bovino[1], K. Leosson[2], P. Laporta[3]

[1] SELEX-SI, Quantum Optics Lab, Genova, 16154, Italy
[2] Univ. of Iceland, Science Institute, Reykjavik, IS-107, Iceland
[3] Politecnico di Milano, Dip. Di Fisica, Milano, Postcode, Italy

EOS2012

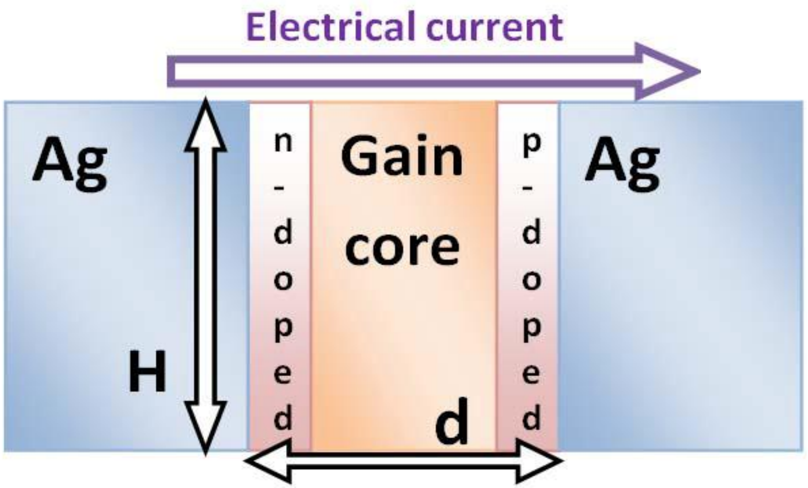
SPP quantum optics

$$\varepsilon_{(-x)} = \varepsilon^*_{(x)}$$



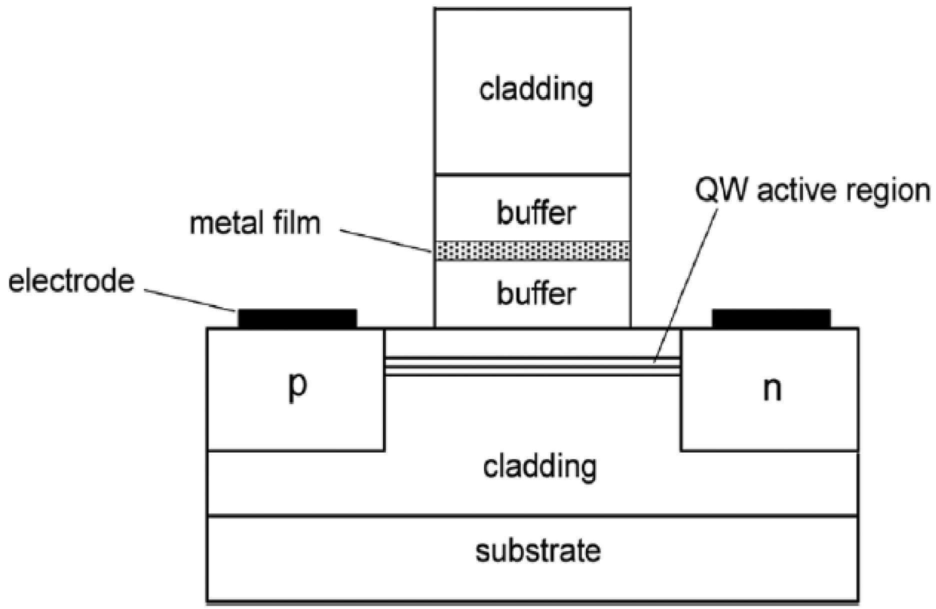
Benisty, H., et al., *Implementation of PT symmetric devices using plasmonics: principle and applications.* Optics Express, 2011. **19**(19): p. 18004-18019.

applications of SPP waveguides



Babicheva, V.E., et al., *Plasmonic modulator based on gain-assisted metal-semiconductor-metal waveguide.* arXiv:1203.3374v1, 2012.

applications of SPP waveguides



Ranjbaran, M. and X. Li, *Optimized Dipole-Surface Plasmon Waveguide Coupling for Enhancement of SLD Performance.* IEEE Photonics Journal, 2010. **2**(5): p. 848 - 857

applications of SPP waveguides

Comparing resonant photon tunneling via cavity modes and Tamm plasmon polariton modes in metal-coated Bragg mirrors

K. Leosson,[1,*] M. Shayestehaminzadeh,[1] T.K. Tryggvason,[1] A.E. Kossoy,[1] B. Agnarsson,[1,2] F. Magnus[1,3], S. Olafsson[1], J.T. Gudmundsson[1,4], E.B. Magnusson[1] and I.A. Shelykh[1,5]

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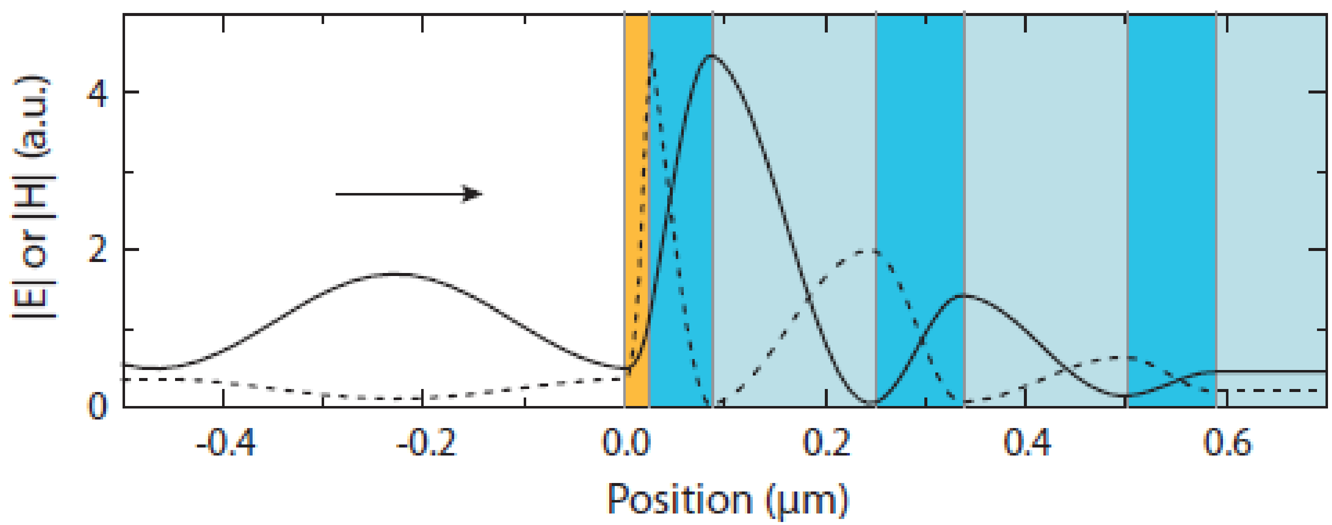
[3] *Department of Physics and Astronomy, Materials Physics Division, Uppsala University, SE-75120 Uppsala, Sweden*
[4] *University of Michigan - Shanghai Jiao Tong University Joint Institute, 200240 Shanghai, China*
[5] *Division of Physics and Applied Physics, Nanyang Technological University, 637371 Singapore*



“In searching for potential uses of (LR)SPP waveguides, it is advisable to focus on applications that turn their limitations (loss, dispersion, polarization dependence) into strengths”

thank you