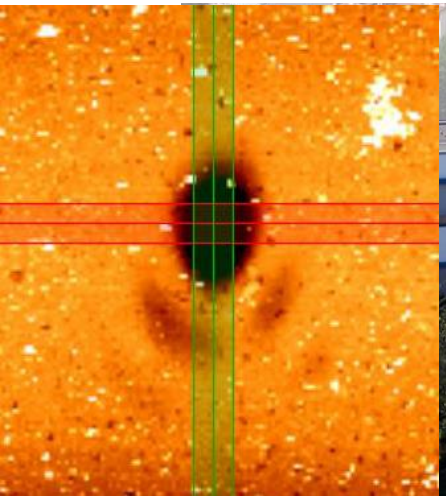
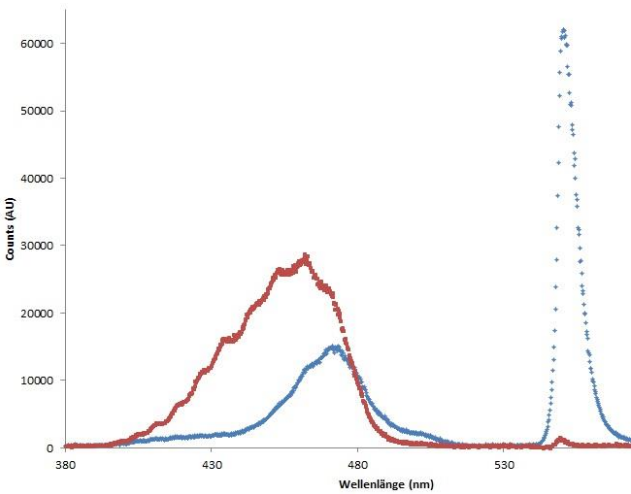
Laser-
Laboratorium
Göttingen e.V.

Principles and applications of optical switching assisted imaging and structuring schemes





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Motivation

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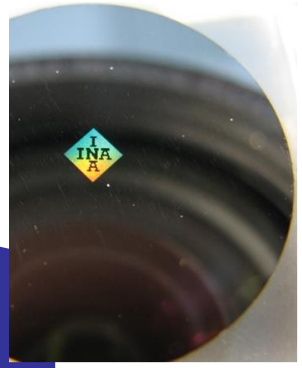
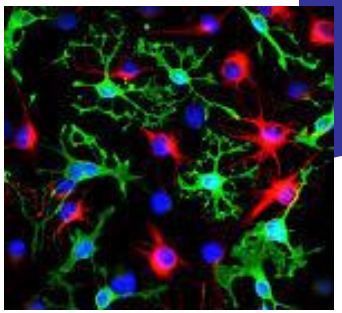
self-cleaning surfaces

holographic design elements

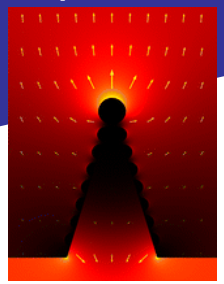


Application areas of nanostructures

cell growth engineering



field amplification

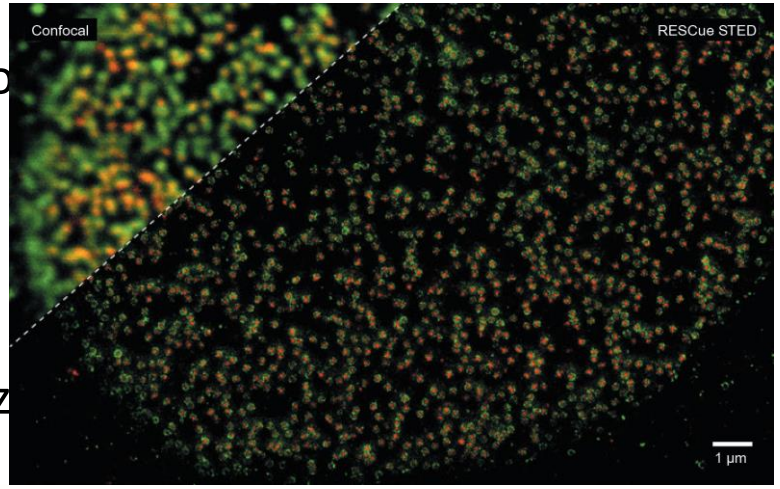


diffractive security features

Alternative approach?

