Wiring microstructures with tapered fibers

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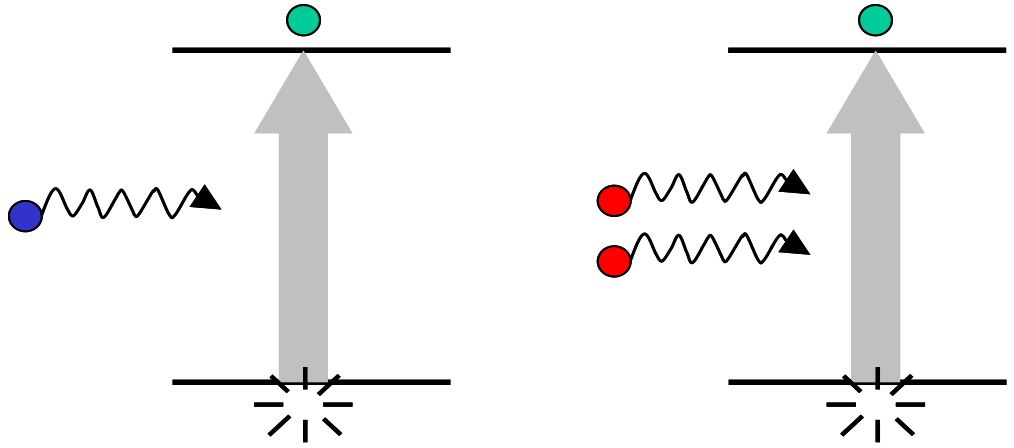
SPIE Photonics West

Motivation

Two-photon polymerization is a powerful method to fabricate three-dimensional microstructures, which can also be doped to produce 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)

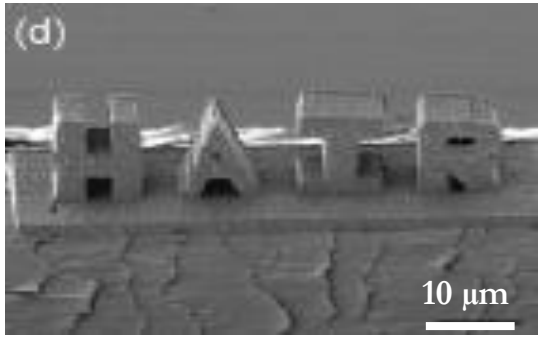
2-photon absorption (nonlinear)

Two photons are absorbed in a single event!

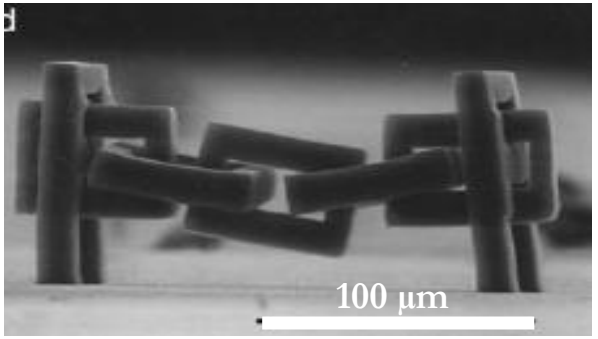
Advantage of the process: spatial selectivity in the absorption

