

# ***Two-photon polymerized microstructures connected by optical fibers***

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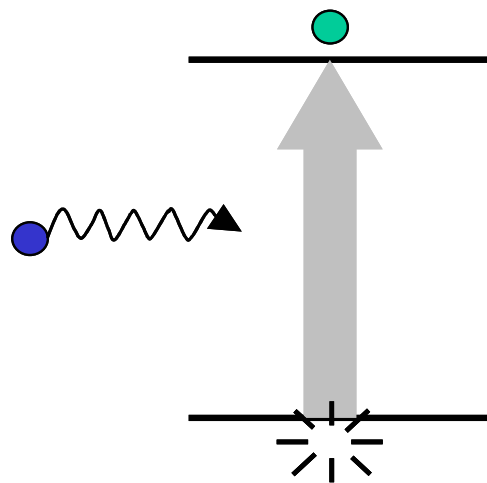


# Motivation

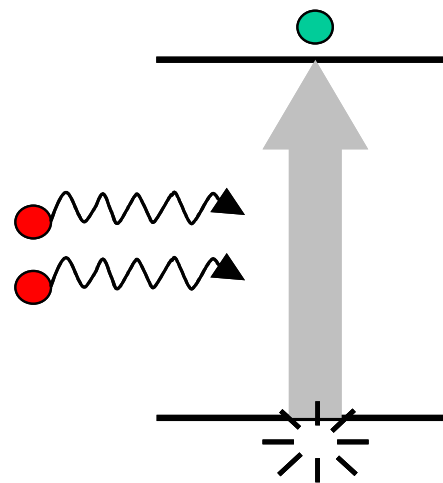


Two-photon polymerization is a powerful method to fabricate three-dimensional microstructures. For tailoring its properties, it is desirable to dope them, aiming at fabricating optically active components. For applications, however, methods to optically integrate these microstructures are still needed. In this work, we present the two-photon polymerization fabrication of microstructures doped with the fluorescent dye rhodamine 6G, which were subsequently wired by tapered fibers. Such fibers were used to inject laser light into the microstructures, as well as to collect its emission, indicating this approach suitable to microscopic optical circuits.

# Two-photon absorption (2PA)



1-photon absorption  
(linear)



2-photon absorption  
(nonlinear)

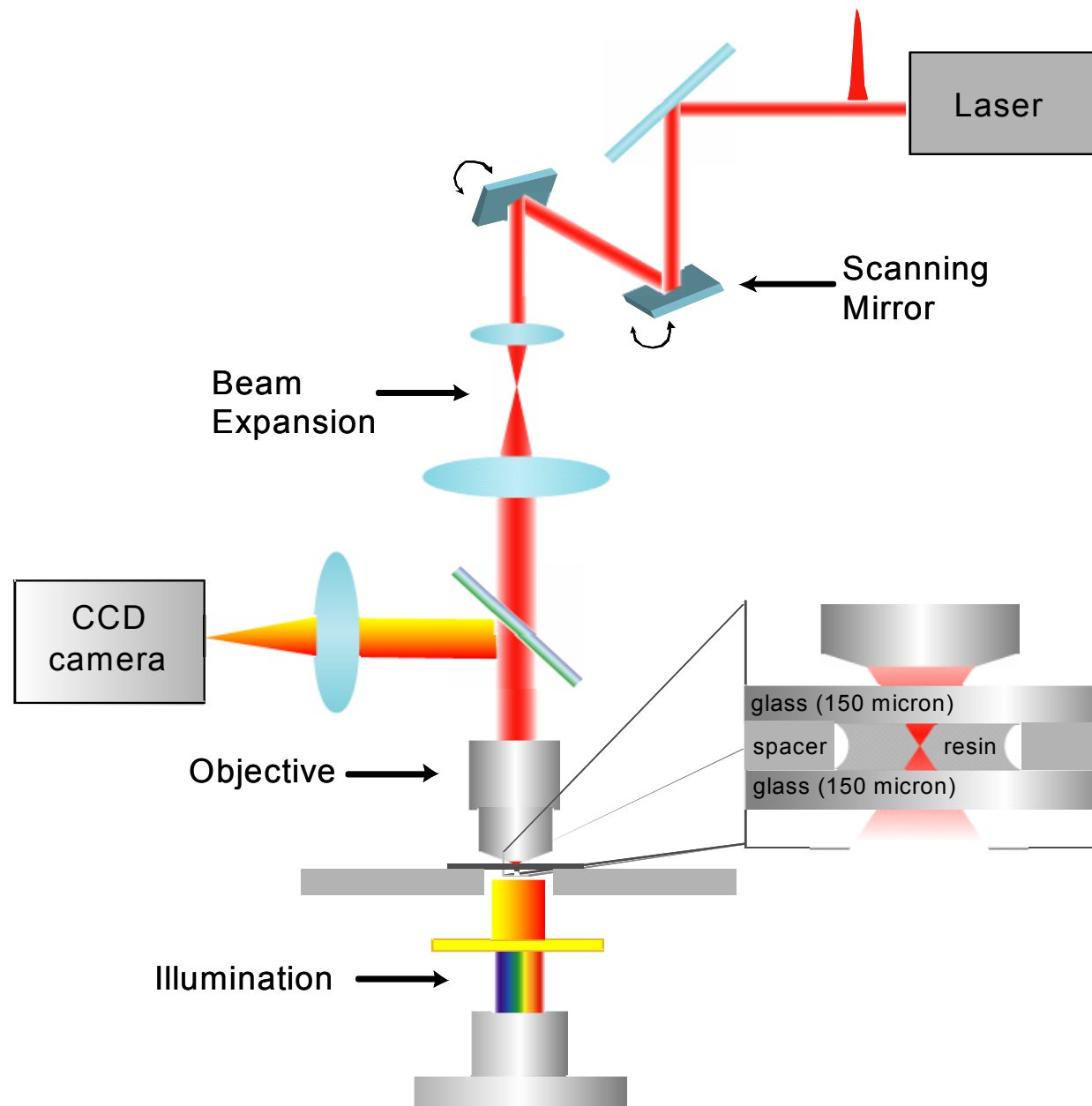
Two photons are absorbed  
in a single event!