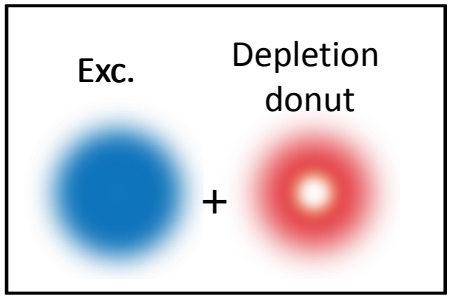
STED microscopy

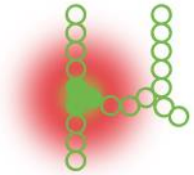
Abberior Instruments, Nature Vol. 526



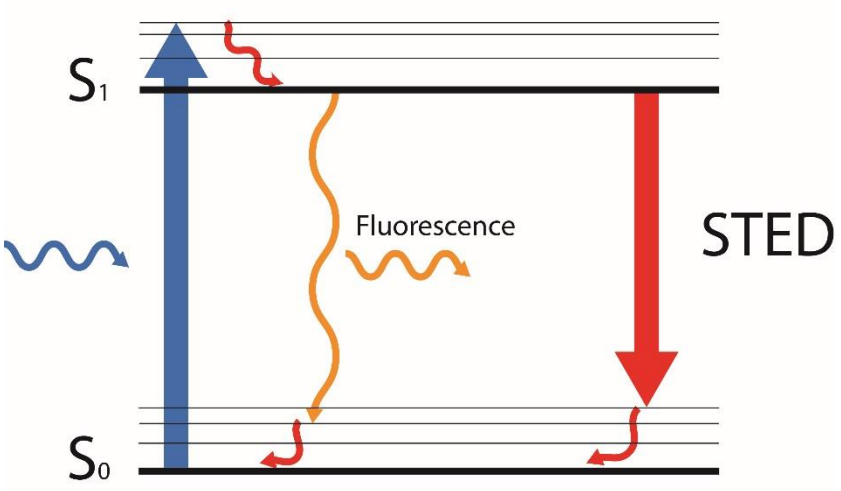
STimulated Emission Depletion micro

- Super-resolution microscopy
- Visible wavelength regime
- Depopulation of excited state
- Nobel prize (Hell, Moerner & Betz