2PA applications

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

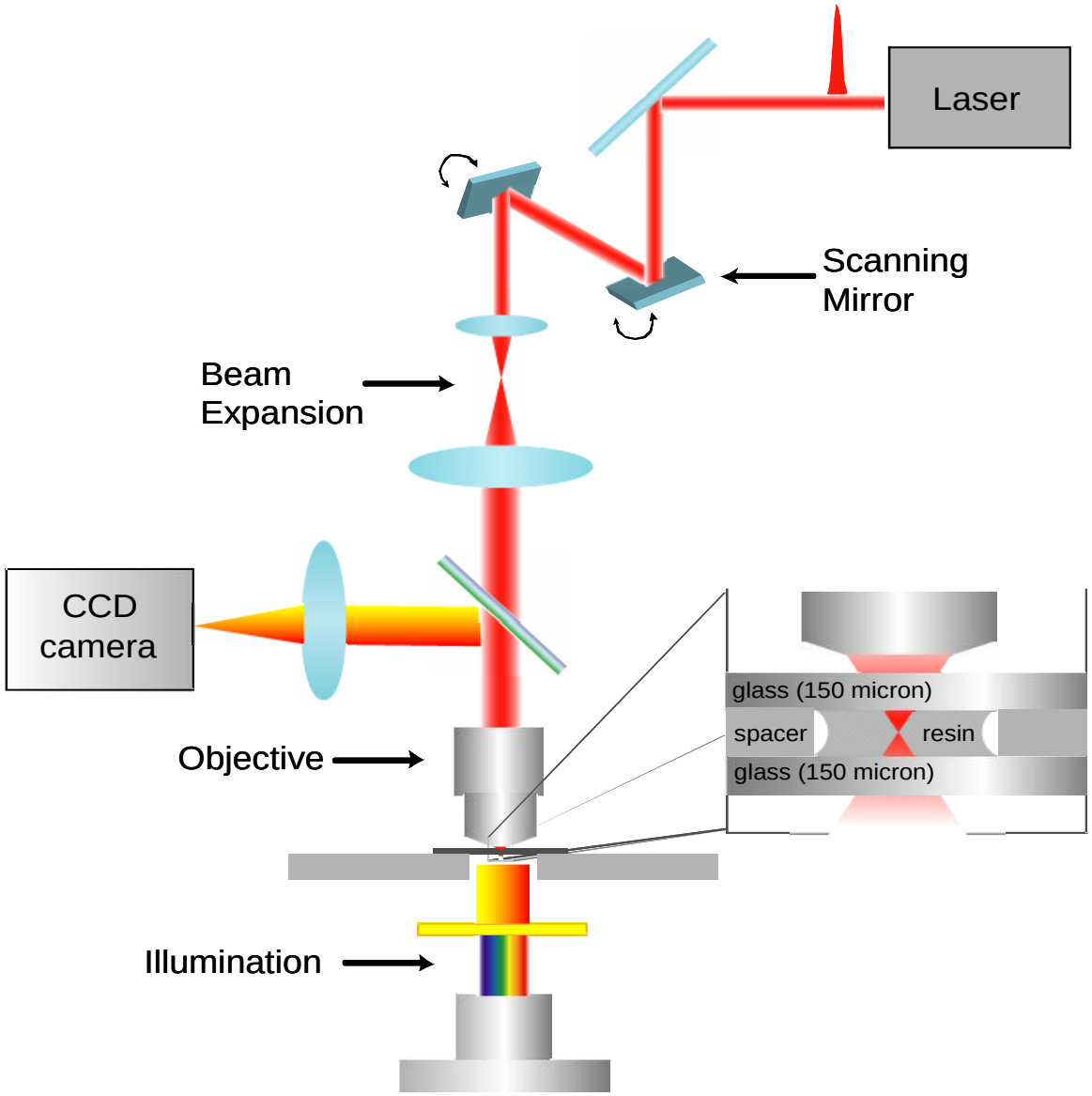


T. Baldacchini et al; *J. Appl. Phys. (*2004)



J. W. Perry et al; *J. Phot. Sci. Tech.* (2001)

2PA polymerization setup



Ti:sapphire laser oscillator

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

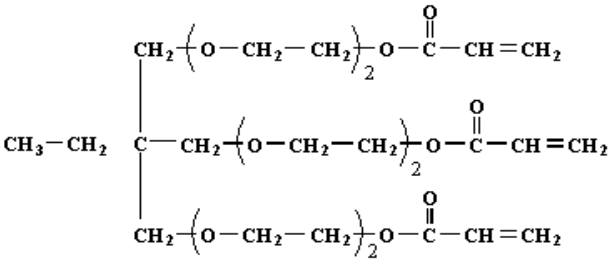
Objective

40 x
0.65 NA

Monomers and photoinitiator

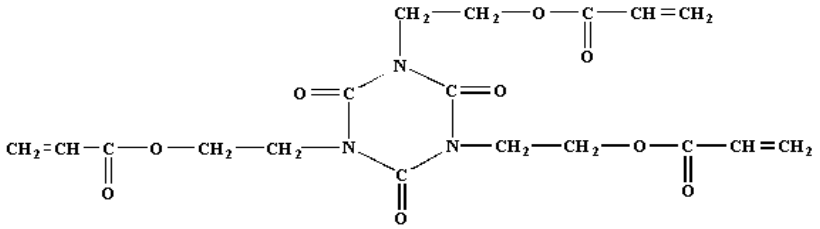
Monomers

SR499



Decreases residual stress during shrinkage

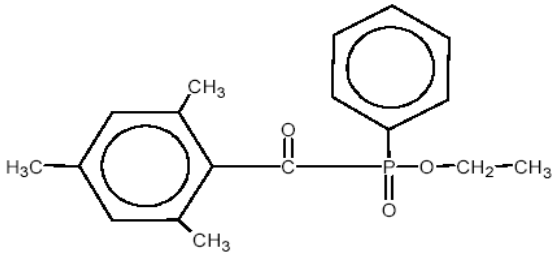
