Characterization and laser operation of PLD grown $Yb^{3+}:Y_2O_3$

S. H. Waeselmann[1], S. Heinrich[1], K. Beil[1], K. A. Sloyan[2], R. W. Eason[2], C. Kränkel[1,3], and G. Huber[1,3]

1) Institut für Laser-Physik, Universität Hamburg
2) Optoelectronics Research Centre, University of Southampton
3) The Hamburg Centre for Ultrafast Imaging

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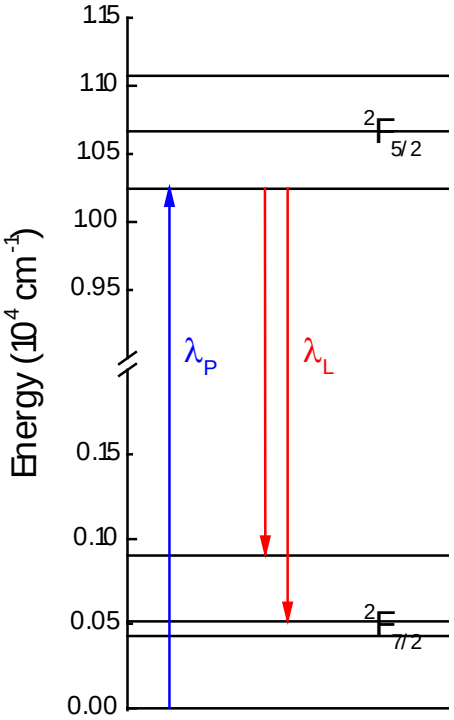
Outline

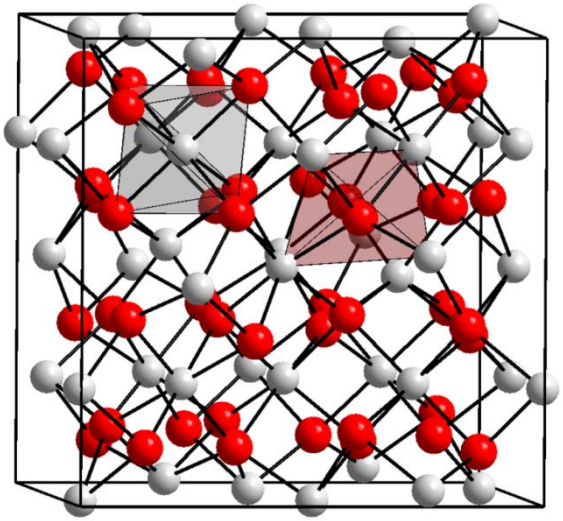
- $Yb:Y_2O_3$
- Pulsed laser deposition
- Characterization of $Yb^{3+}:Y_2O_3$ thin films
- Laser experiments
- Outlook

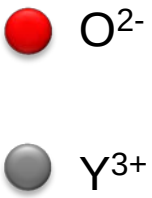
Yb:Y_2O_3 material properties

Yb^{3+}



Y_2O_3



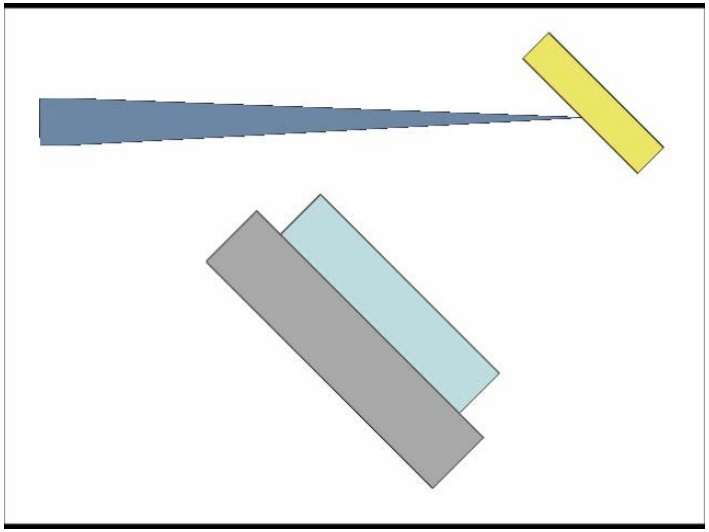


- Quasi 3-level scheme
- Low quantum defect

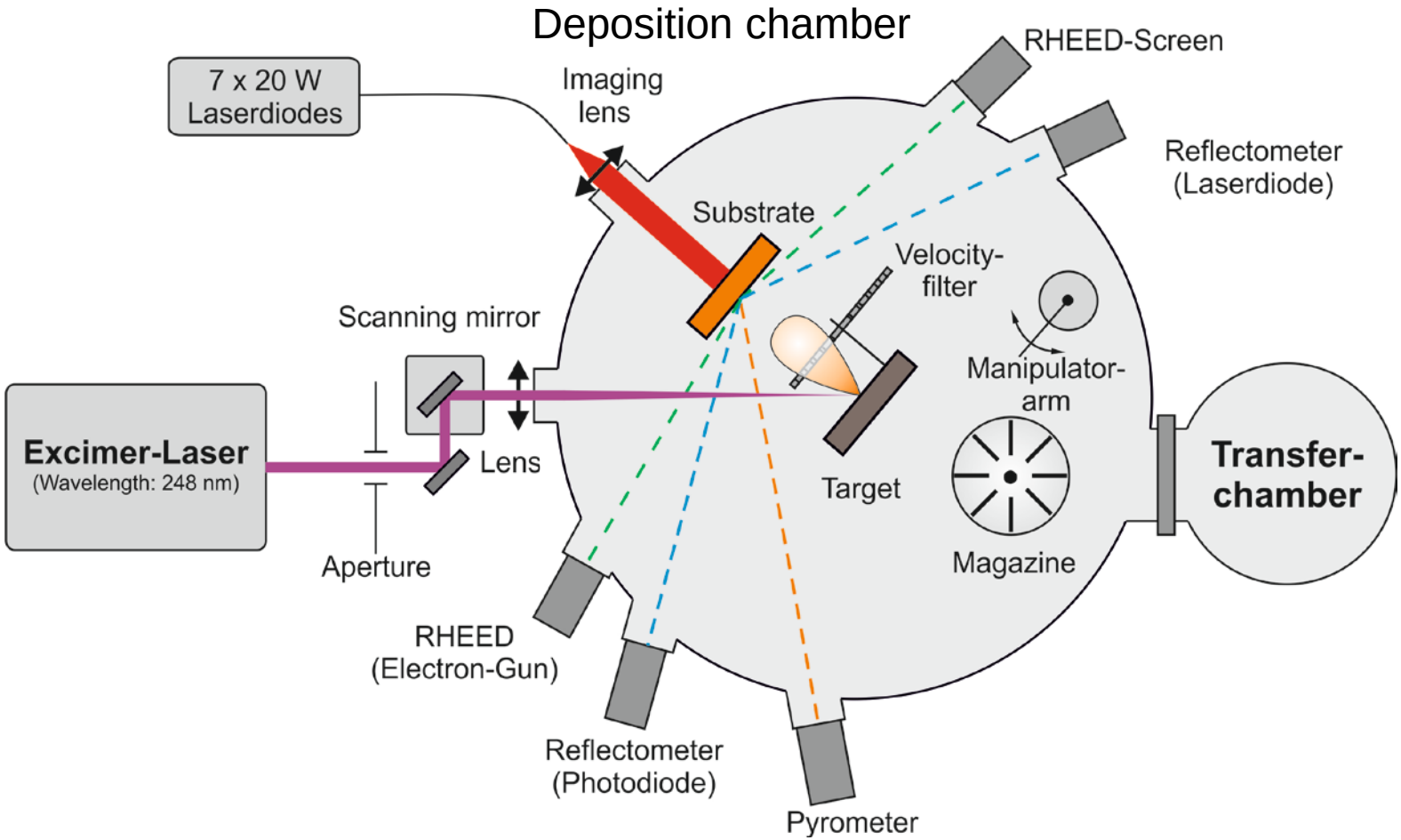
- Cubic lattice, spacegroup $I\bar{a}3$
- Good thermo-mechanical properties