Advantage of the process: **spatial selectivity in the absorption**

Applications in:

- 2PA fluorescence microscopy
- Optical limiting
- Photodynamic therapy
- **Fabrication of microdevices via 2PA polymerization**

# 2PA polymerization setup



Ti:sapphire laser oscillator

- 130 fs
- 800 nm
- 76 MHz
- 20 mW

Objective

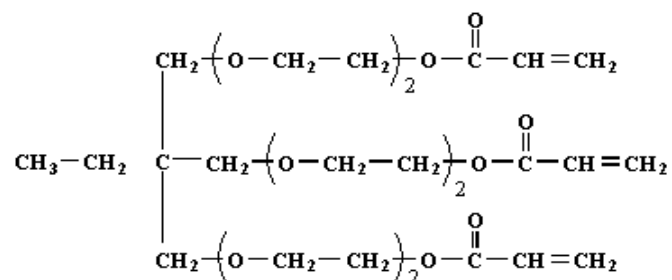
40 x  
0.65 NA



# Monomers and photoinitiator

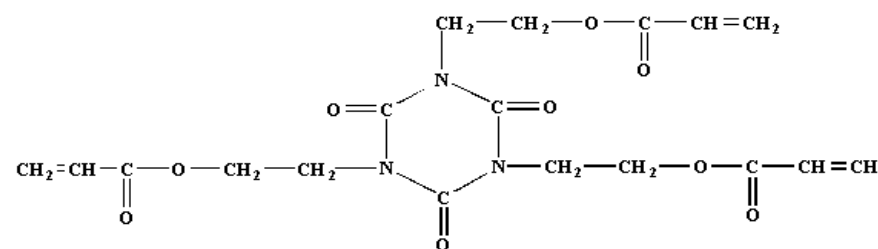
## Monomers

SR499



Decreases residual stress during shrinkage

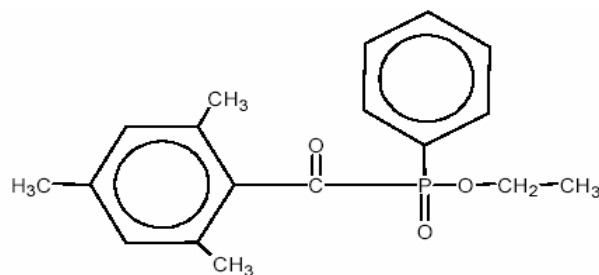
SR368



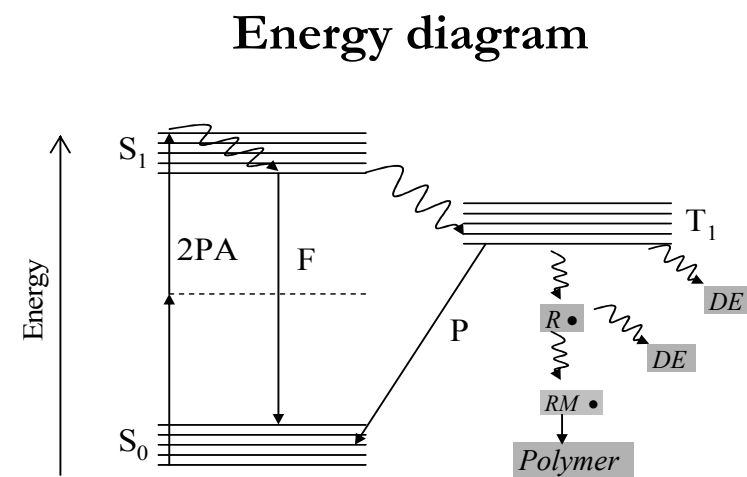
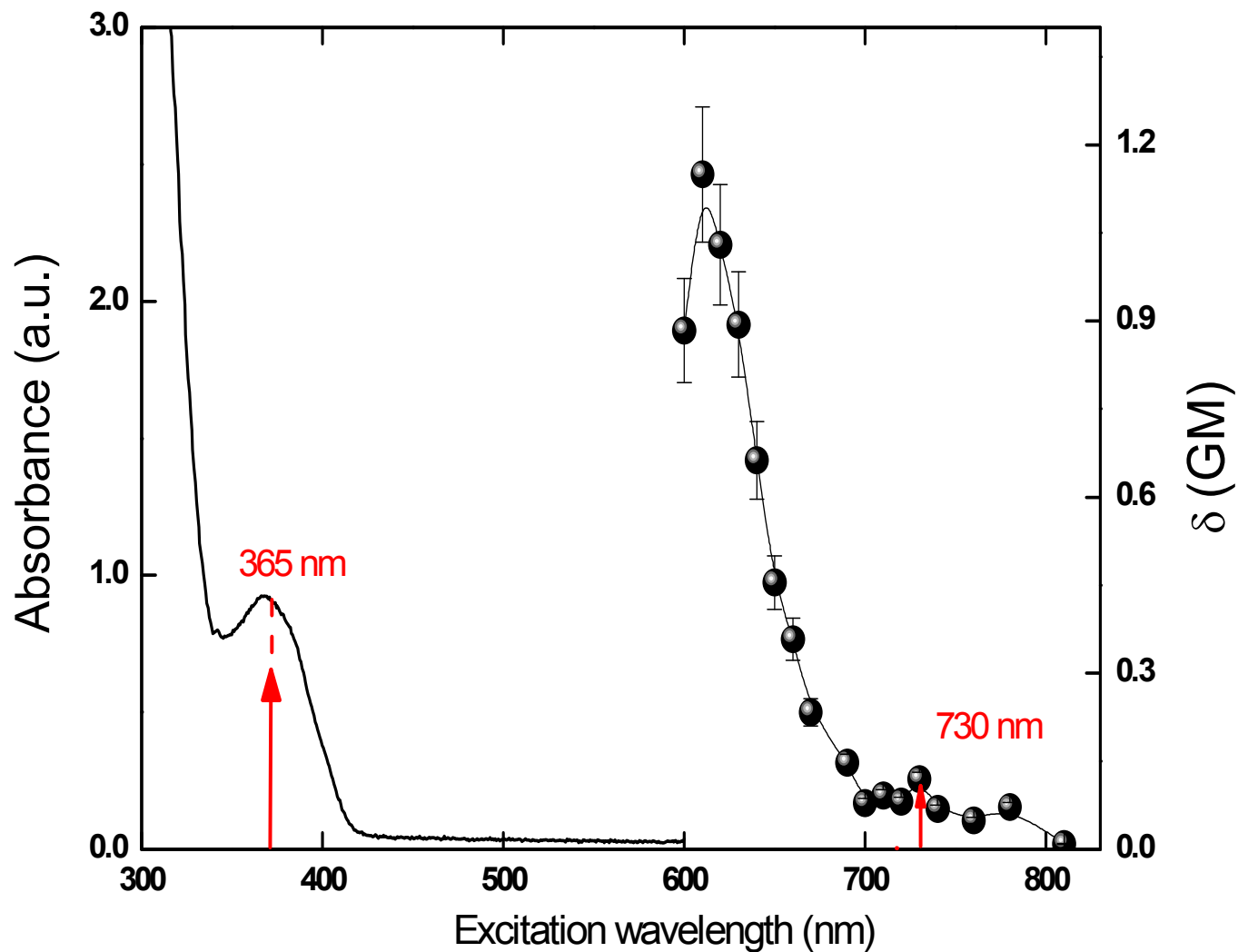
Provides hardness to the polymeric structure