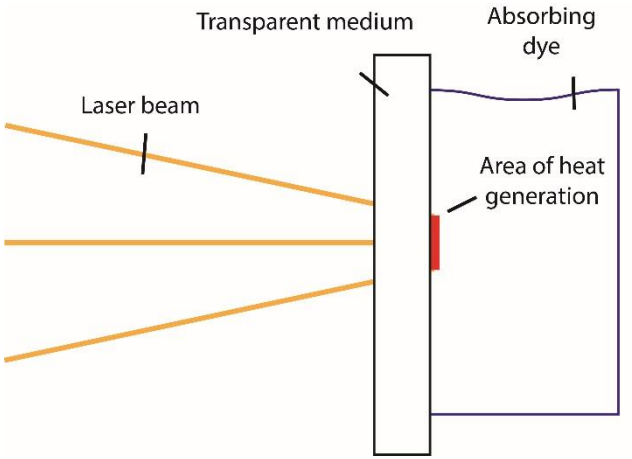


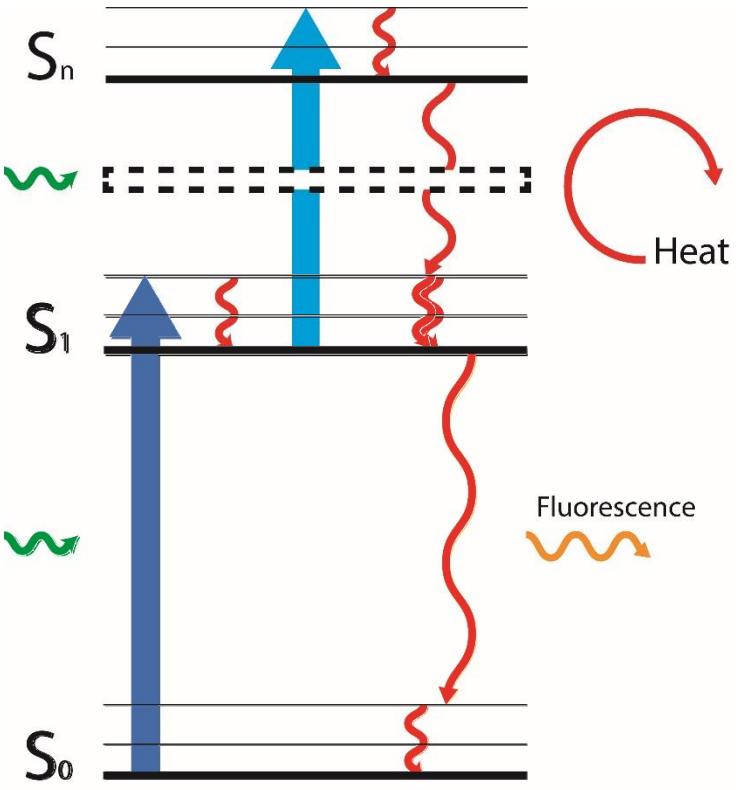
$$\sim \frac{\lambda}{2n}$$



Laser Induced Backside Wet Etching:

- Fluorophores deposit energy
- Able to structure fused silica, sapphire etc.
- Excimer laser (UV)





LIBWE + STED

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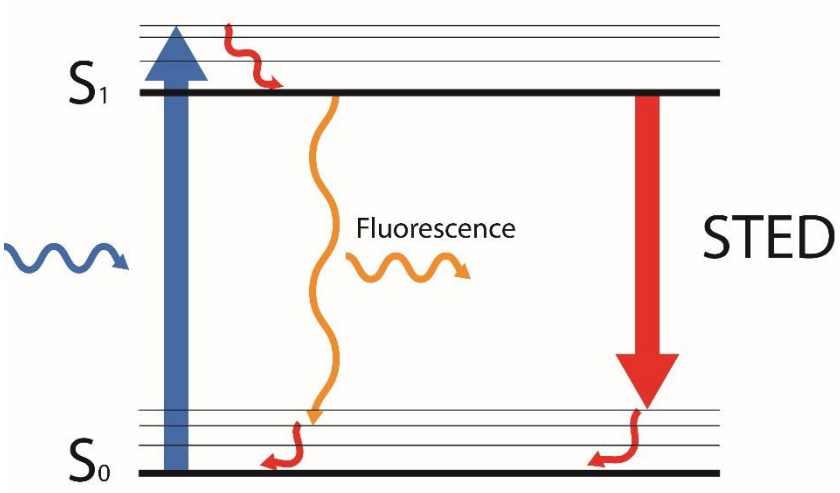
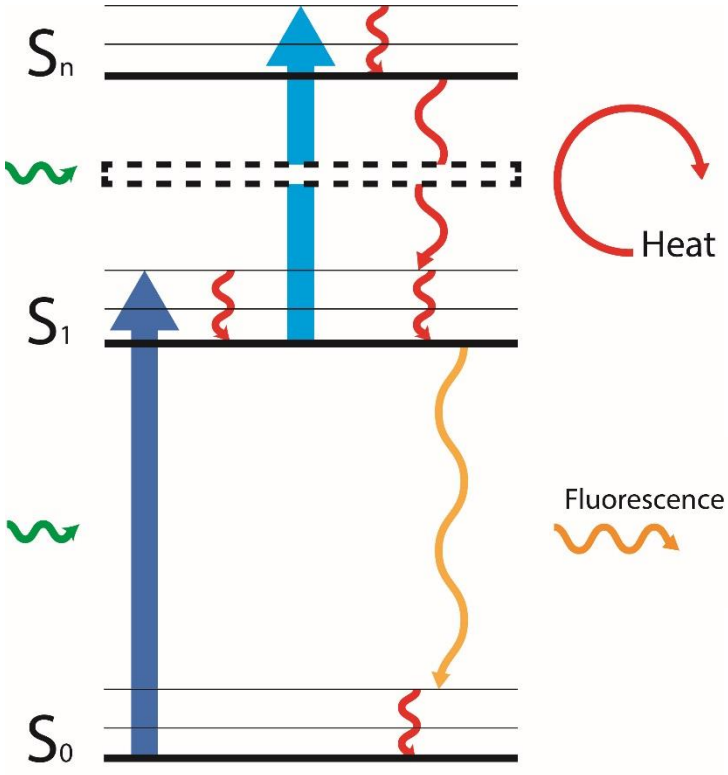
STED