Pulsed Laser Deposition

- Film is grown far away from thermal equilibrium
- Target stochiometry is transferred to thin film
- Epitaxial layer-by-layer growth
- Possibility to grow “difficult“ materials



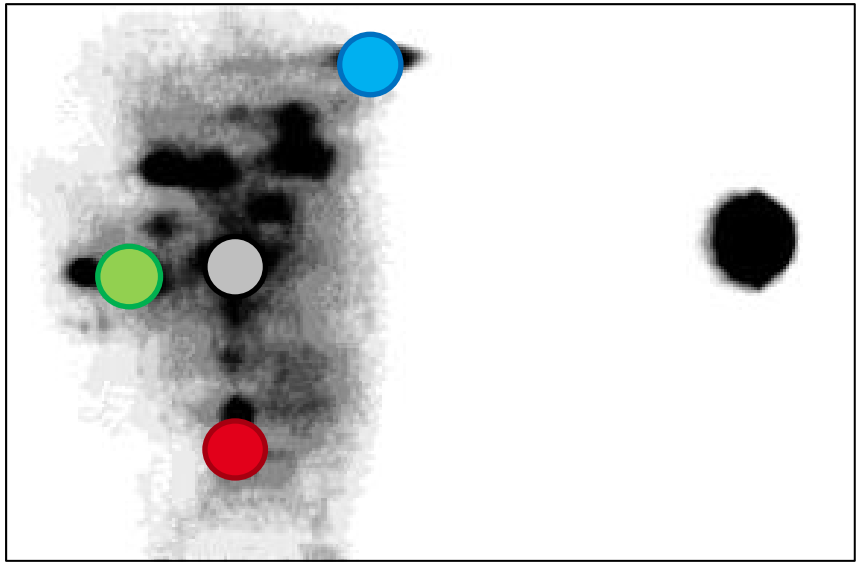
Pulsed Laser Deposition



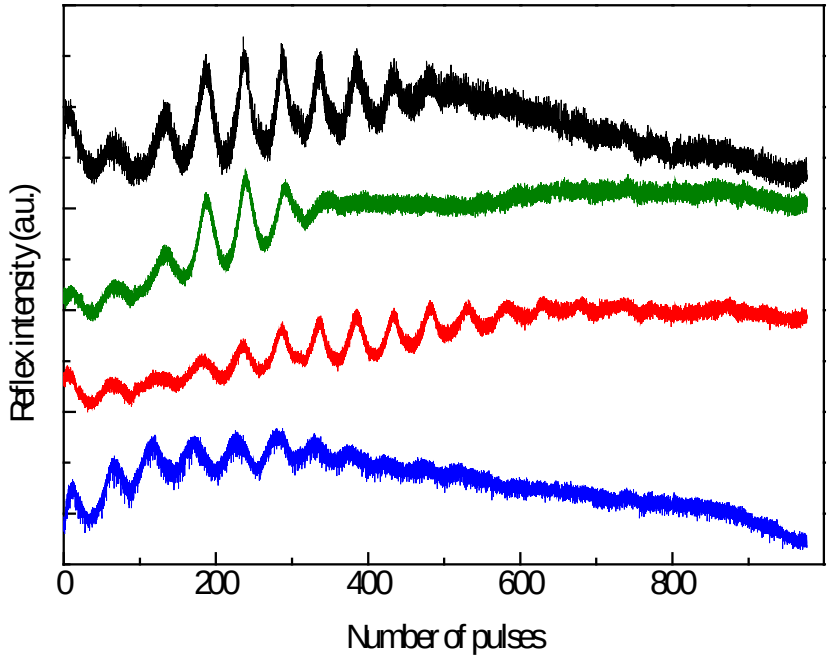
- Excimer Laser: E ≤ 1.2 J; τ = 25 ns; f ≤ 50 Hz
- Substrate remperature: ≤ 1050 °C
- Growth rate: 10^{-2} - 10^{-3} nm/Pulse