## Photoinitiator

Lucirin TPO-L



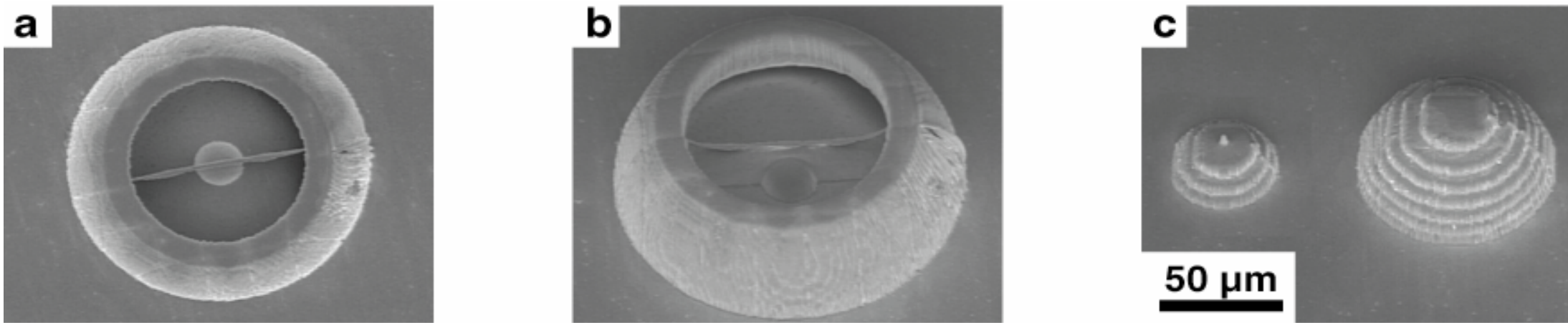
# 2PA spectrum of Lucirin TPO-L



C. R. Mendonça, D. S. Correa, T. Baldacchini, P. Tayalia, E. Mazur  
*Appl. Phys. A*, 90, 633-636 (2008)

# Samples of the microstructures

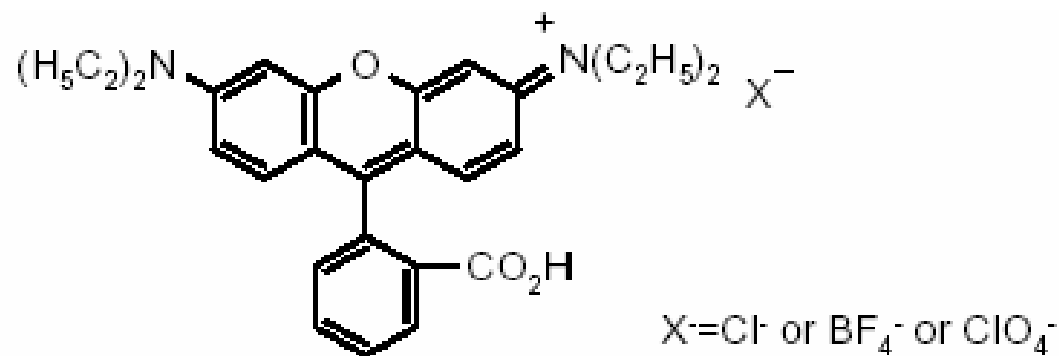
SEM of some microstructures fabricated via 2PA polymerization



