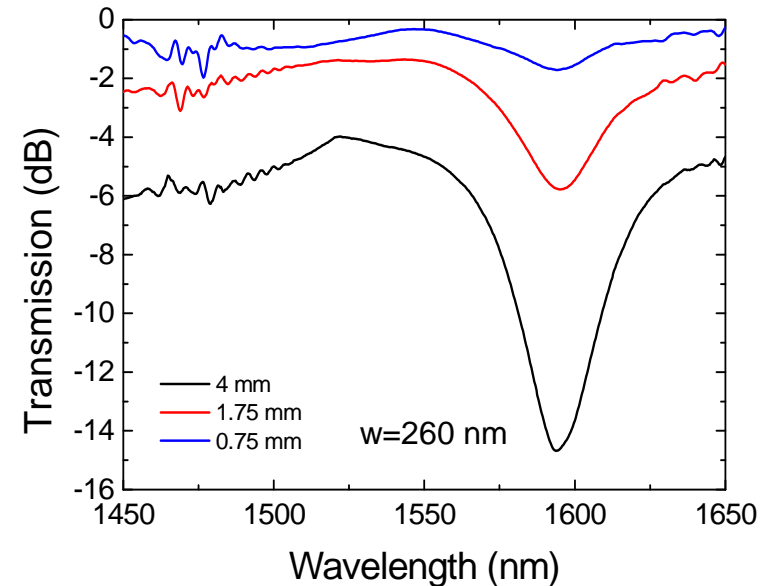


Long-range Surface Plasmon Polariton Devices Fabricated by Nanoimprint Lithography



R. H. Pedersen, A. Boltasseva, K. B. Jørgensen, D..M. Johansen, T. Nielsen,
K. Leosson, J.E. Østergaard, and A. Kristensen



MIC – Department of Micro and Nanotechnology
Nano•DTU, Technical University of Denmark

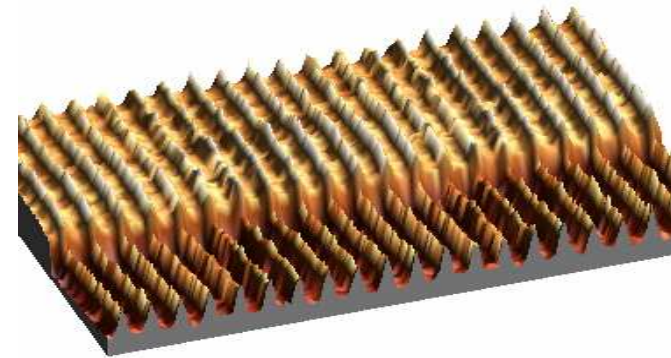
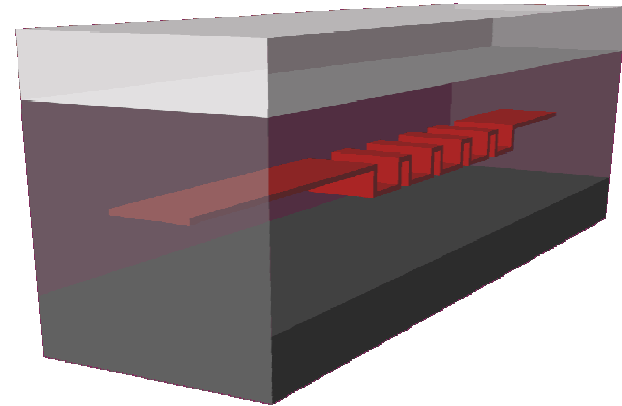
Nano•DTU
Center for Nanotechnology at DTU



Long-range Surface Plasmon Polariton Devices Fabricated by Nanoimprint Lithography

Outline:

- Polymer based, nanostructured LR-SPP waveguide components
- COC spin-on resist
- Simple fabrication by NIL
- Basic optical characterization