Homoepitaxial growth of $Yb^{3+}:Y_2O_3$

Tracking of RHEED intensity



RHEED oscillations

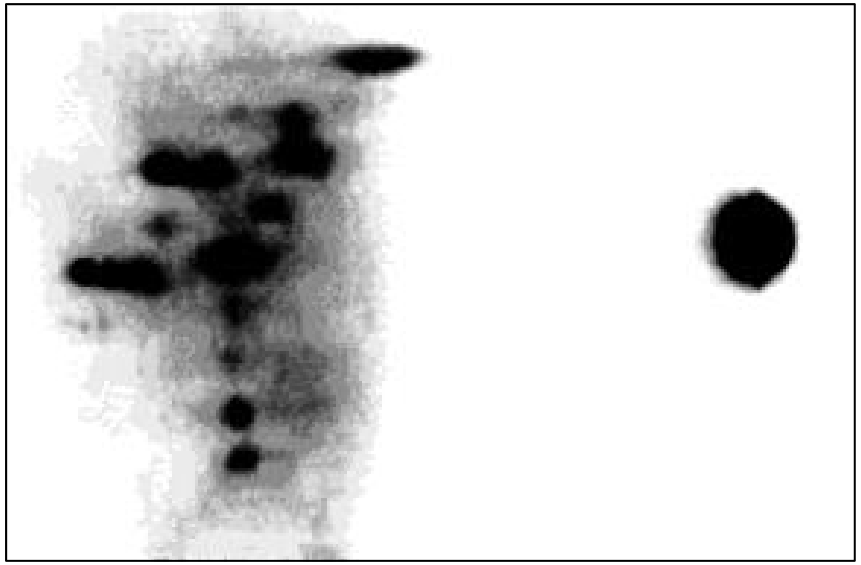


Growth rate calculated by fitting oscillations of RHEED intensity

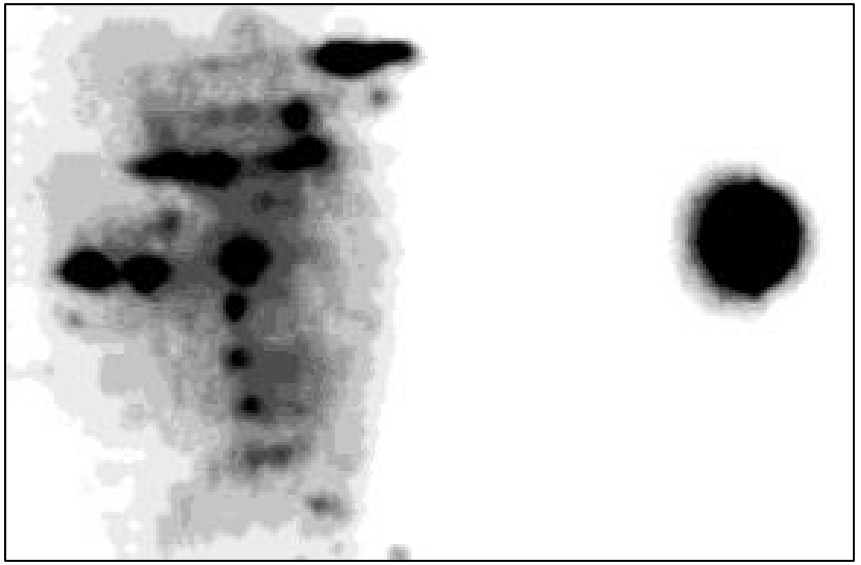
→ 0.005 nm/pulse