- (a) Top view
- (b) 30 ° view of semi-spherical structure
- (c) Conical microstructures

**Microstructures show excellent integrity**

# “Doping” material → Rhodamine



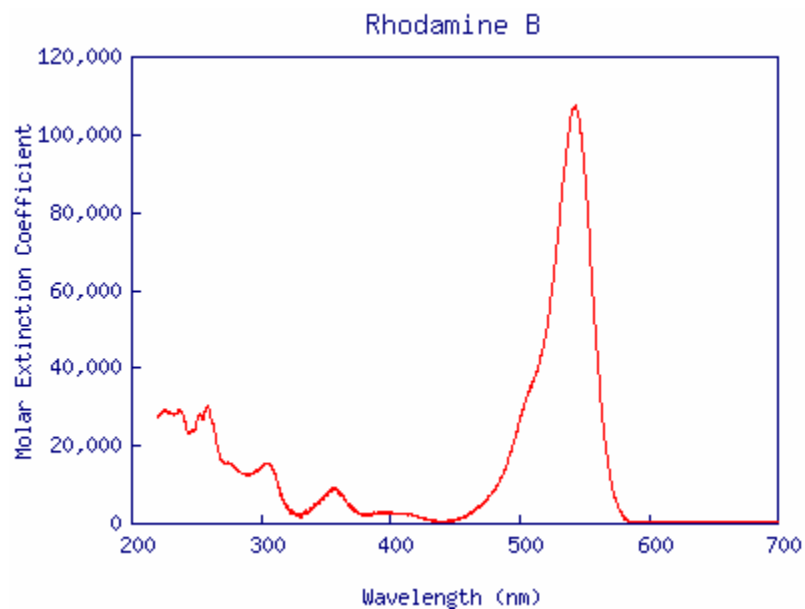
610, N-[9-(2-carboxyphenyl)-6-(diethylamino)-3H-xanthen-3-ylidene]-N-ethyl-ethanaminium perchlorate

**Why doping the basic resin with rhodamine?**

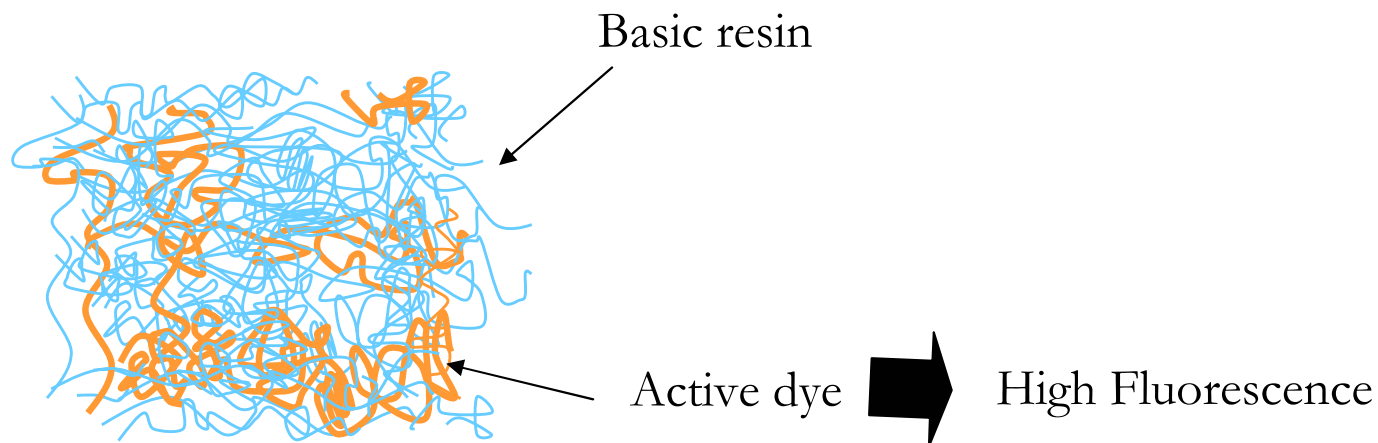
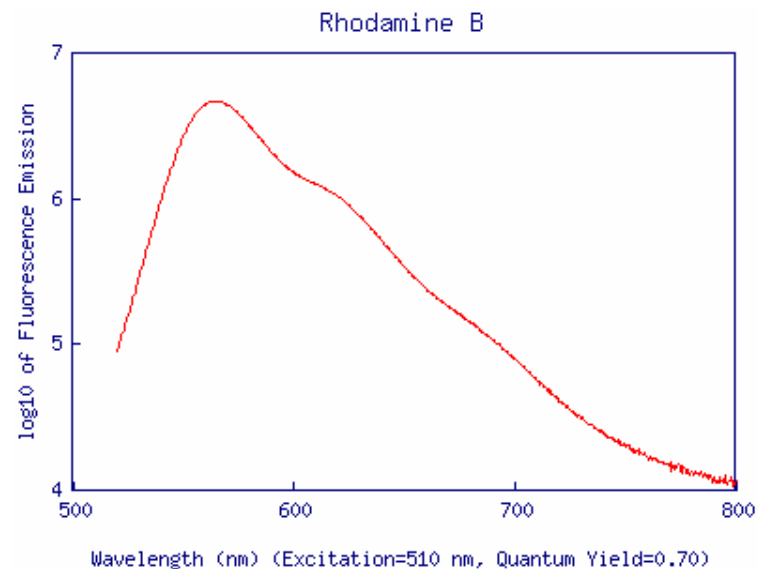
- Dye presenting high fluorescence signal
- Soluble in many organic compounds
- High thermal and chemical stability