Polymer based LR-SPP stripe waveguides

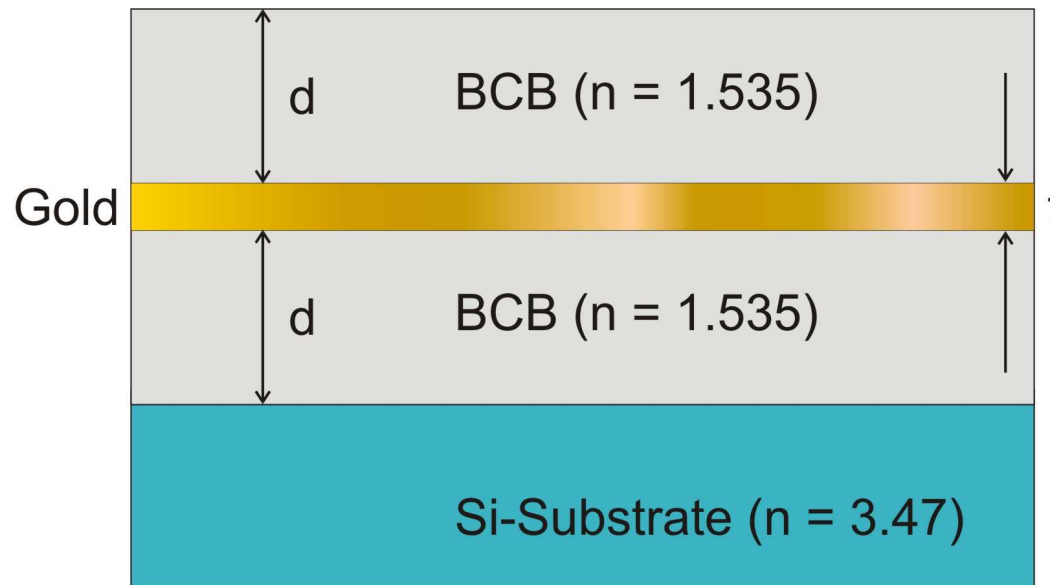
APPLIED PHYSICS LETTERS

VOLUME 82, NUMBER 5

3 FEBRUARY 2003

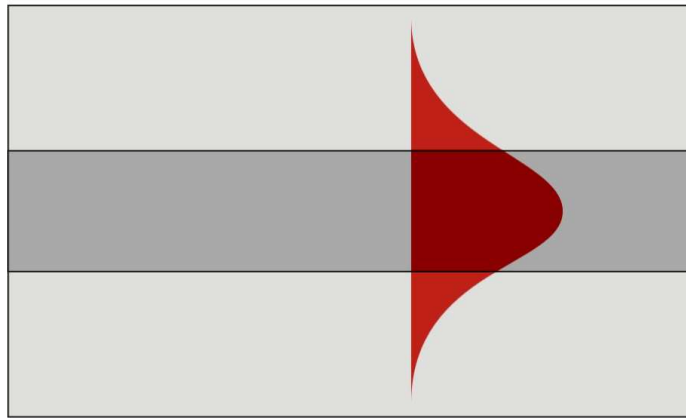
Polymer-based surface-plasmon-polariton stripe waveguides at telecommunication wavelengths

Thomas Nikolajsen,^{a)} Kristijan Leosson, Ildar Salakhutdinov, and Sergey I. Bozhevolnyi
*Micro Managed Photons A/S, Technical University of Denmark, Diplomvej 373,
DK-2800 Kongens Lyngby, Denmark*

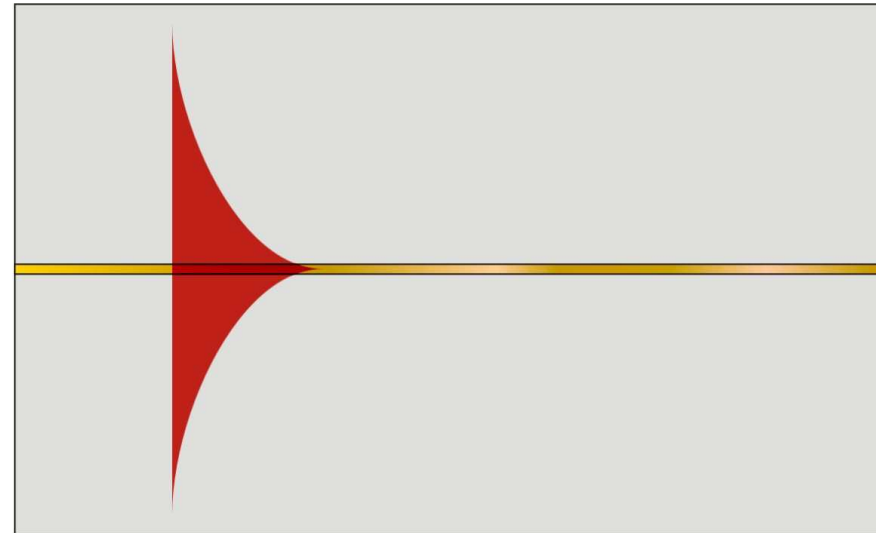


LR-SPP waveguides $\sim 10 \mu\text{m}$ mode field diameter

"End-fire" coupling technique for exciting long-range surface plasmon polaritons using standard optical fiber.