Control shape



LIBWE

Deposit heat



Dye

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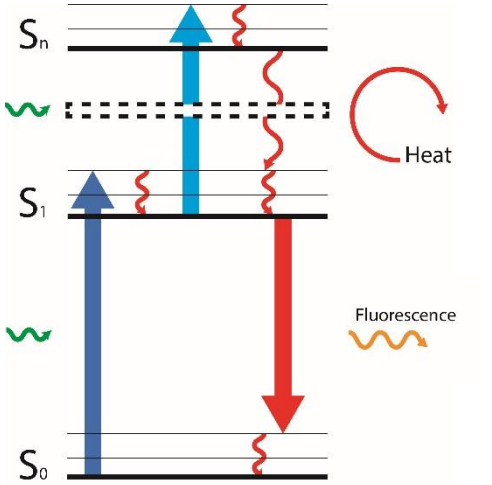
Required dye properties:

- Excited State Absorption (ESA) in the visible range
- Soluble at high dye concentrations
- High fluorescence quantum efficiency

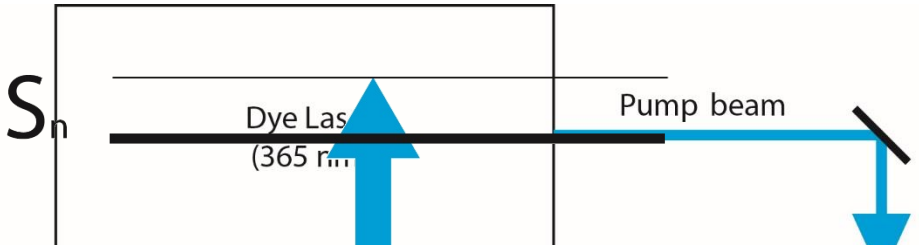
  ➔ Laser dye



Our choice: Rhodamine 6G

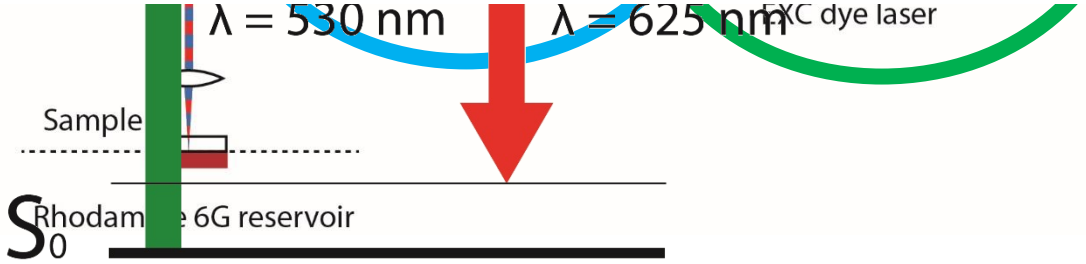
- Excited state absorption: λ = 440 nm
- Soluble in ethanol up to c = 0.16 mol/l, in methanol up to c = 0.66 mol/l
- Fluorescence quantum yield: 96 %
- Ground state absorption maximum: λ = 530 nm

Setup

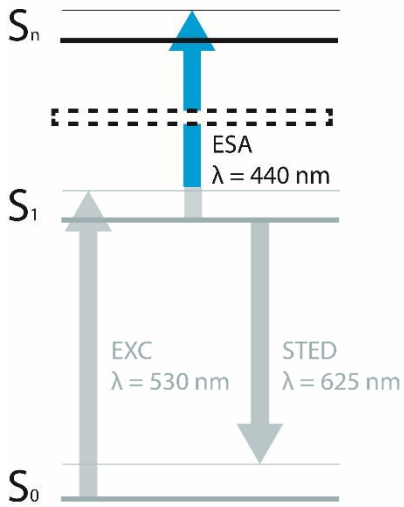


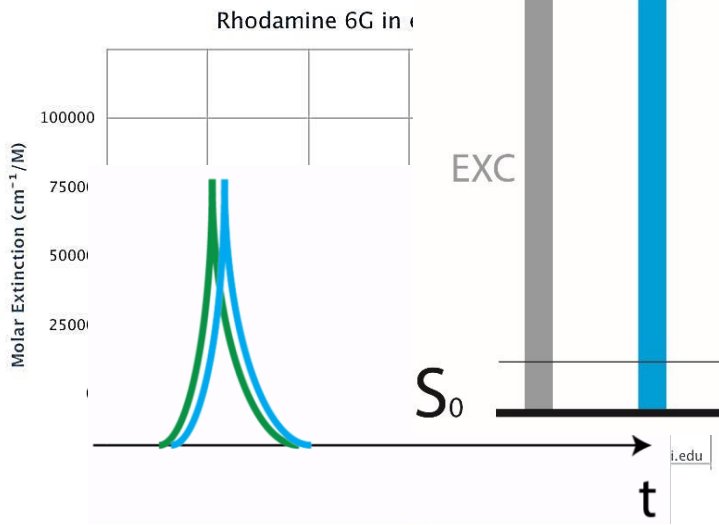
Laser parameters:

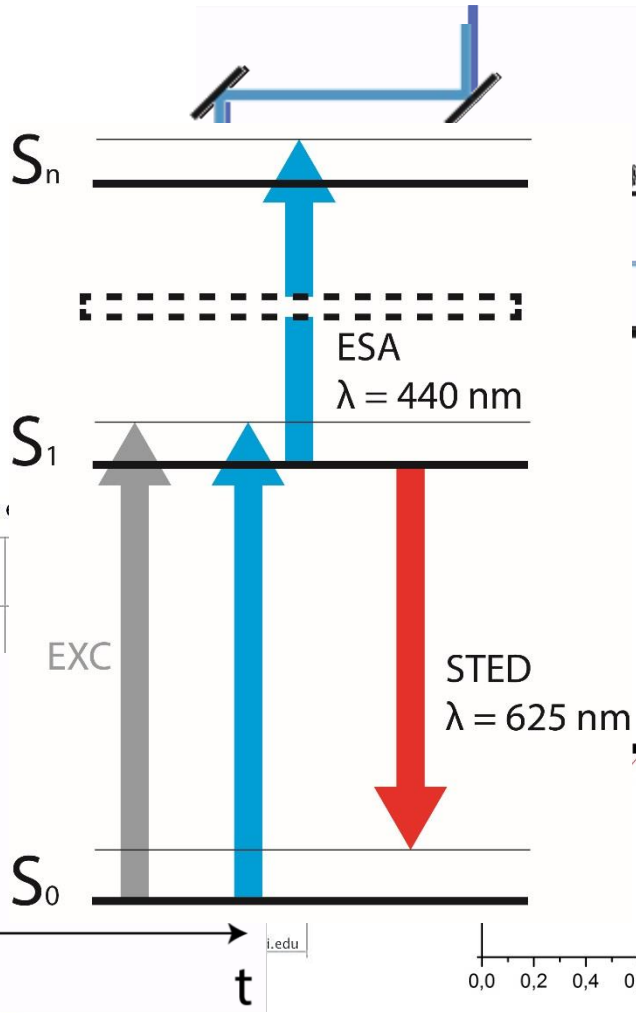
- ESA laser beam: 440 nm, 50 ps, >1000 mJ/cm²
- EXCitation laser beam: 530 nm, 50 ps, > 1000 mJ/cm²
- STED laser beam: 625 nm, 50 ps, >1000 mJ/cm²
- All laser beams synchronized
- Repetition rate: 4 Hz