# Microstructures doped with Rhodamine

Absorption spectrum

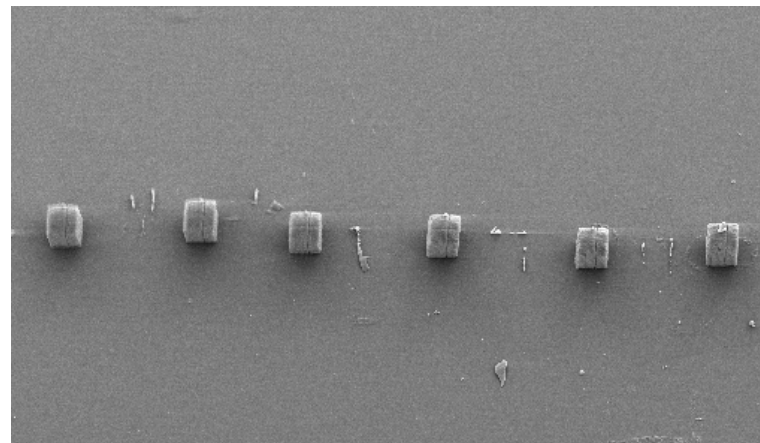
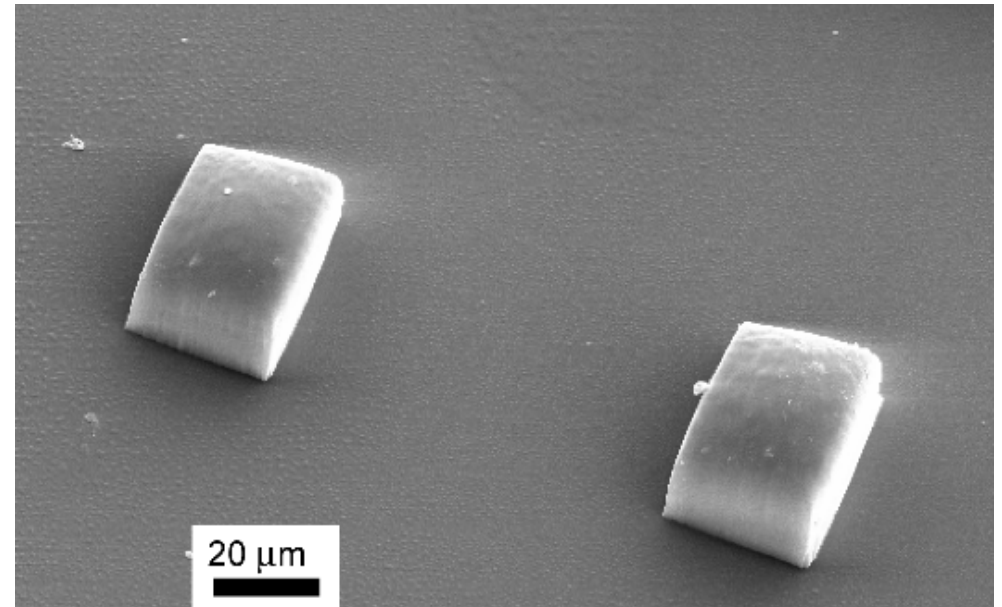
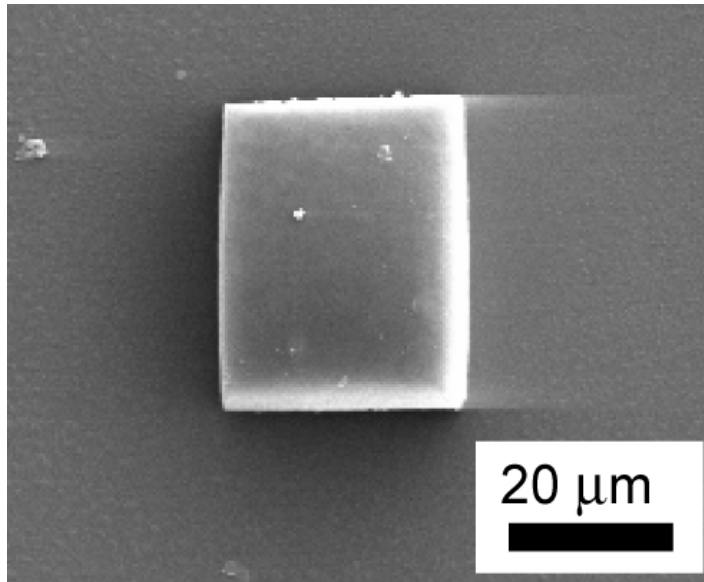


Fluorescence spectrum



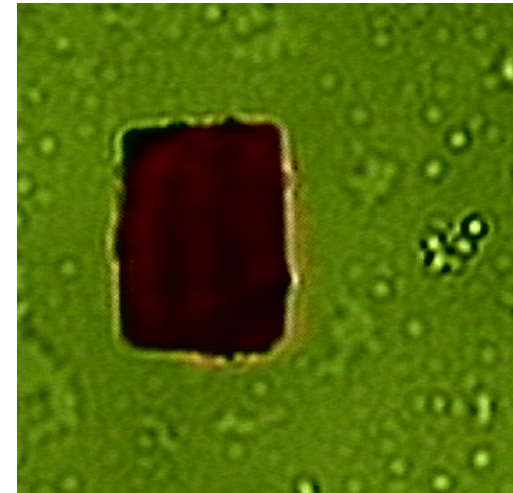
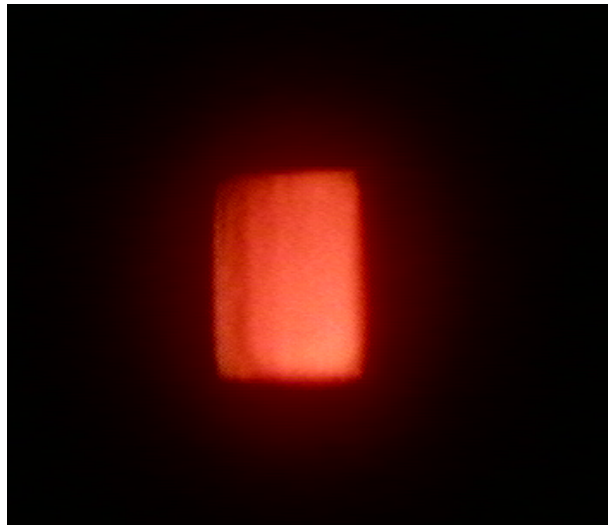
# Microstructures doped with Rhodamine