Homoepitaxial growth of $Yb^{3+}:Y_2O_3$

RHEED of Y_2O_3 substrate



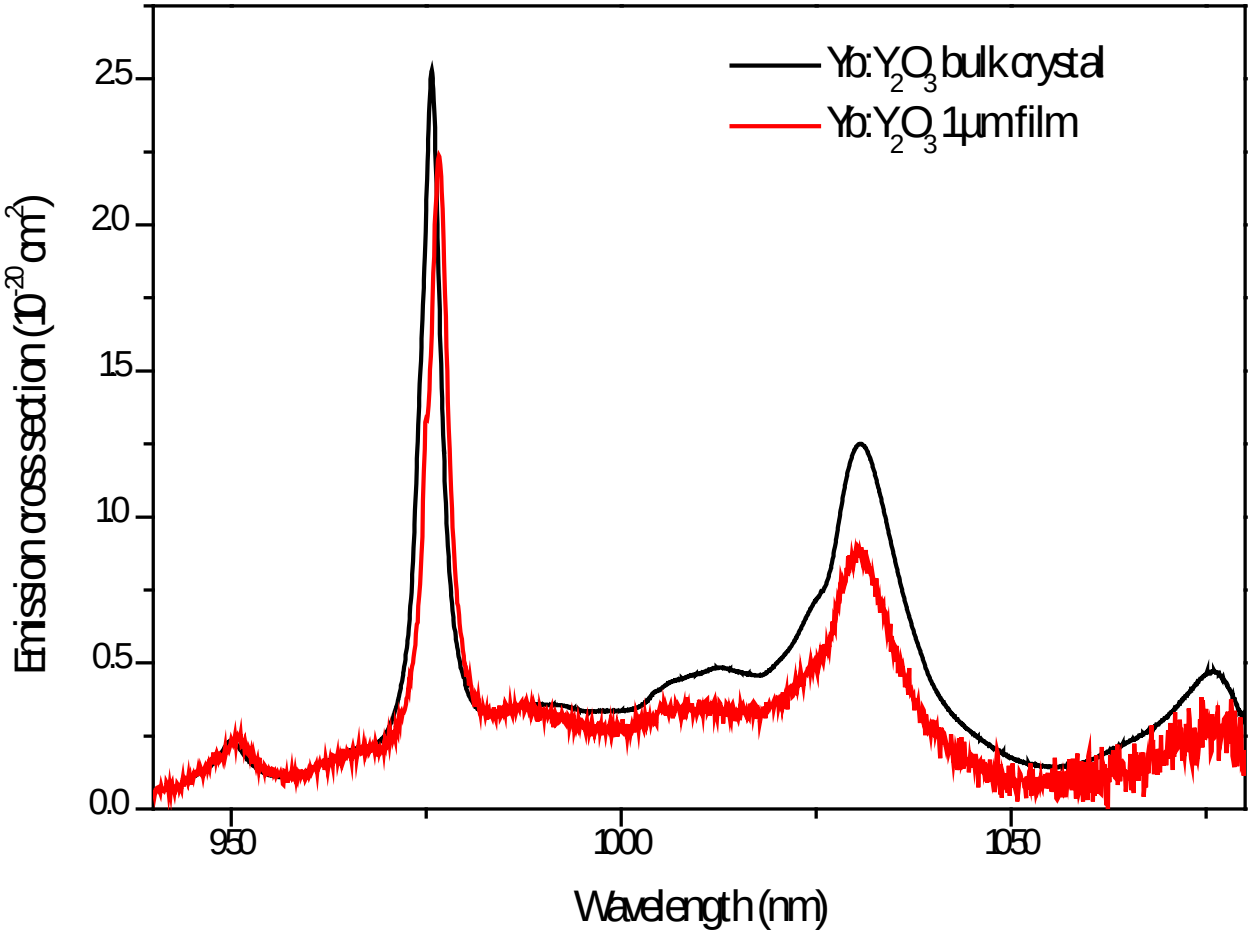
RHEED ~1 µm thick $Yb:Y_2O_3$ film



No changes in RHEED pattern after deposition of 200.000 pulses

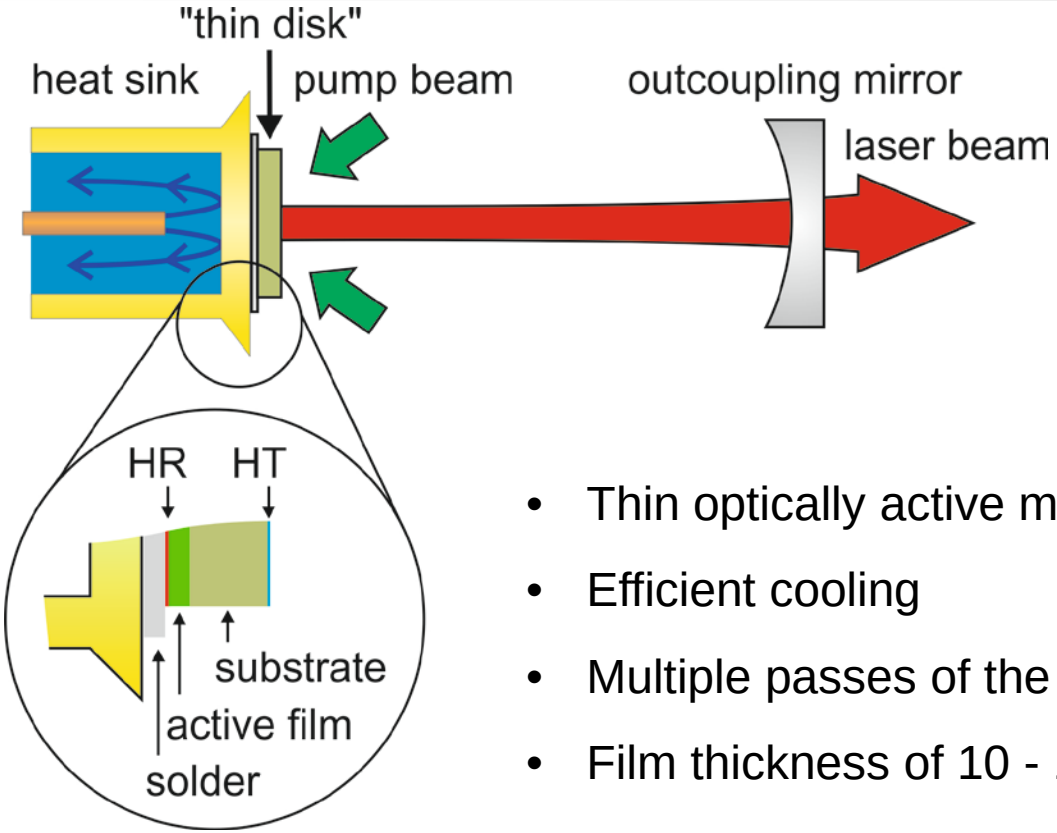
→ epitaxial growth!