Optical Fiber

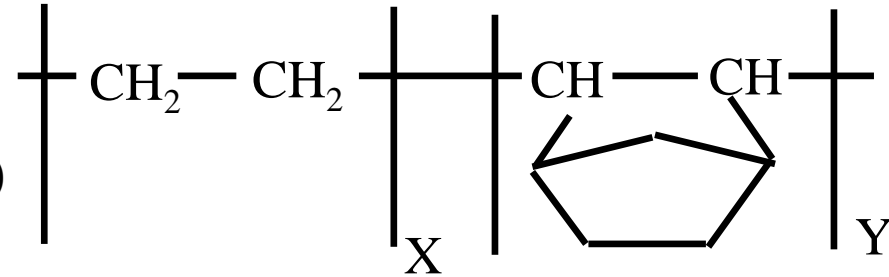


LR-SPP Waveguide

TOPAS (COC) NIL resist with high chemical resistance

Ticona

Topas[®] is a cyclo olefin copolymer (COC)



Topas grade 8007

Glass transition temperature $T_g = 80^\circ\text{C}$

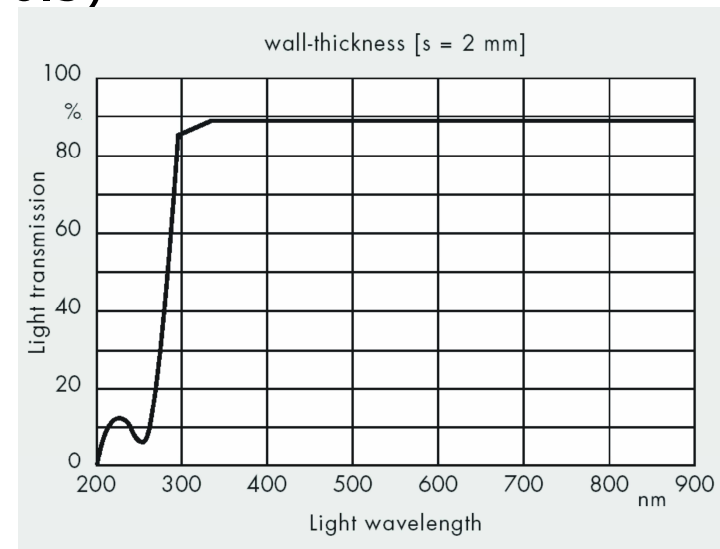
Water absorption (%) < 0.01 (PMMA: 0.3)