SEM of some fabricated microstructures

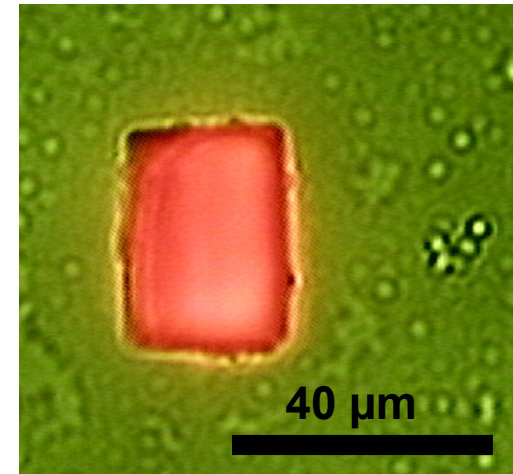


# Microstructures doped with Rhodamine

Microscopy fluorescence images of cubes and cylinders (top view)



Excitation OFF

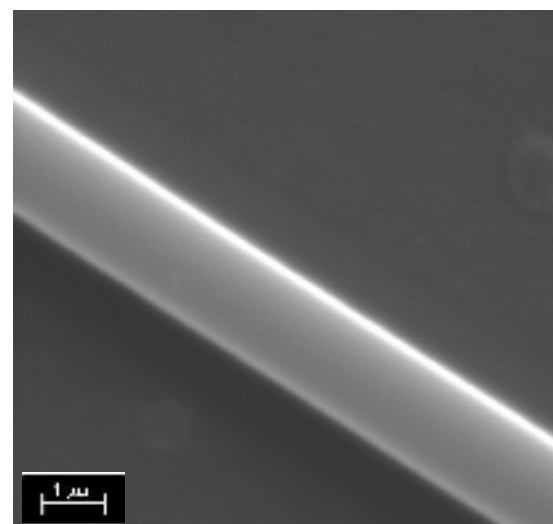
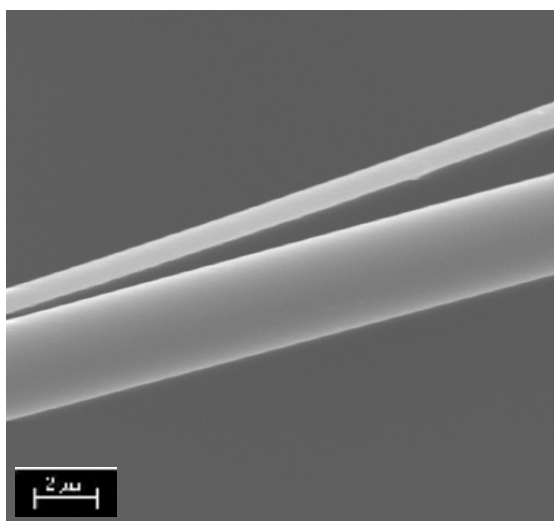
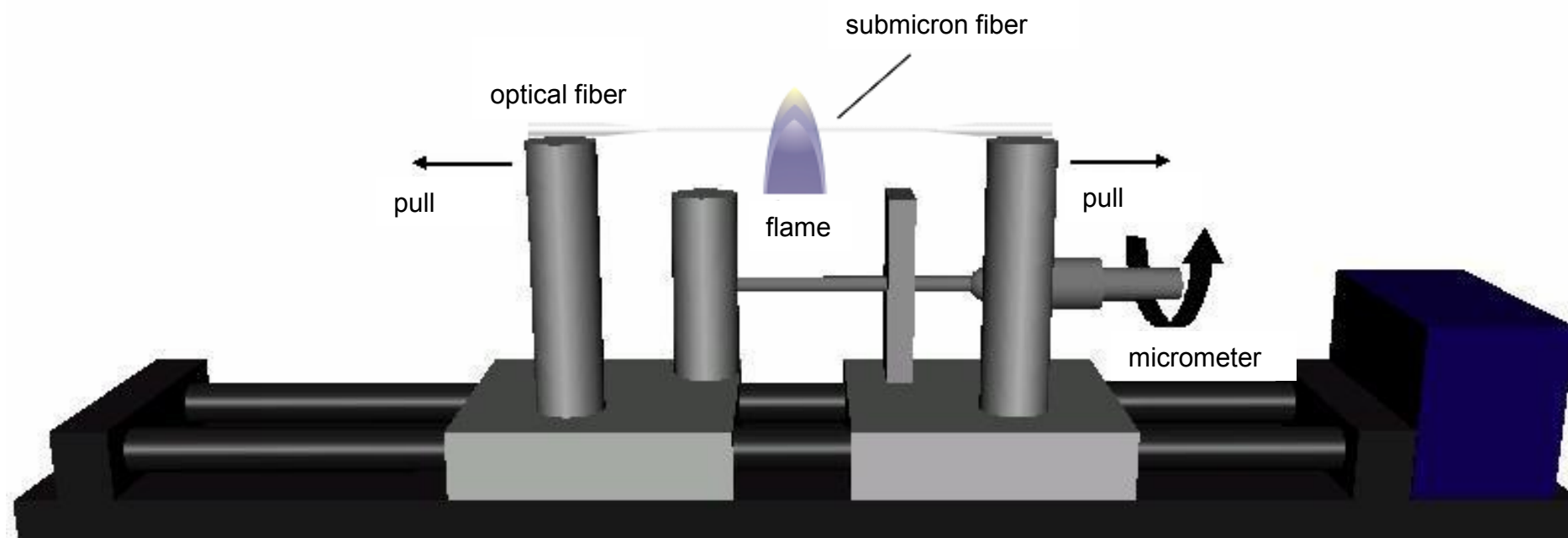