Spectroscopy



- Film spectrum comparable to bulk spectrum
- Excitation wavelength = 905 nm

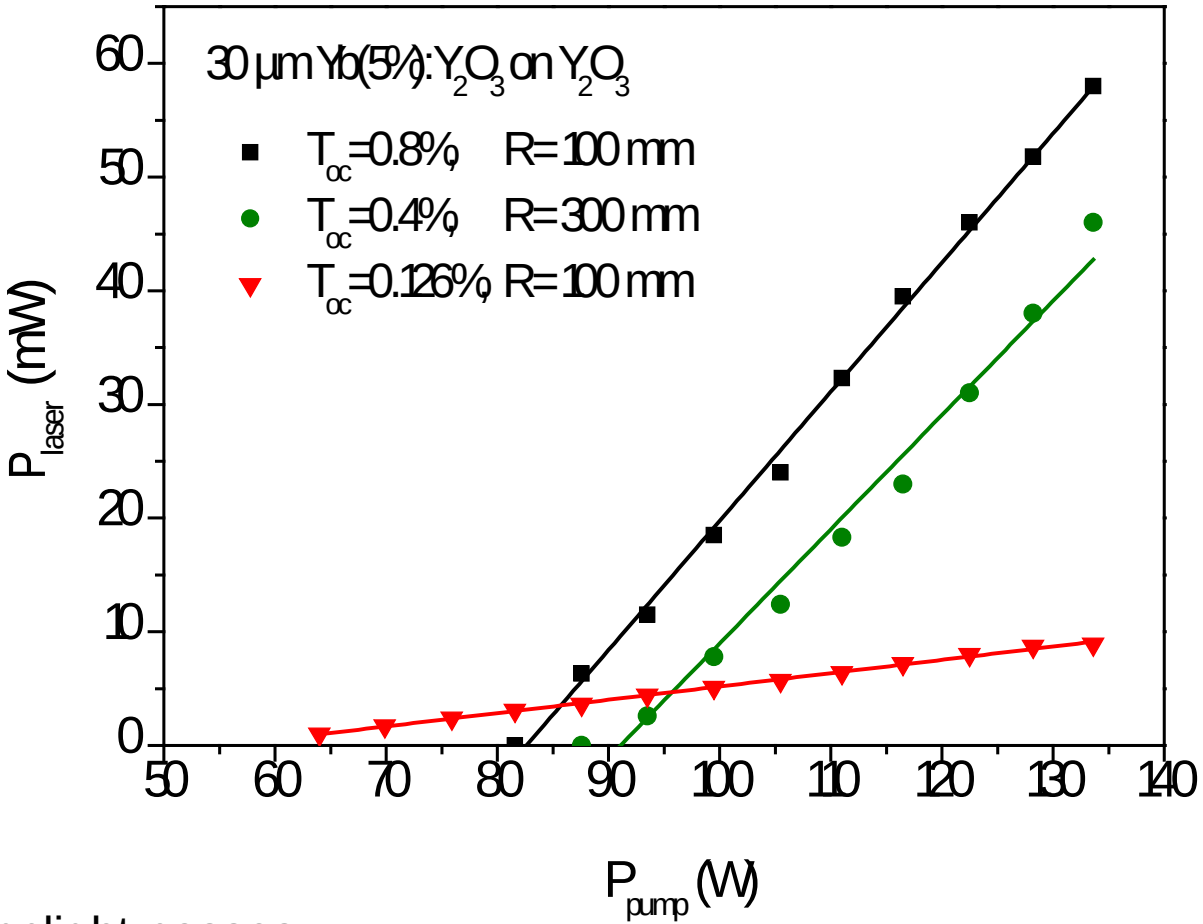
Thin Disk Laser



- Thin optically active medium
- Efficient cooling
- Multiple passes of the pump beam
- Film thickness of 10 - 100 µm necessary

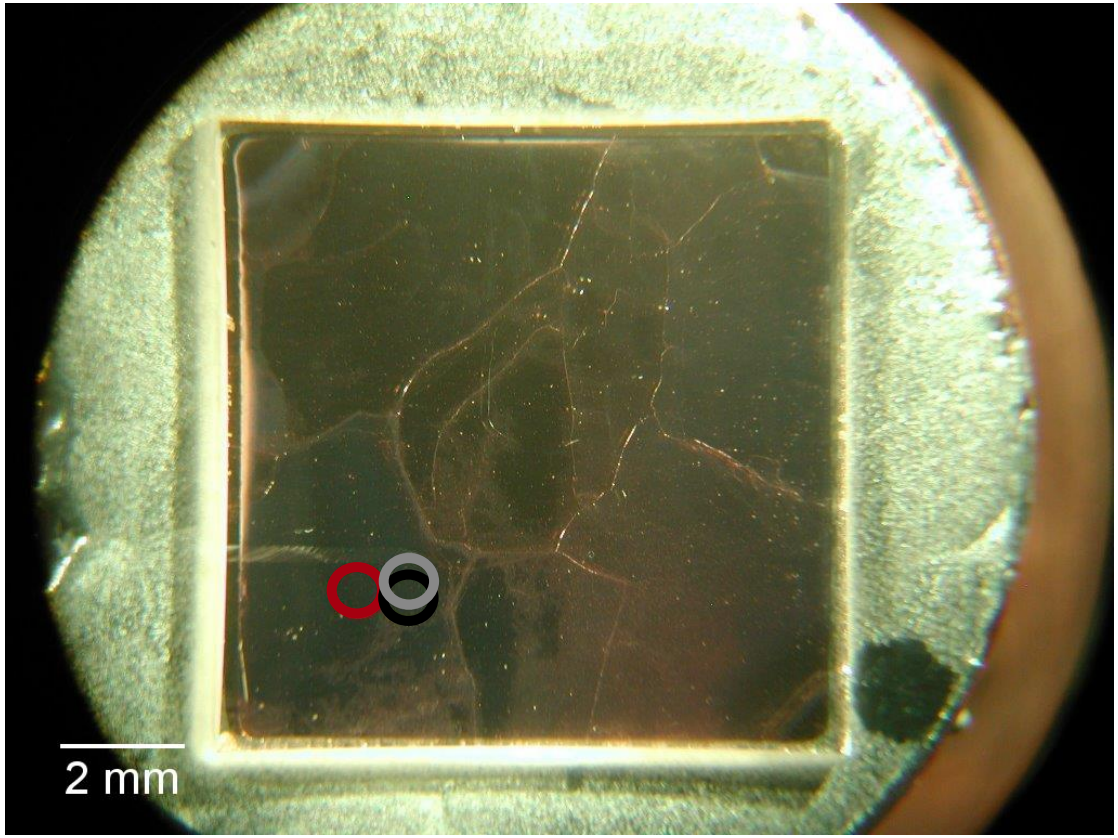
	Hamburg	Southampton
Laser repitition rate	3 Hz	20 Hz
Growth rate	0.005 nm/pulse	0.09 nm/pulse
Thickness	1 µm	30 µm

Laser Experiments



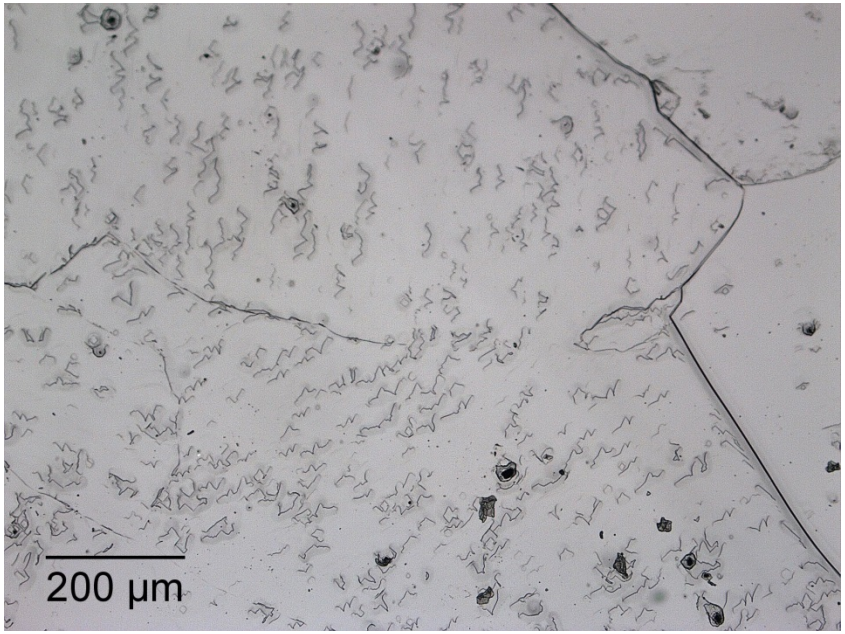
- 24 pumplight passes
- Pump wavelength = 976 nm, laser wavelength = 1033 nm
- Slope < 1%