SR368



Provides hardness to the polymeric structure

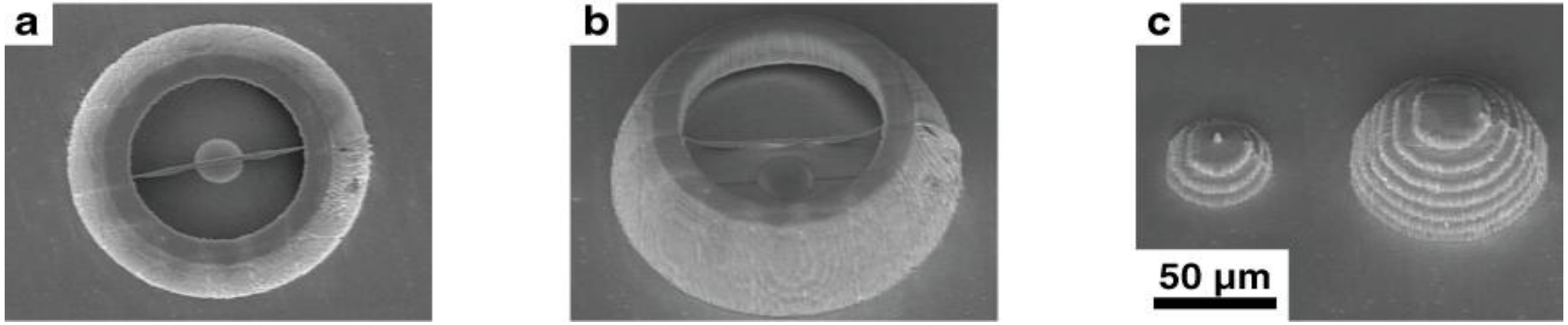
Photoinitiador

Lucirin TPO-L



Samples of the microstructures

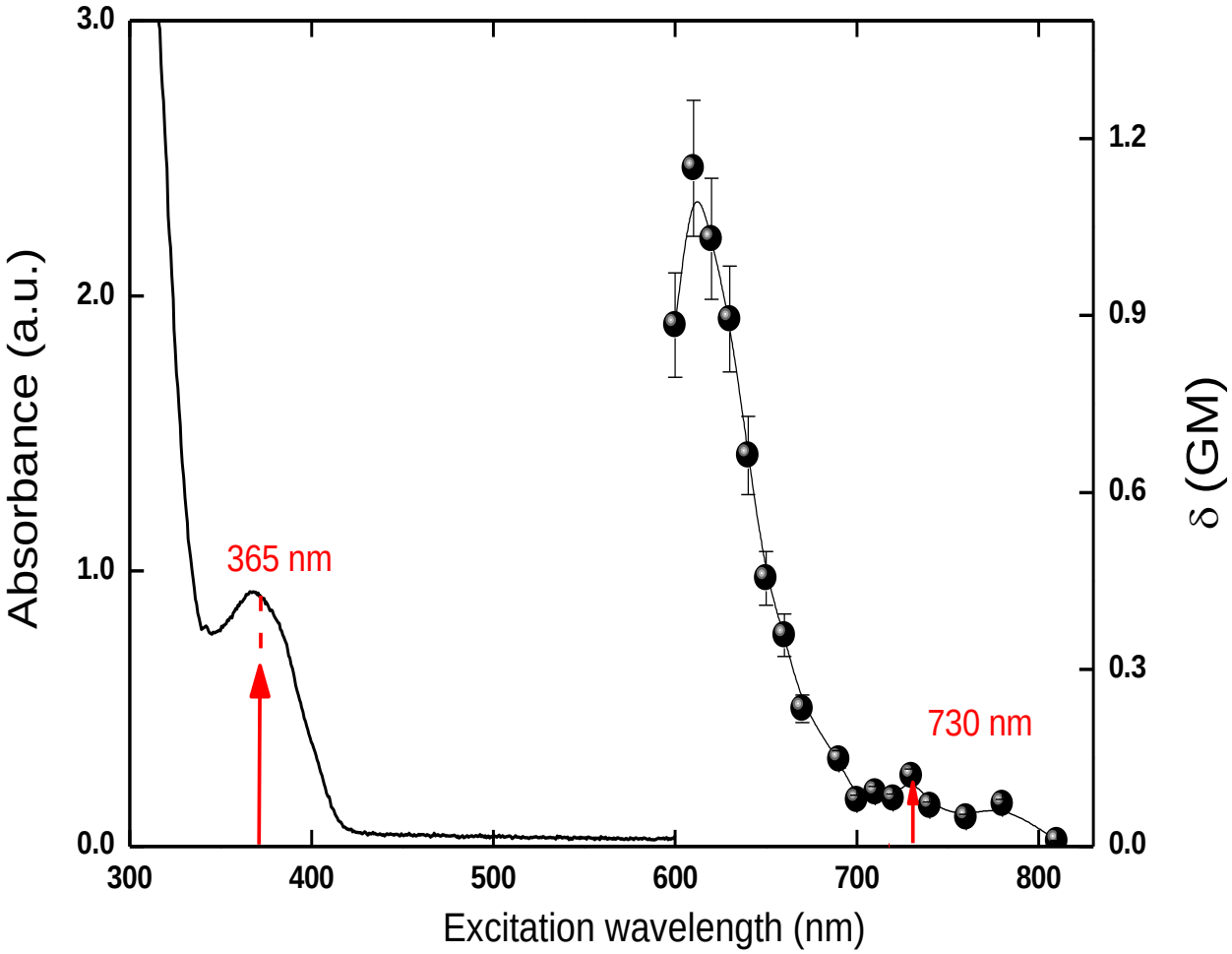
SEM of some microstructures fabricated via 2PA polymerization



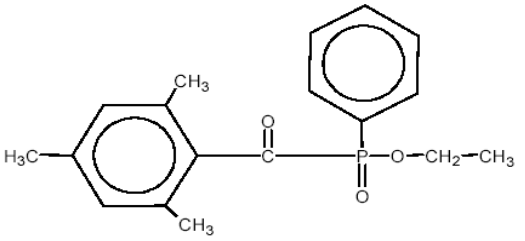
(a) Top view
(b) 30 º view of semi-spherical structure
(c) Conical microstructures

Microstructures show excellent integrity

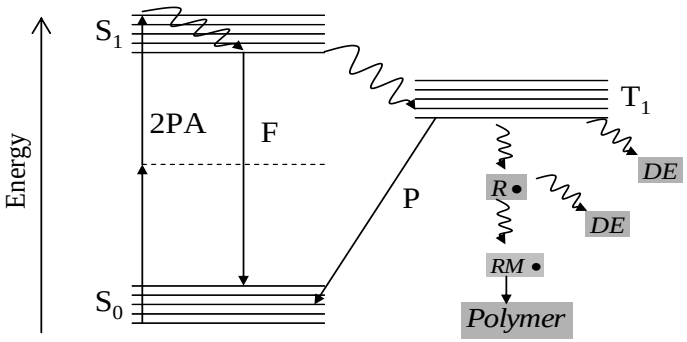
2PA spectrum of Lucirin TPO-L



C.R. Mendonça et al, *Appl. Phys A* (2008)