Excitation ON

red fluorescence typical of rhodamine

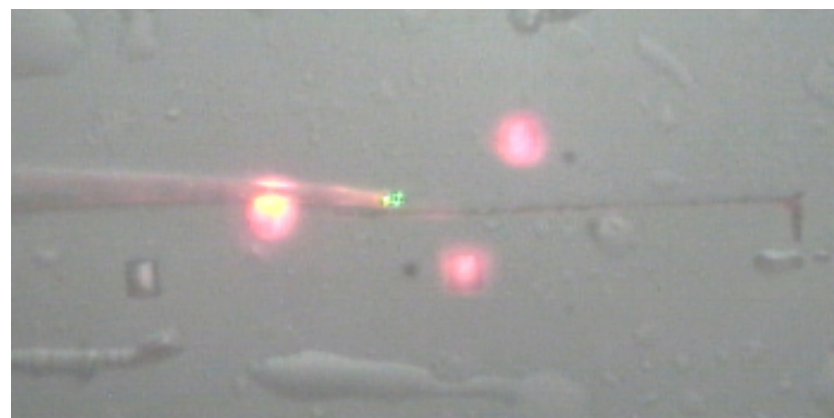
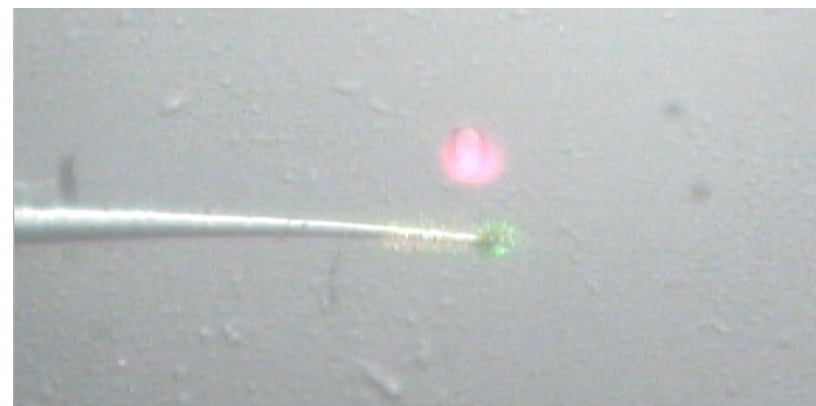
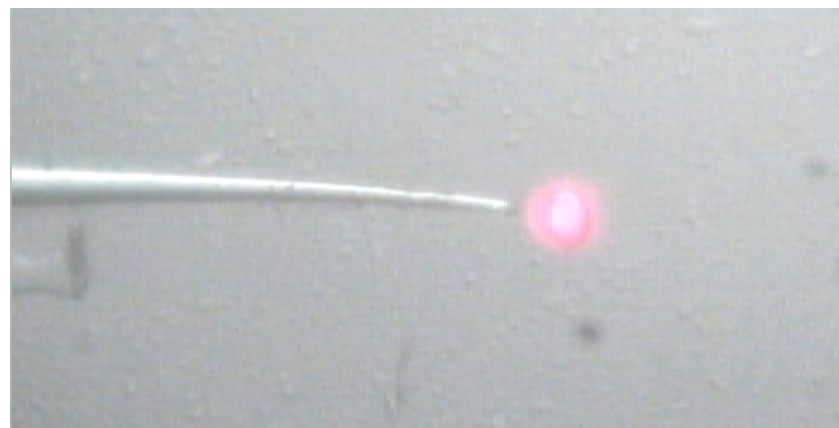
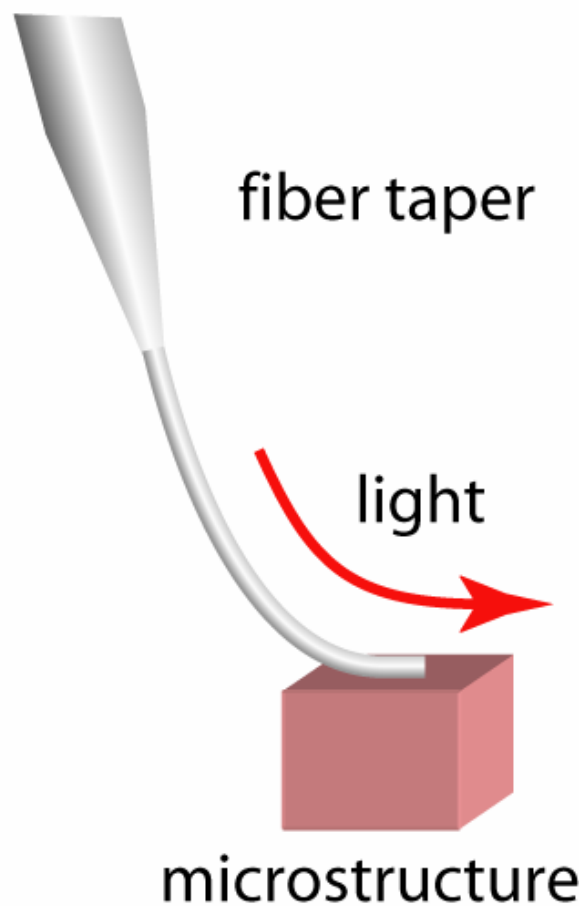