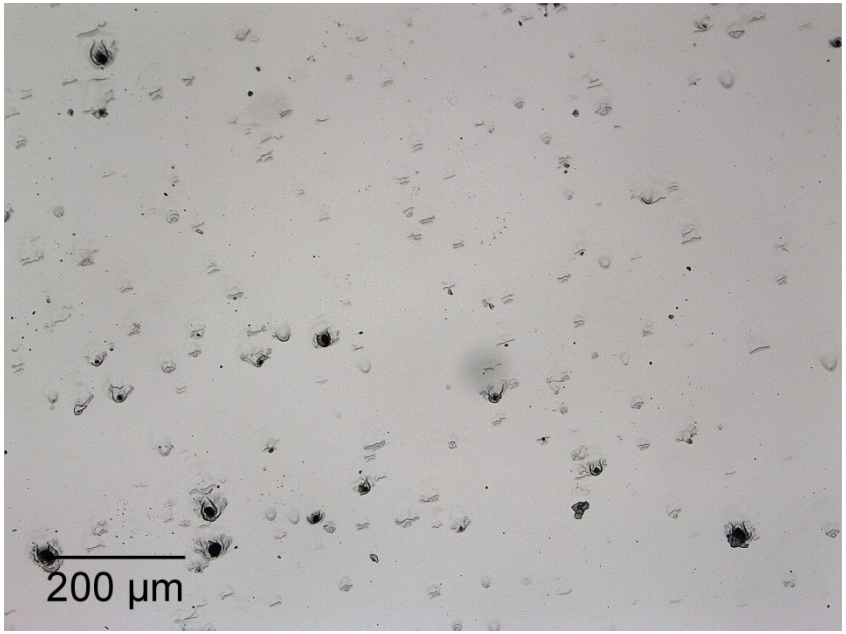
Thin Disk



- Microscopic image of coated Yb:Y_2O_3 film
- Laser oscillation achieved on marked spots