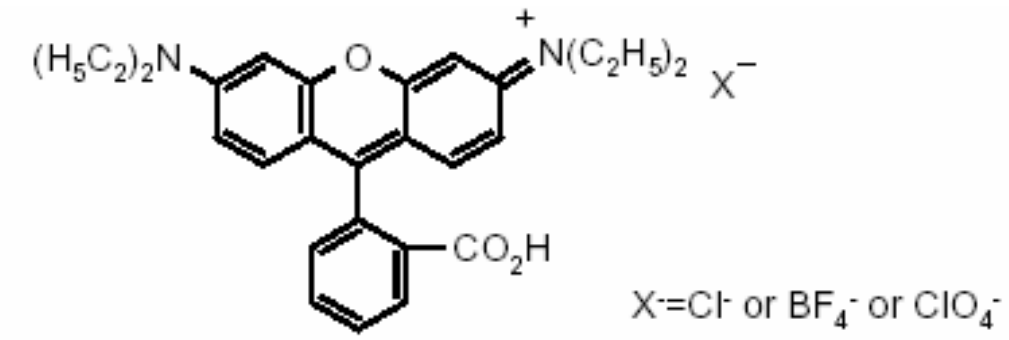


Chemical structure



Energy diagram

“Doping” material → Rhodamine



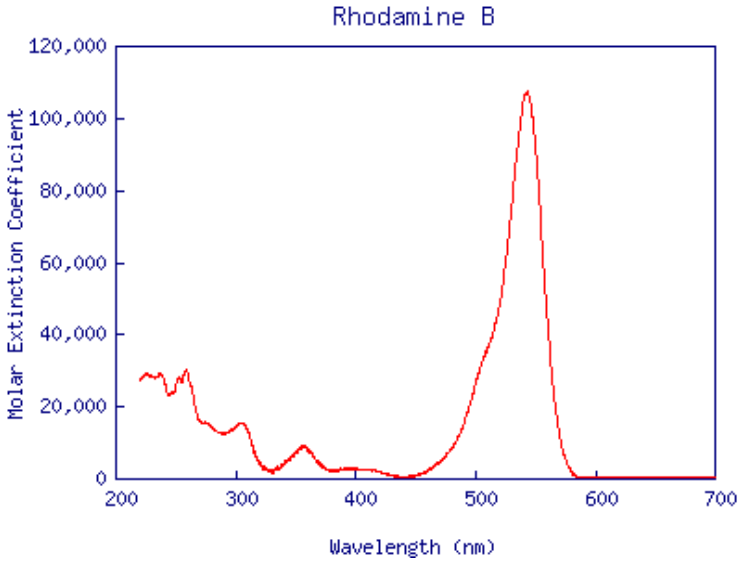
610, N-[9-(2-carboxyphenyl)-6-(diethylamino)-3H-xanthen-3-ylidine]-N-ethyl-ethanaminium perchlorate

Why doping the basic resin with rhodamine?

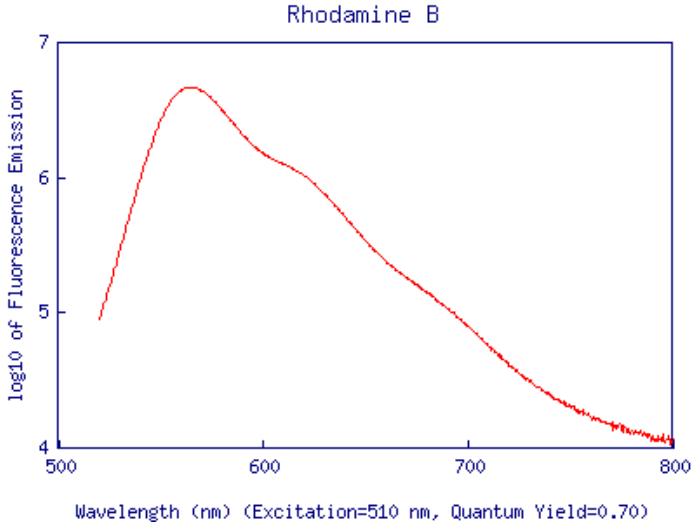
- → Dye presenting high fluorescence signal
- → Soluble in many organic compounds
- → High thermal and chemical stability