Refractive index $n = 1.53$

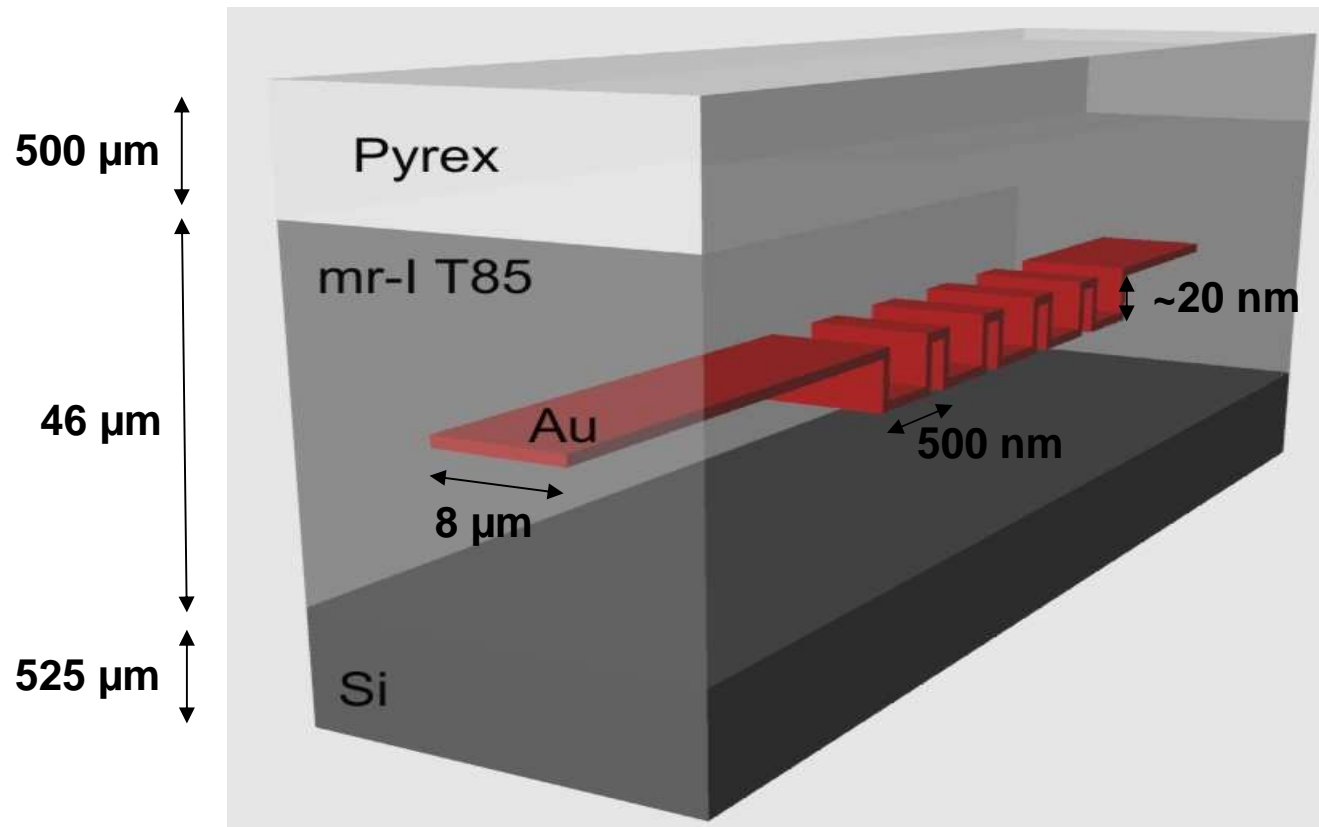
Chemically resistant

Transparent into the UV

COC NIL resist mr-I T85

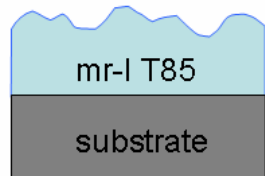


Device Design



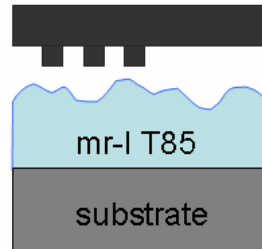
Fabrication by Nanoimprint and Metal Lift-off

(a) Spincoat mr-I T85



Spincoat:
mr-I T85
spincoat 2000 rpm
bake 10 min 200°C
h = 23 μm

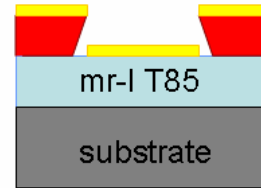
(b) Imprint/planarize



Si stamp:
30 nm TEBN-1
100 kV EBL
D = 4.1 mC/cm²
Dev.: MIBK
RIE:
O₂, CHF₃, SF₆

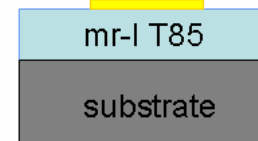
Imprint;
T = 160°C
p = 6 bar
t = 5 min.