Film quality

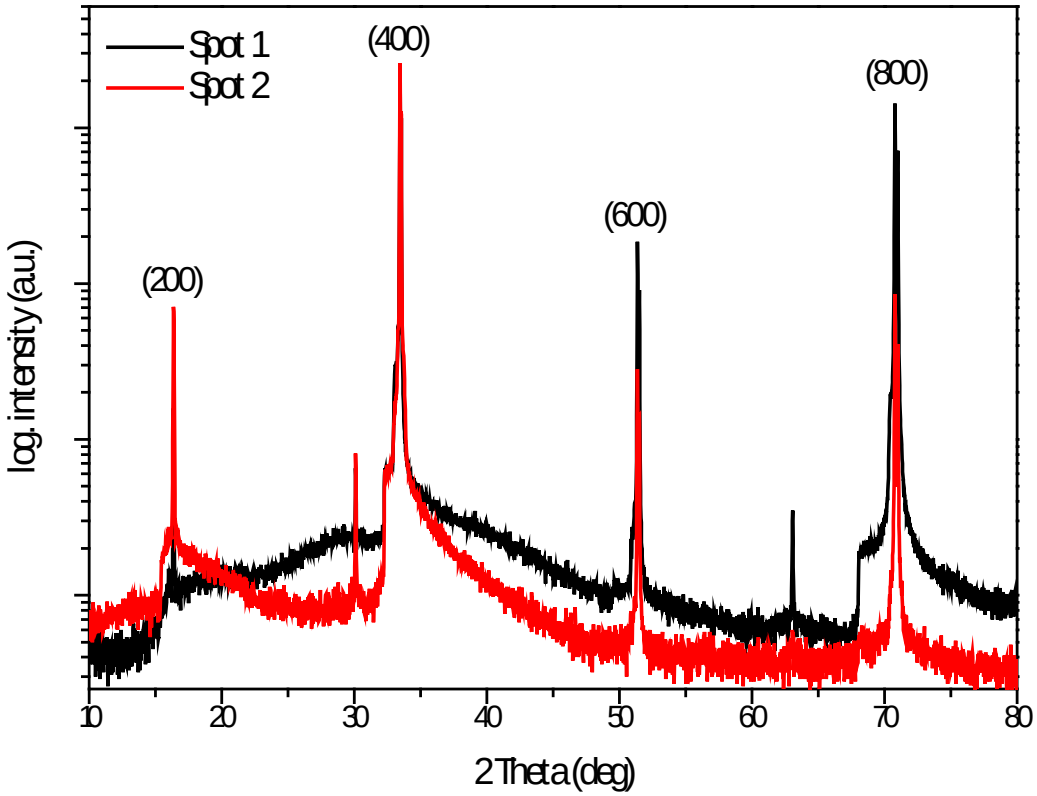




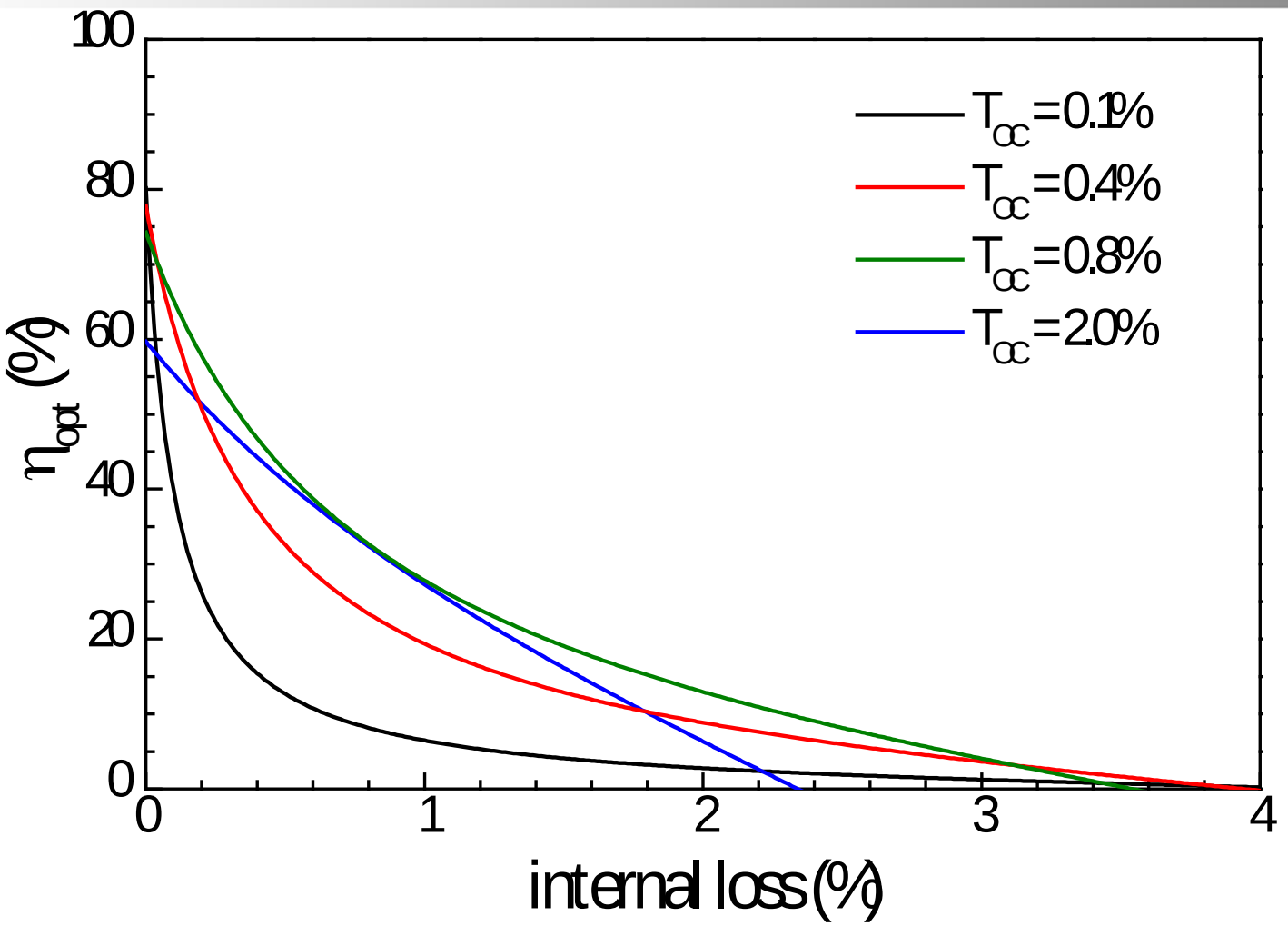
Microscopic images taken on different spots of thick Yb:Y_2O_3 film

X-ray diffraction

- 30 µm thick Yb:Y_2O_3 film grown on <100> Y_2O_3 substrate
- XRD pattern is coherent with epitaxial growth in <100>
- Differences in patterns of same film indicate non-uniform film