# Fabrication of nanowires

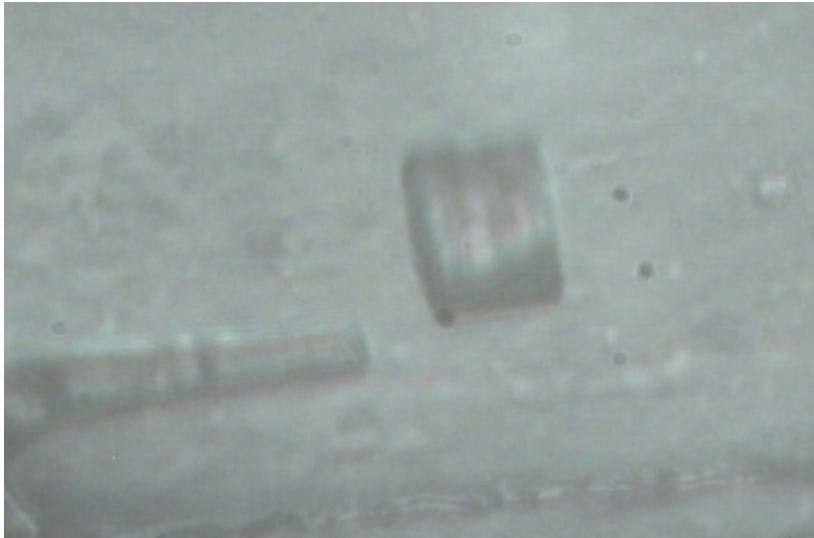




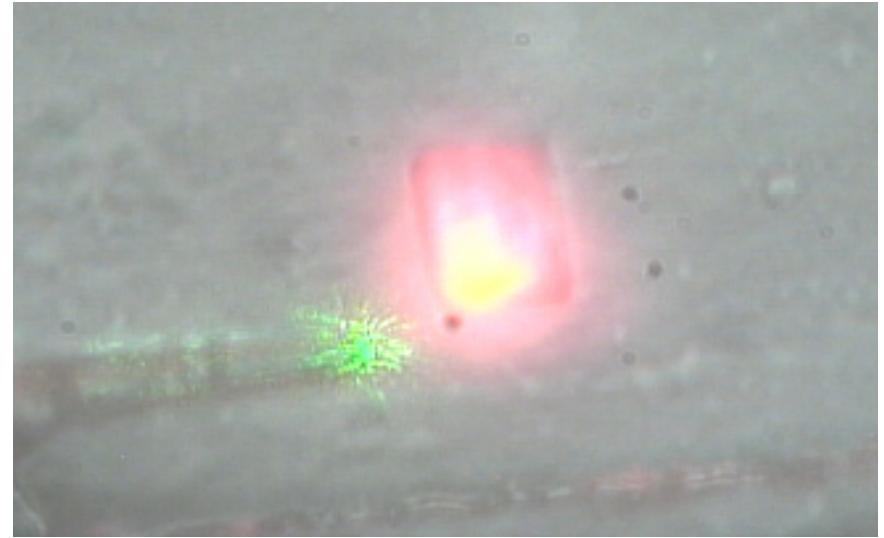
# Microstructures excitation by the nanowires



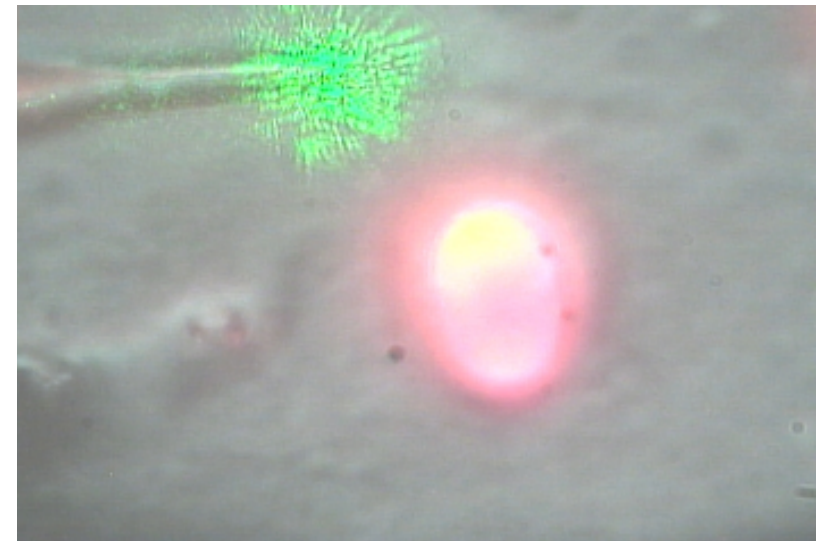
# Fluorescence microscopy images



no laser excitation



laser excitation at 480 nm



## Conclusions

- 3D-microstructures containing rhodamine can be fabricated via 2PA polymerization.
- Rhodamine preserves its luminescent properties when contained into the microstructure bulk.
- Submicrometric wires can be used to couple light into the microstructures

## Acknowledgments