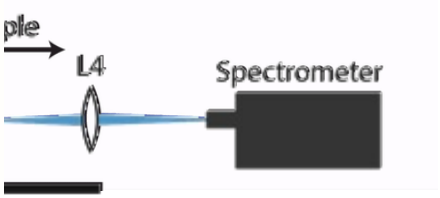


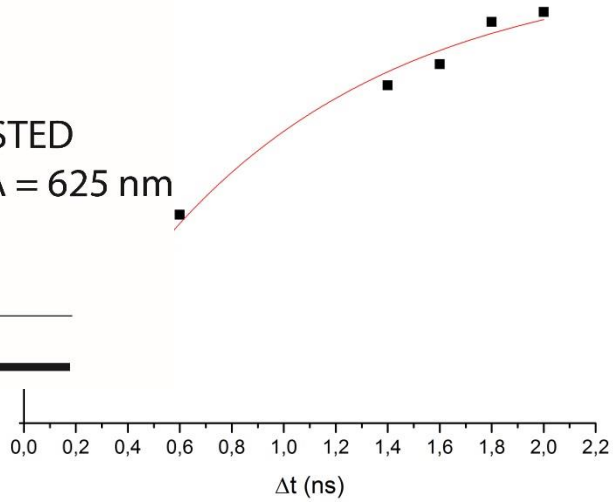
ESA with Rhodamine 6G



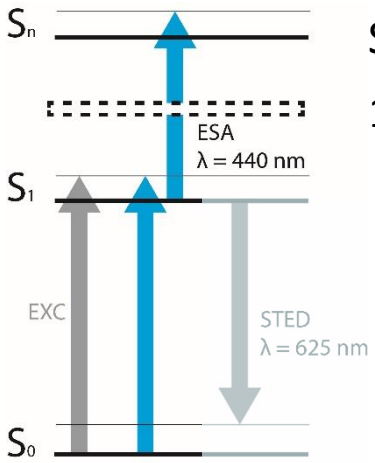






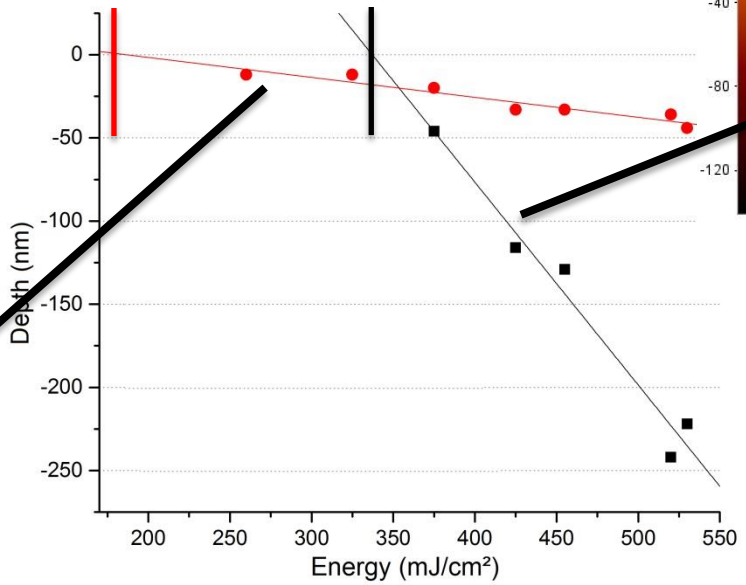


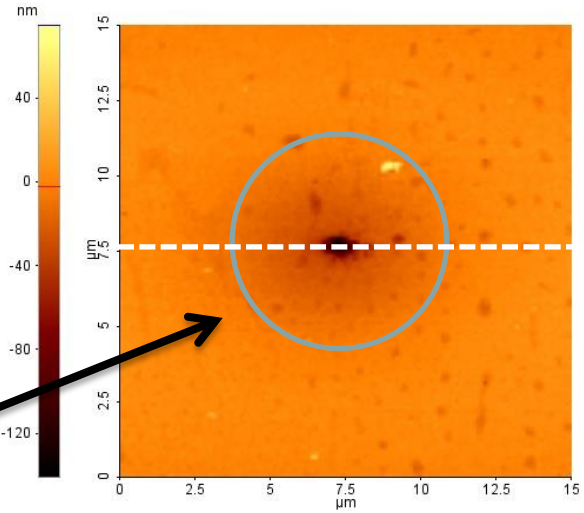
PMMA ablation



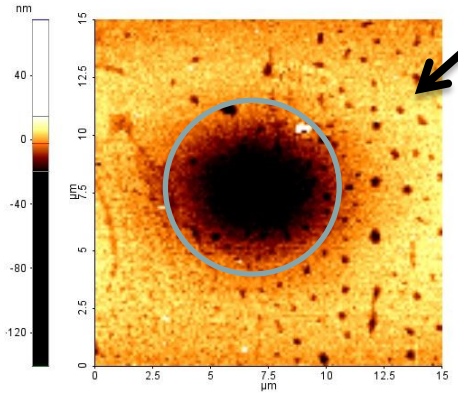
Sample: PMMA

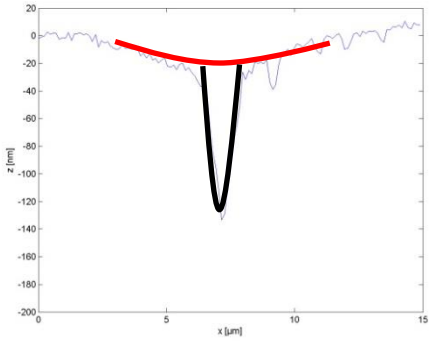
1000 pulses



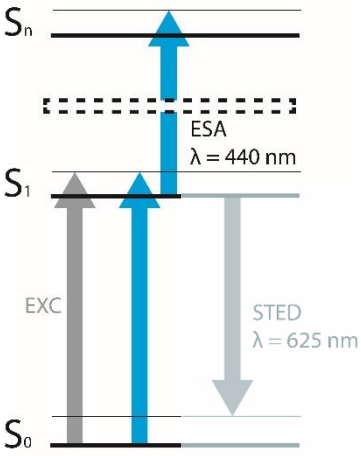


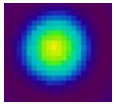
AFM Image

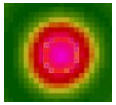


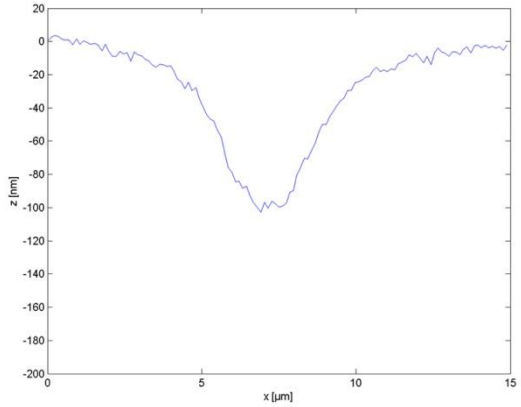


ESA+STED