(c) Gold deposition

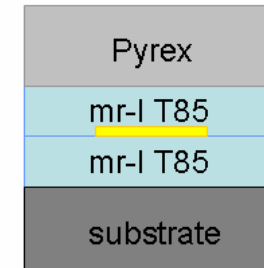


UV lithography:
1.5 μm PR
Thermal Evap.:
~12 nm Au

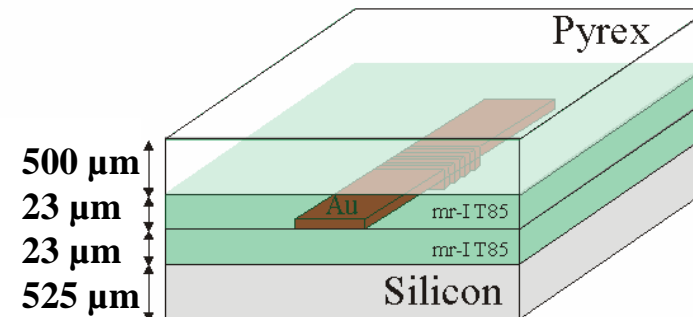
(d) Lift-off



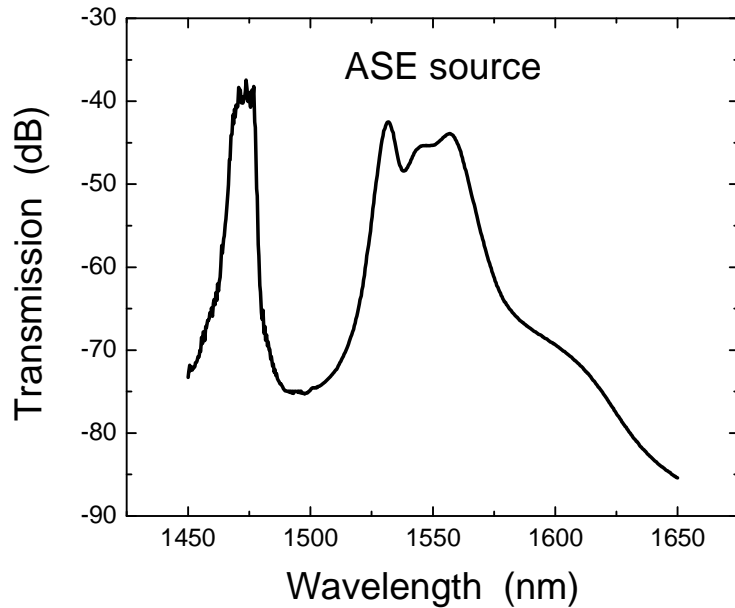
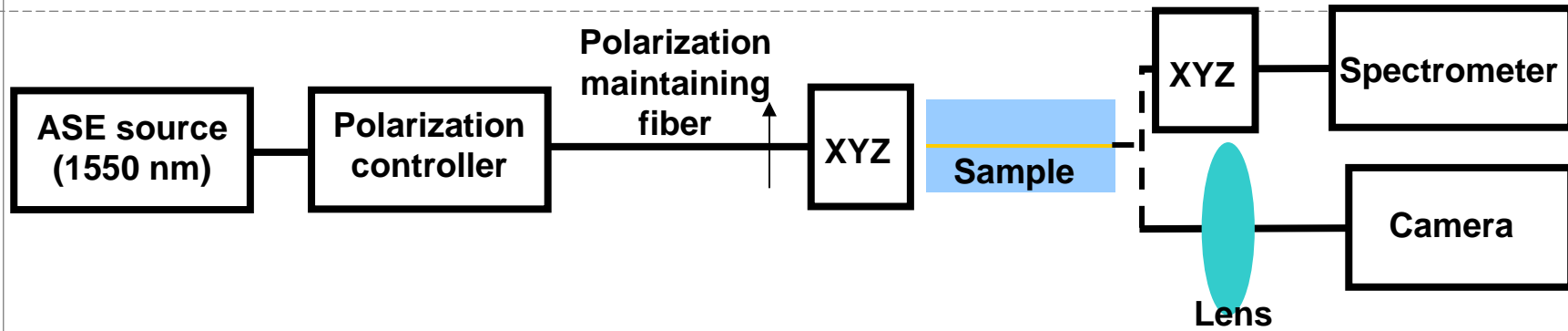
(e) Thermal bonding



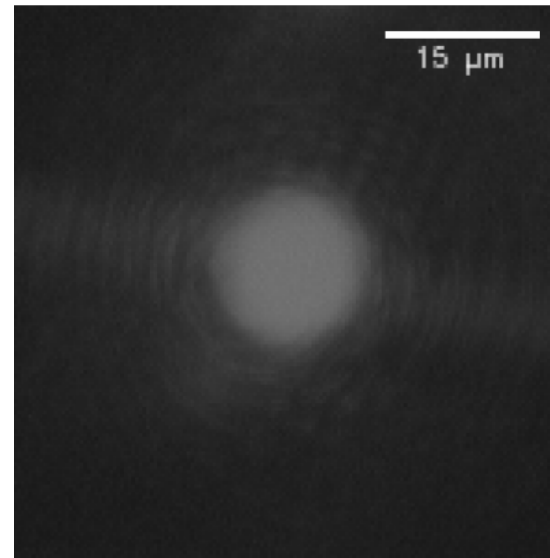
Polymer bonding:
T = 100°C
p = 13 bar
t = 10 min.