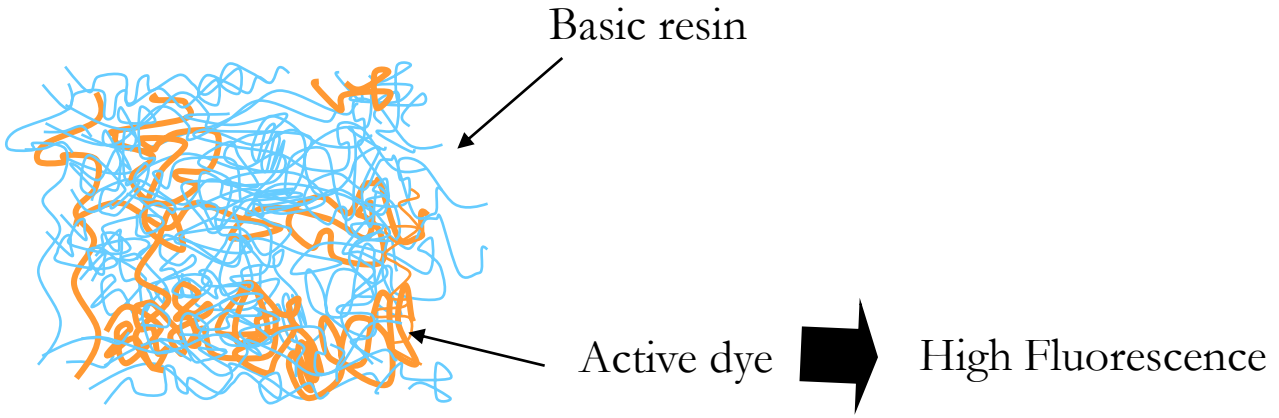
Microstructures doped with Rhodamine

Absorption spectrum



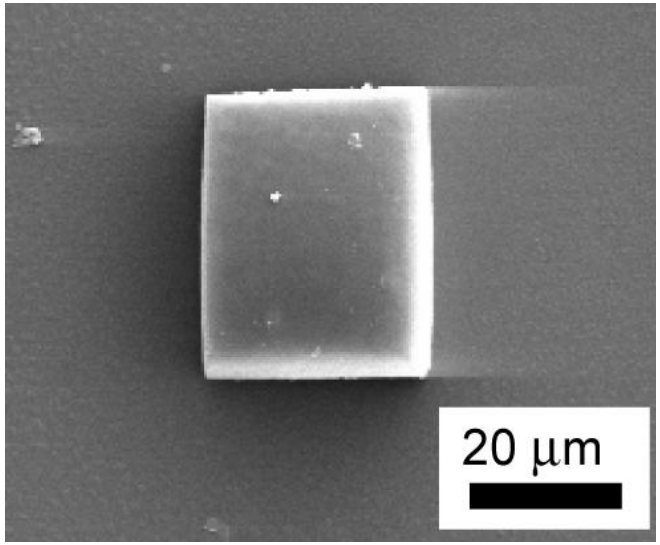
Fluorescence spectrum

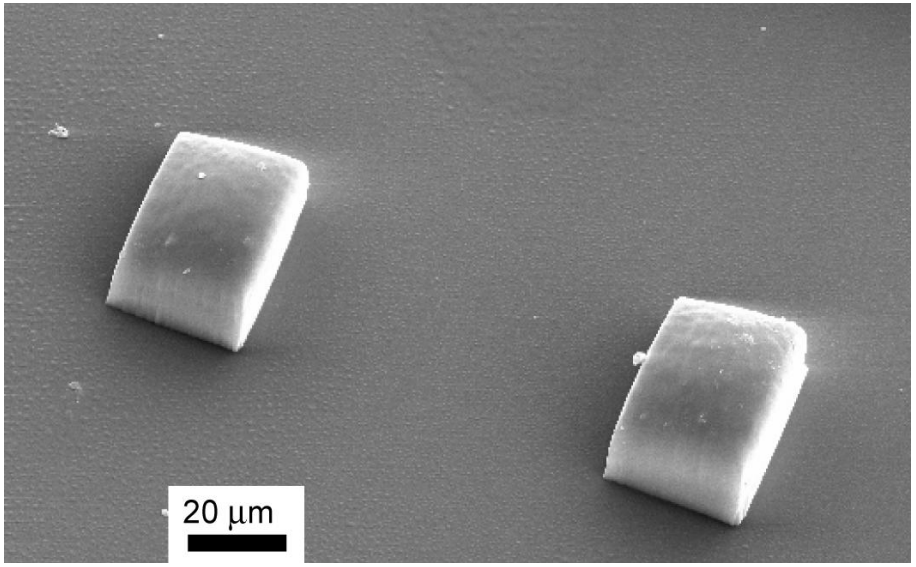


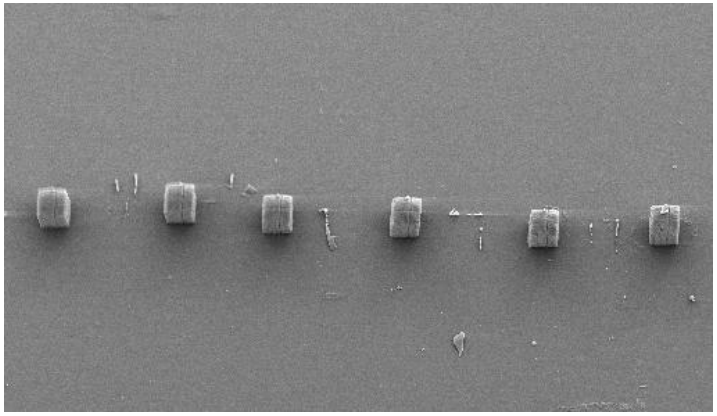


Microstructures doped with Rhodamine

SEM of some fabricated microstructures

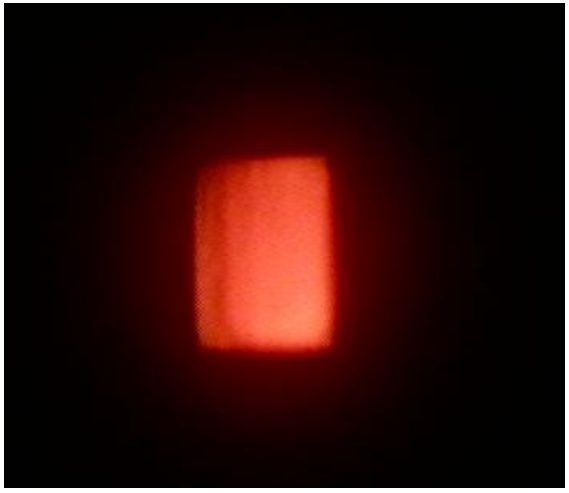


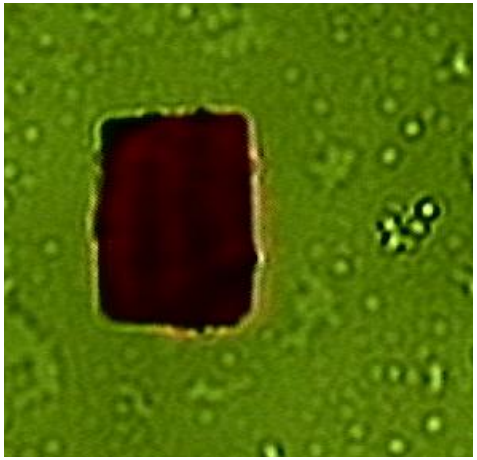




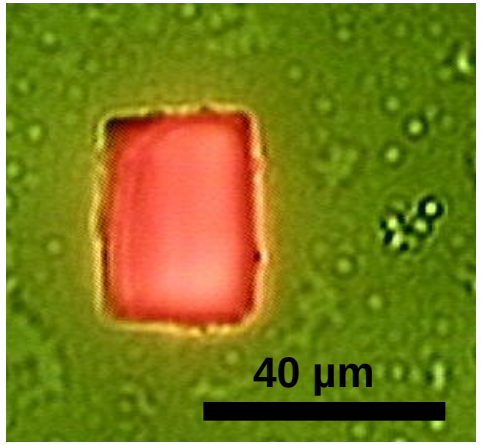
Microstructures doped with Rhodamine

Microscopy fluorescence images of cubes and cylinders (top view)