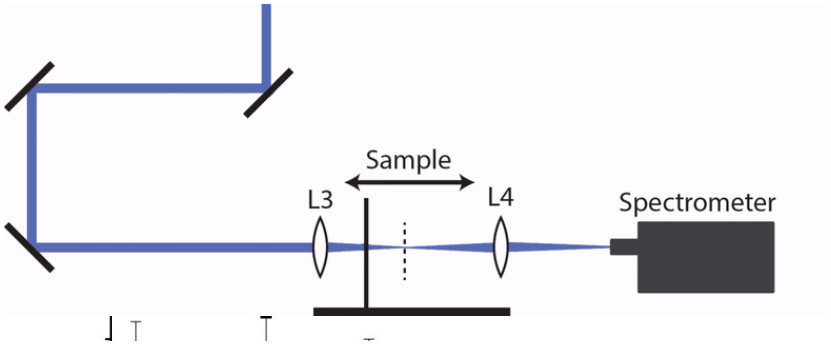


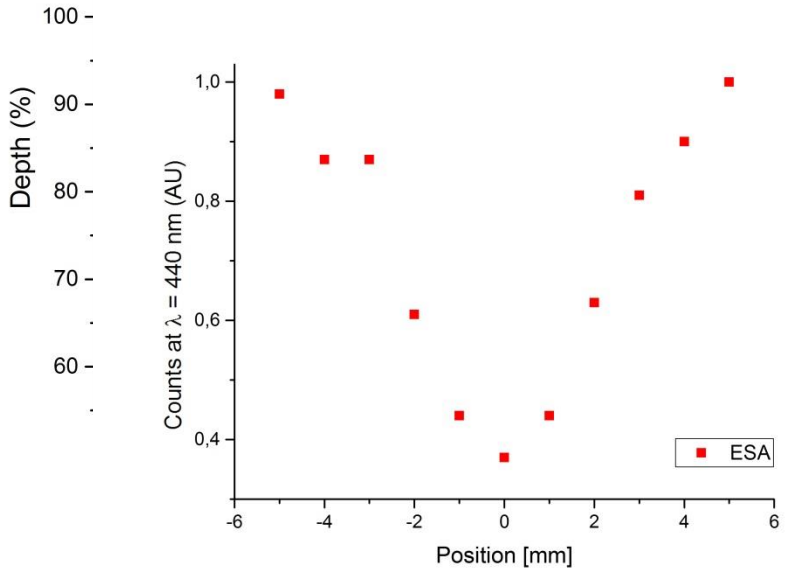






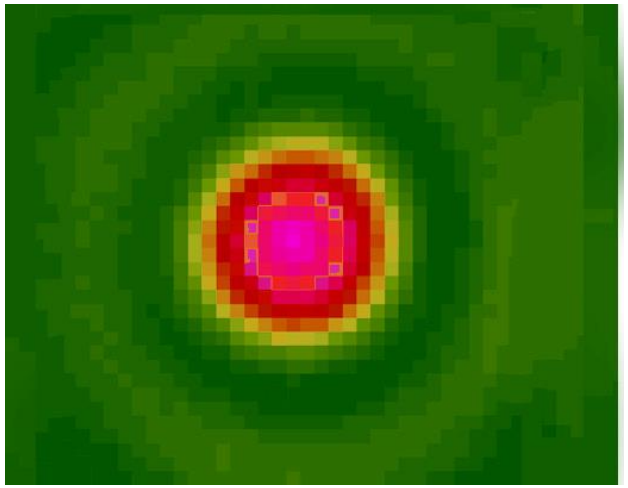
Superimpose STED and ESA laser beam

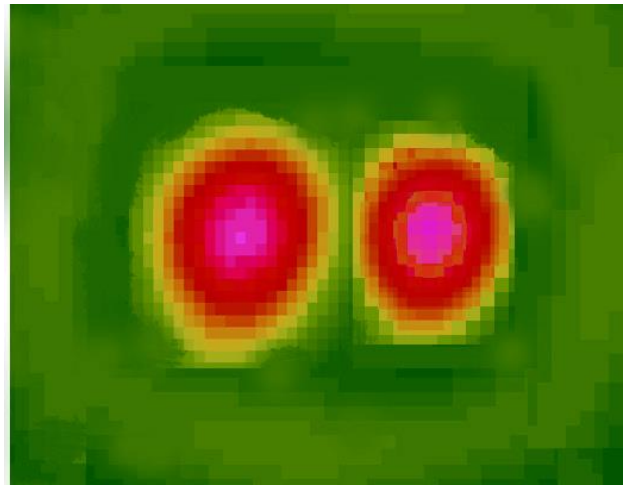




Shape control

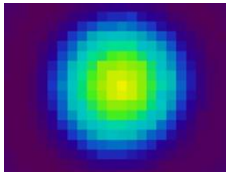
Add phase plate to STED laser beam

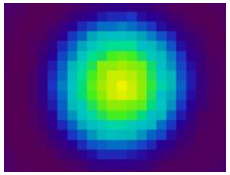




Shape control

ESA STED





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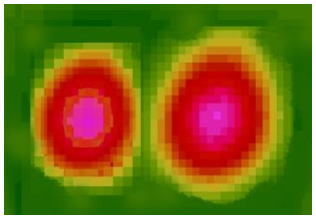

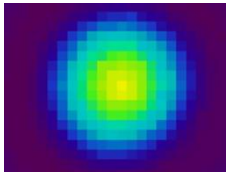

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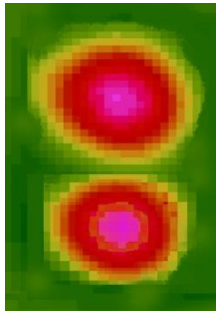