Optical Characterization - Setup

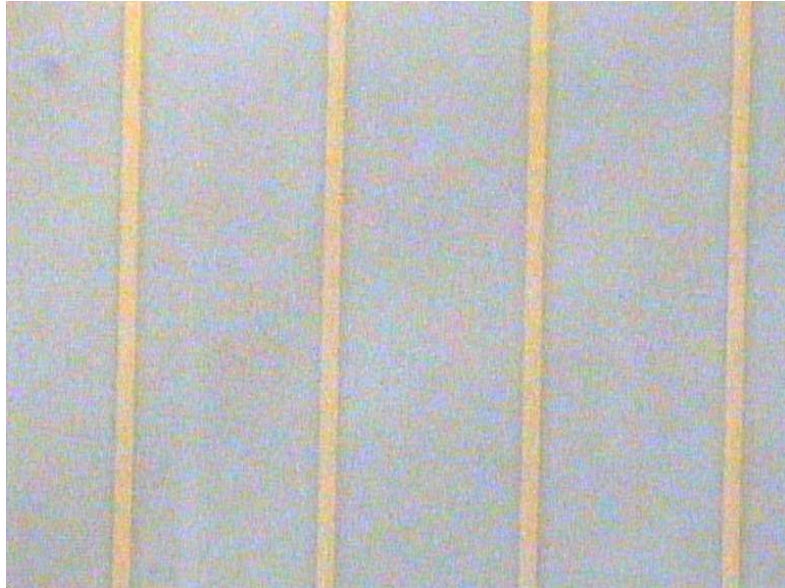


Transmission signal through PM fiber

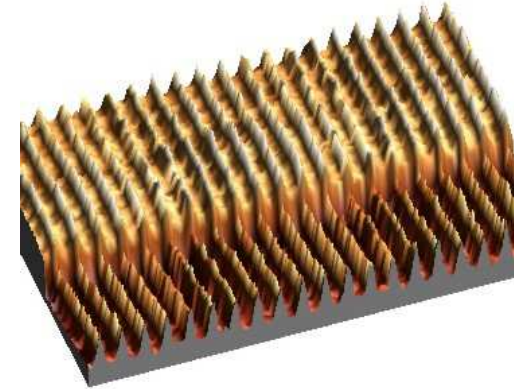


Output of the polarization maintaining fiber
Mode field diameter: 10.8 μm

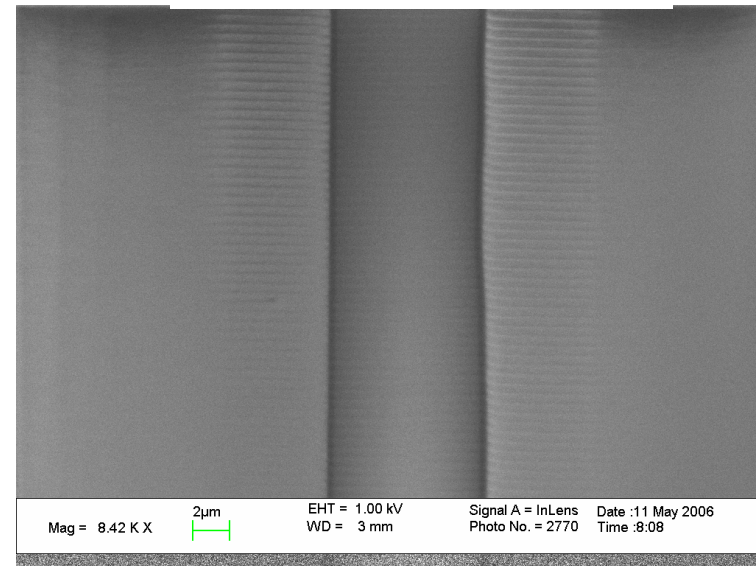
Fabrication results



Au lines defined on top of mr-I T85

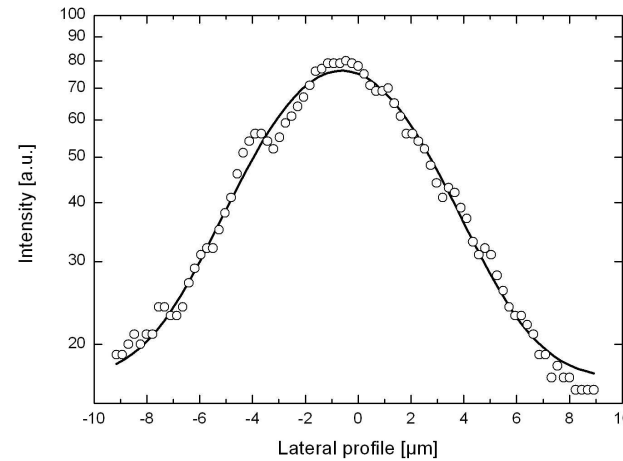
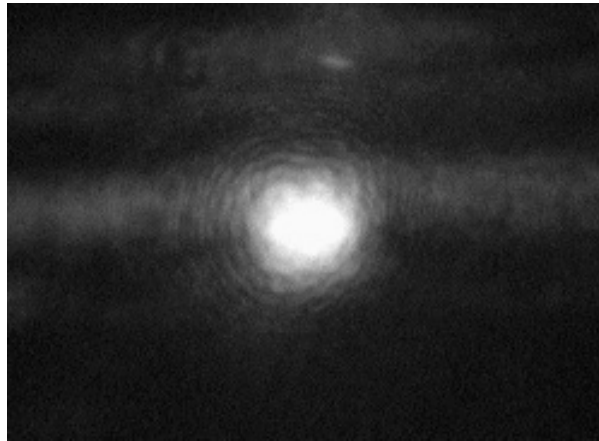