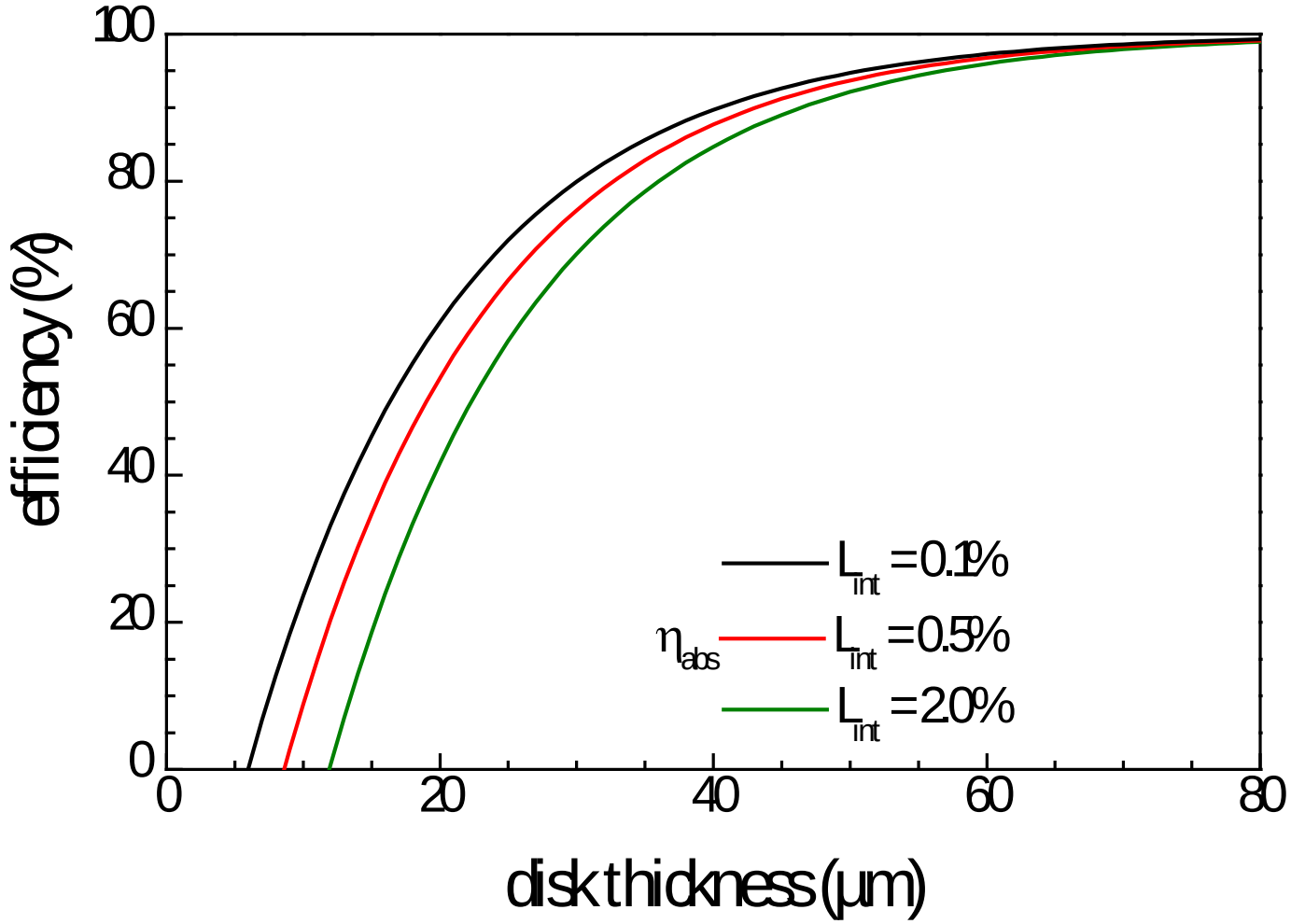


Problems to be overcome

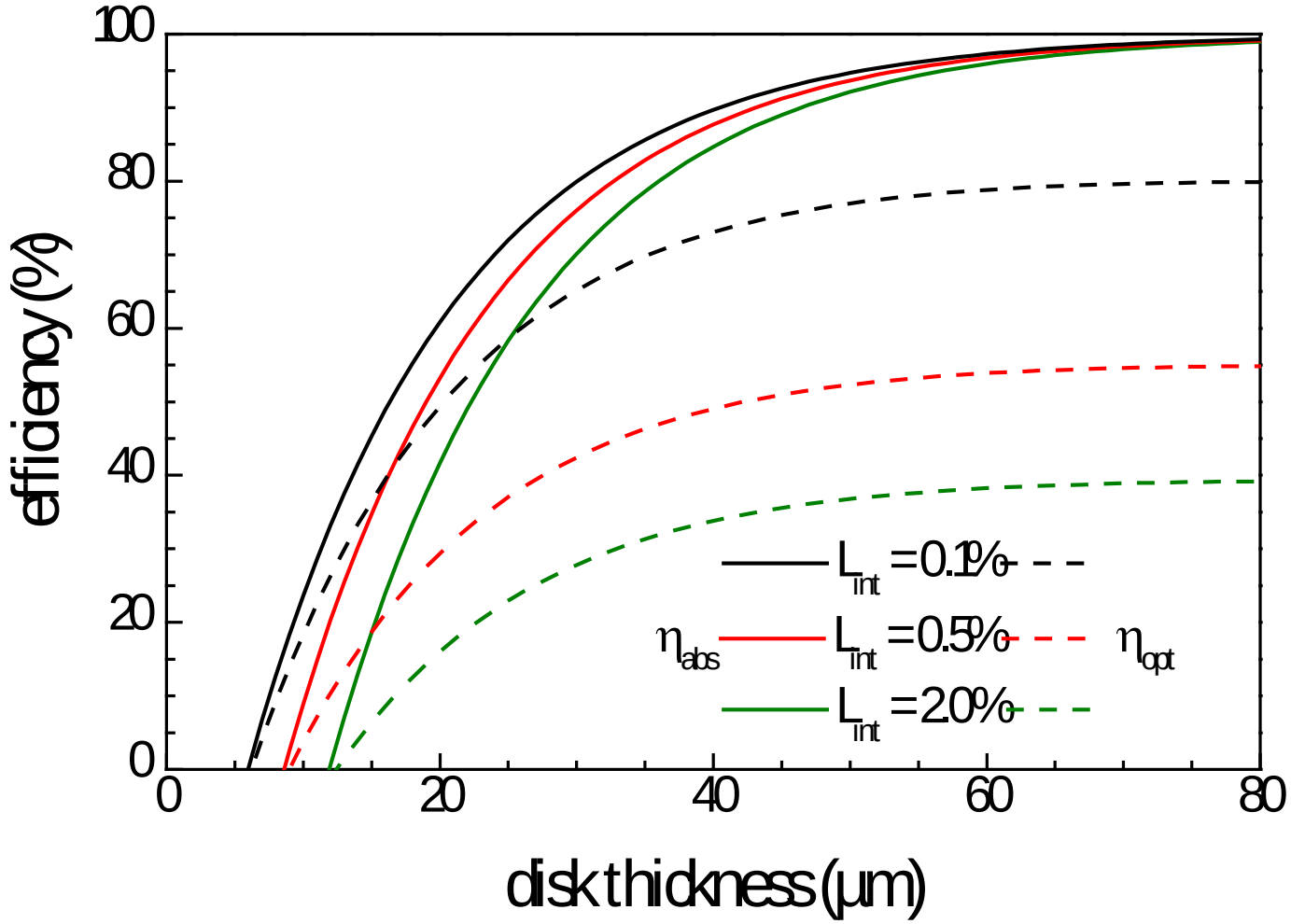


- Internal losses have to be decreased!

Problems to be overcome



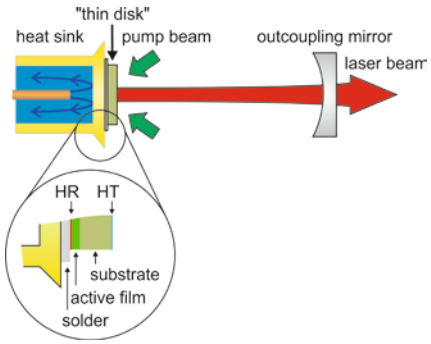
Problems to be overcome



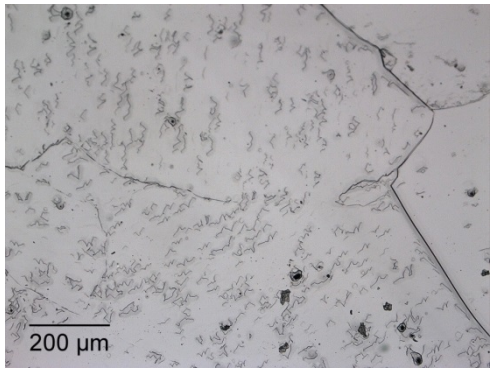
- Film thickness has to be increased!

Outlook

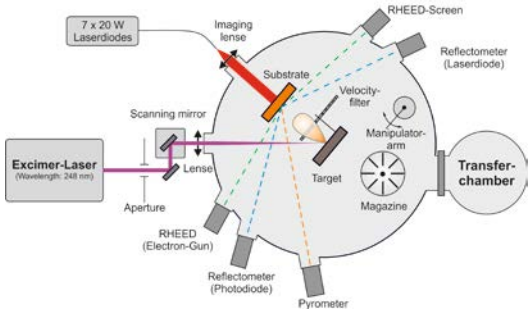
- Films with ∽100 µm thickness



- Increase film quality



- Yb:Y2O3 films grown on different substrates



Thank you for your attention

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