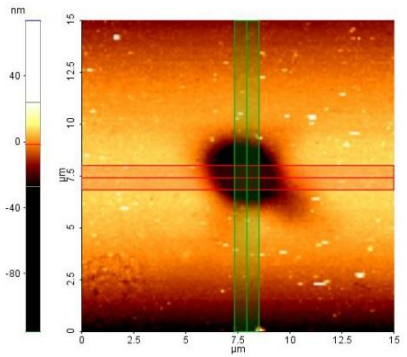

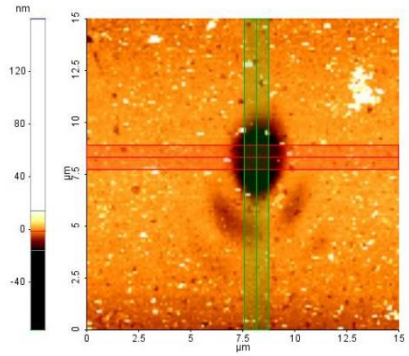

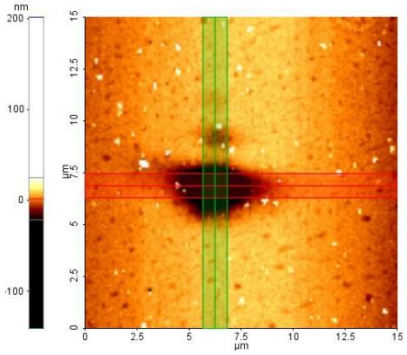

Outlook

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Summary

- Proof of principle

  STED laser beam reduces structure size

- *Interesting effect for higher ESA energies*

Outlook

- Work with higher Numerical Aperture
- Optimize laser parameters (repetition rate, pulse width)
- Better fluorophores
- Other substrate material

Acknowledgements

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