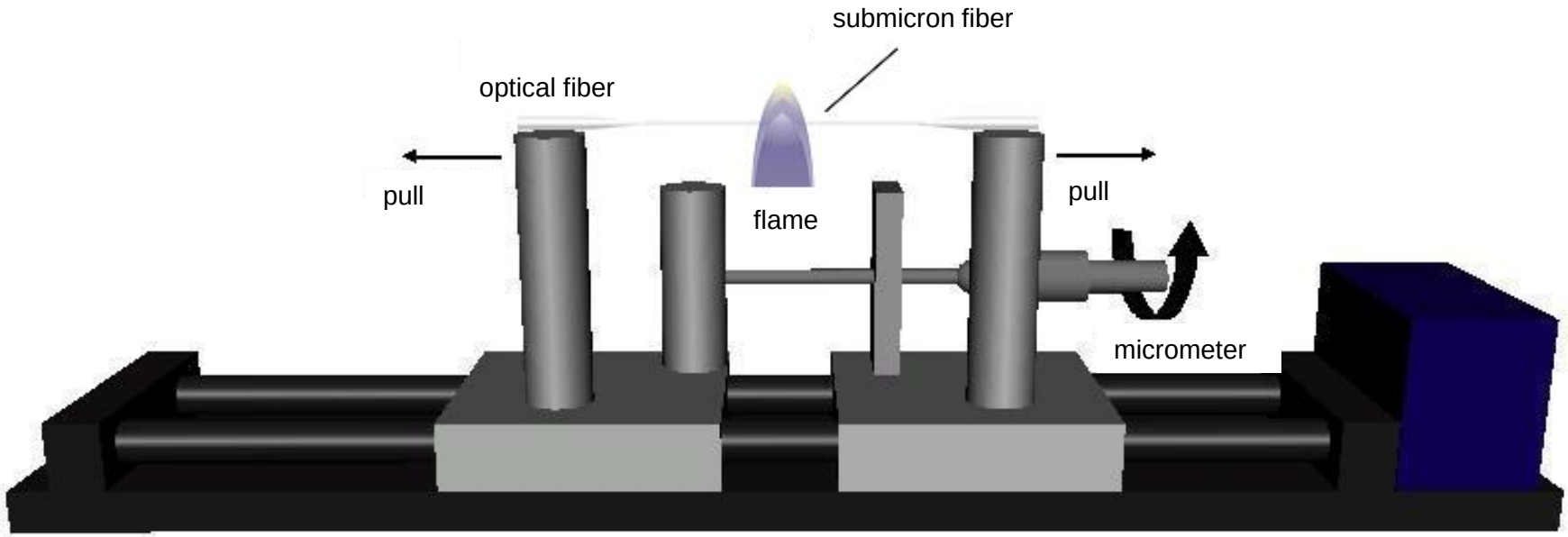
Excitation OFF

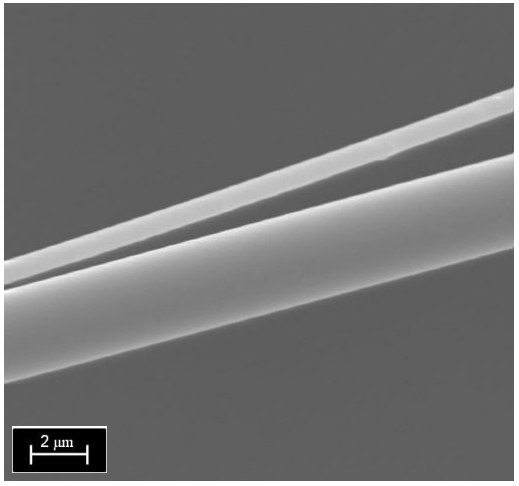


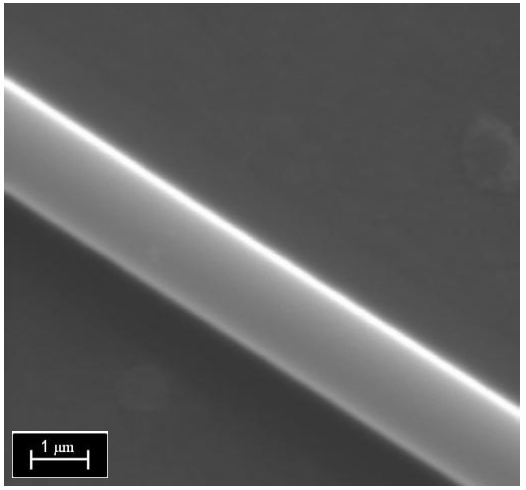
Excitation ON

red fluorescence typical of rhodamine

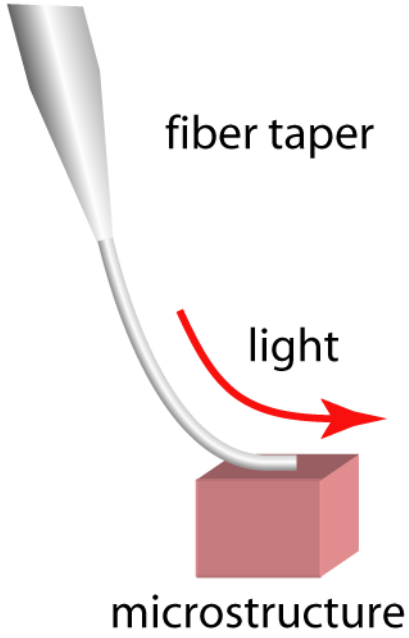