**Grating definition
Protrusion width 380 nm**

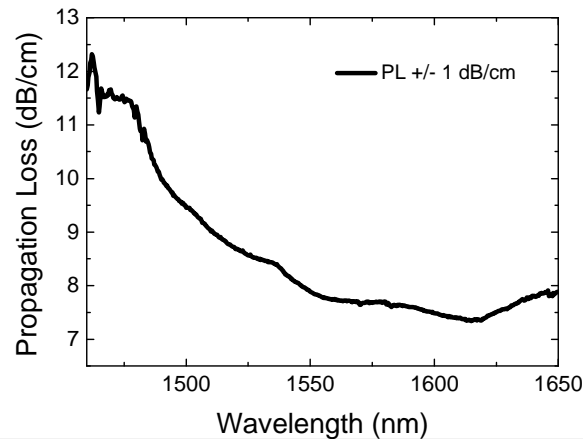


Optical Characterization – Unstructured Waveguides

Image of the output facet of an 8 μm wide gold stripe waveguide

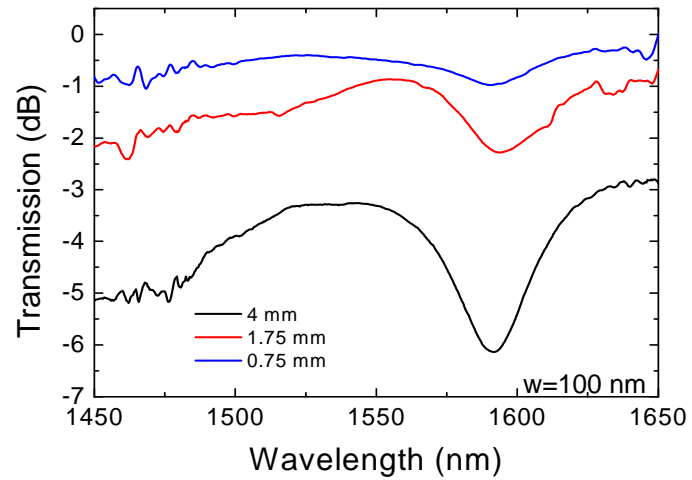
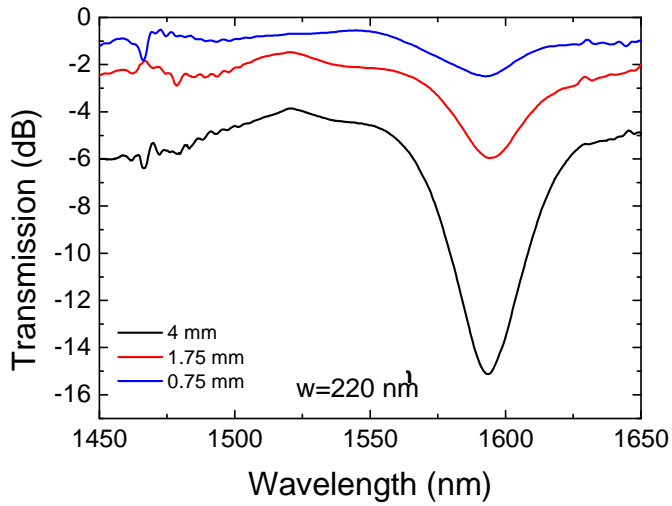
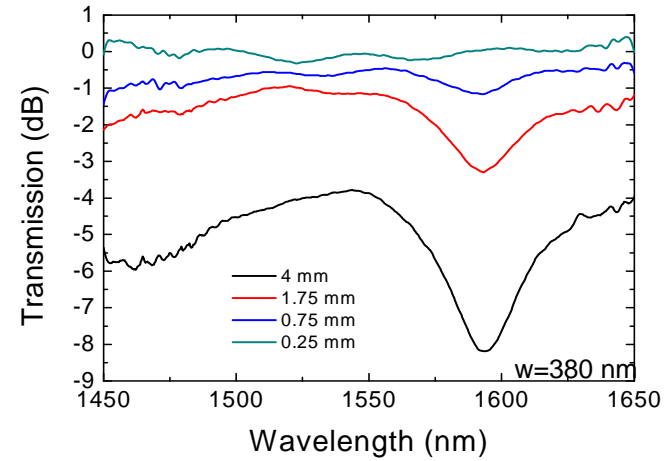
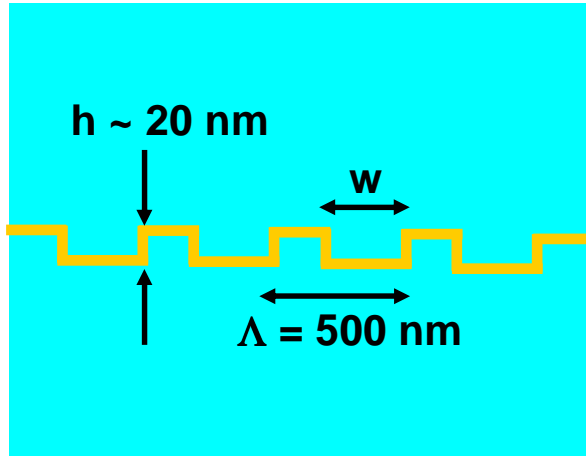