Fabrication of nanowires

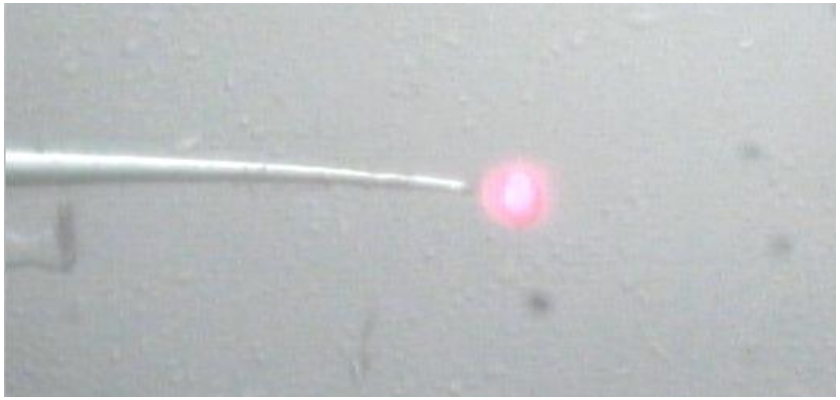




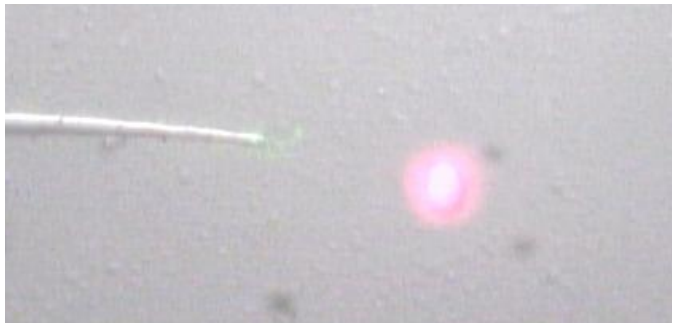


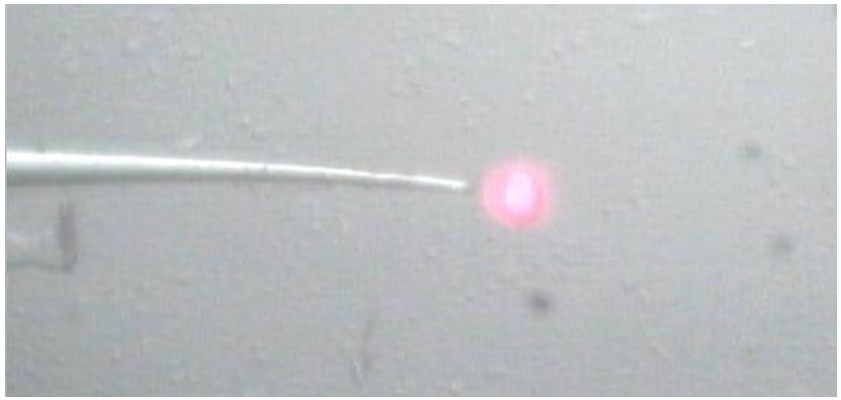
Microstructures excitation by the nanowires