Lateral mode profile fitted by a Gaussian mode profile - mode field diameter of 12.8 μm



Propagation loss ~ 8 dB/cm at 1550 nm

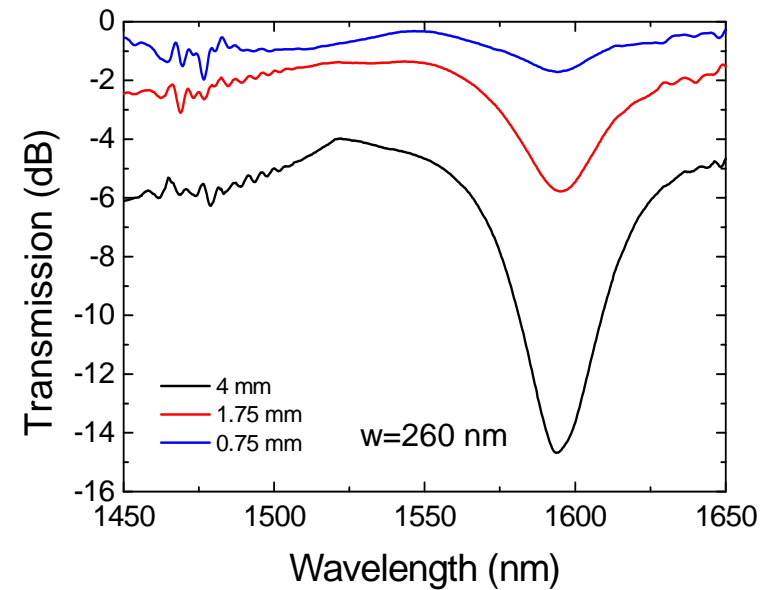
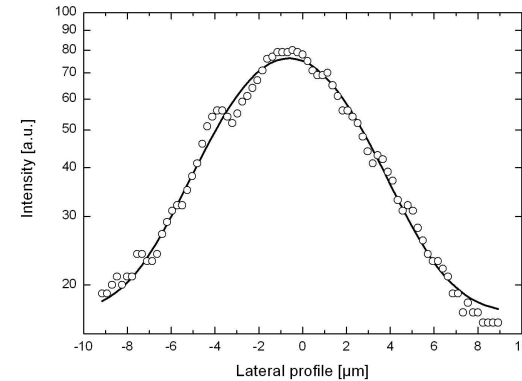
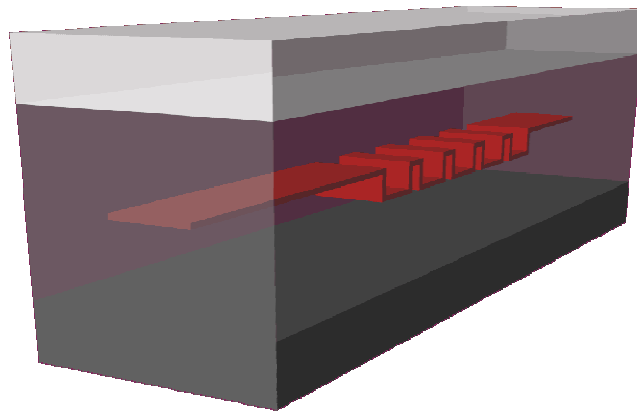
Grating Transmission



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Summary

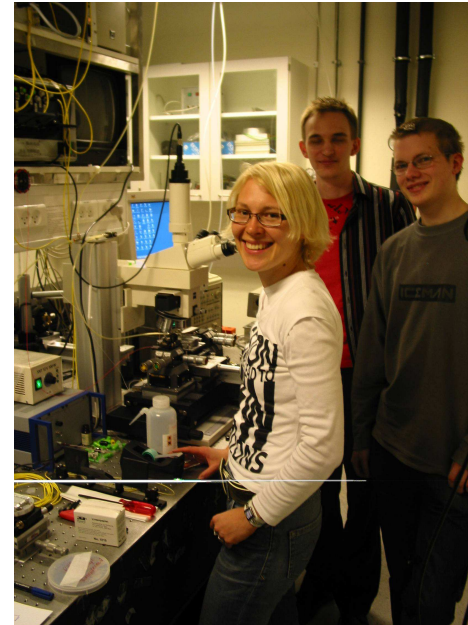
- ➔ NIL process for polymer based LR-SPP waveguide components
- ➔ Mode field diameter of $12.8 \mu\text{m}$
- ➔ Waveguides with nanostructured gratings exhibit Bragg reflectance



Long-range Surface Plasmon Polariton Devices Fabricated by Nanoimprint Lithography

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