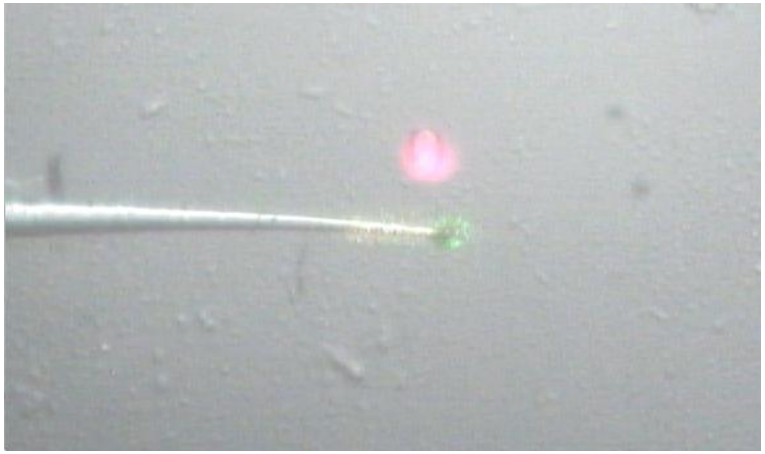


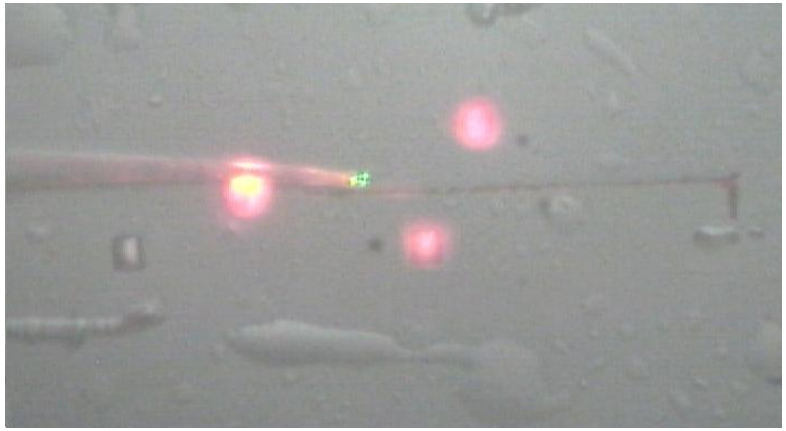


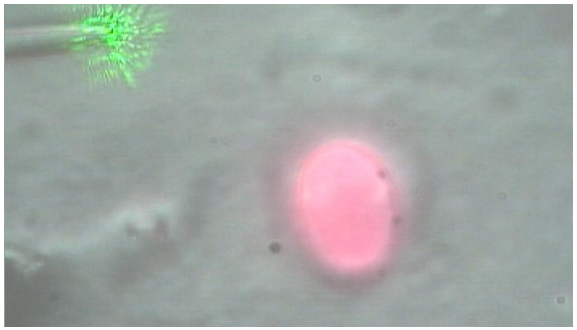
Fluorescence microscopy images



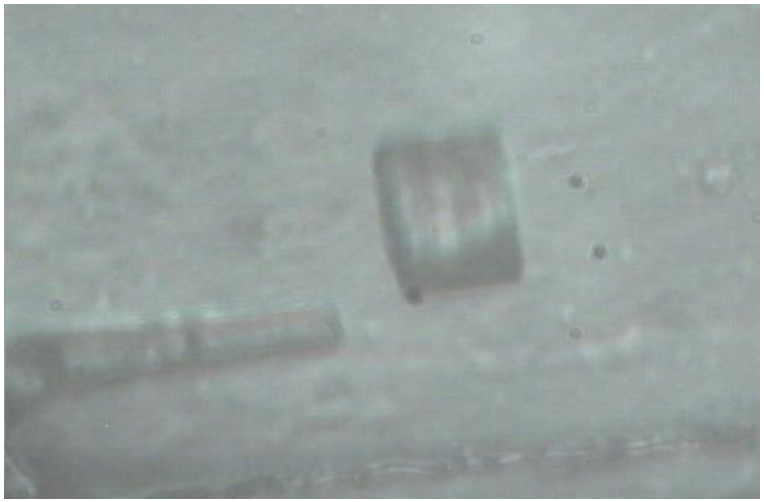




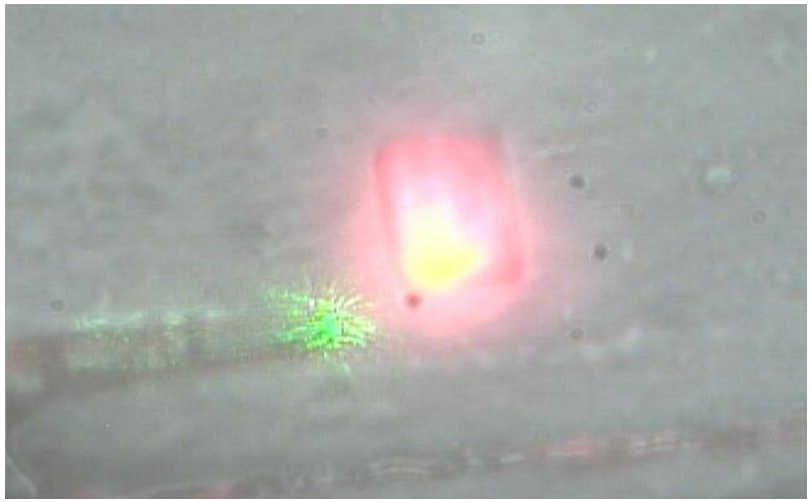




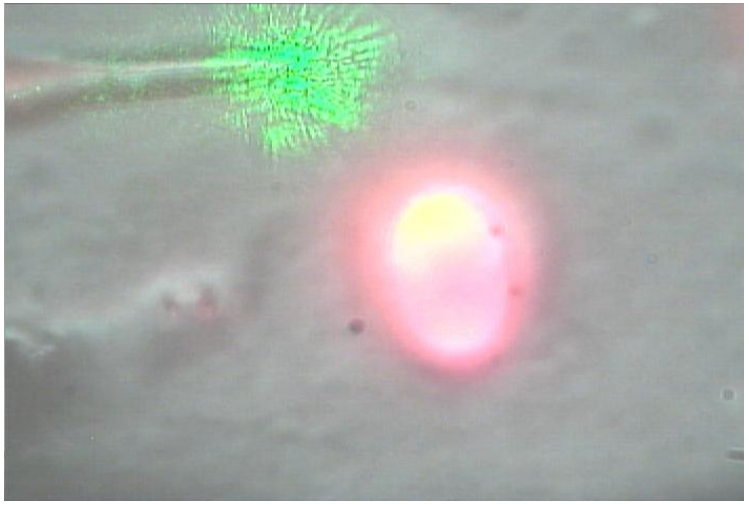
Fluorescence microscopy images



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 ligth into the microstructures

Acknowledgments

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