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Tailoring of geometries in Er^{3+} doped monolithic 1-D dielectric microcavity fabricated by rf-sputtering for coherent emission at 1.5 μm

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CHARACTERIZATION and DEVELOPMENT of MATERIALS for PHOTONICS and OPTOELECTRONICS Laboratory

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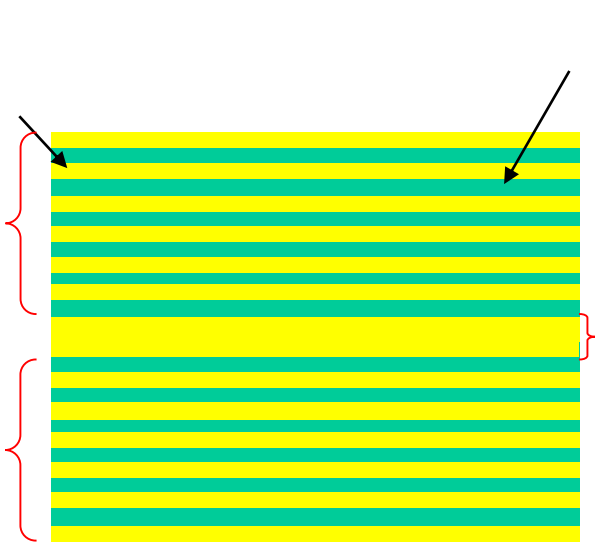
Summary

- Fabrication Protocol – Target composition
- Structure of the microcavity
  - Bragg reflectors with 20 Layers
  - Bragg reflectors with 10 Layers
  - Bragg reflectors with 14 Layers
- Conclusions
- Acknowledgements

Fabrication Protocol – Target composition



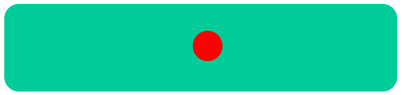
Bragg Mirror
10, 14 or 20 alternated quarter wave layers TiO_2 and SiO_2 activated with Er^{3+} ions.

Active layer half wave SiO_2 activated with Er^{3+} ions.

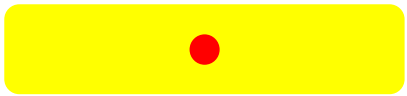
TiO_2 n = 2.20 (@ 1550 nm)

SiO_2 n = 1.44 (@ 1550 nm)

TiO_2 + Er Target



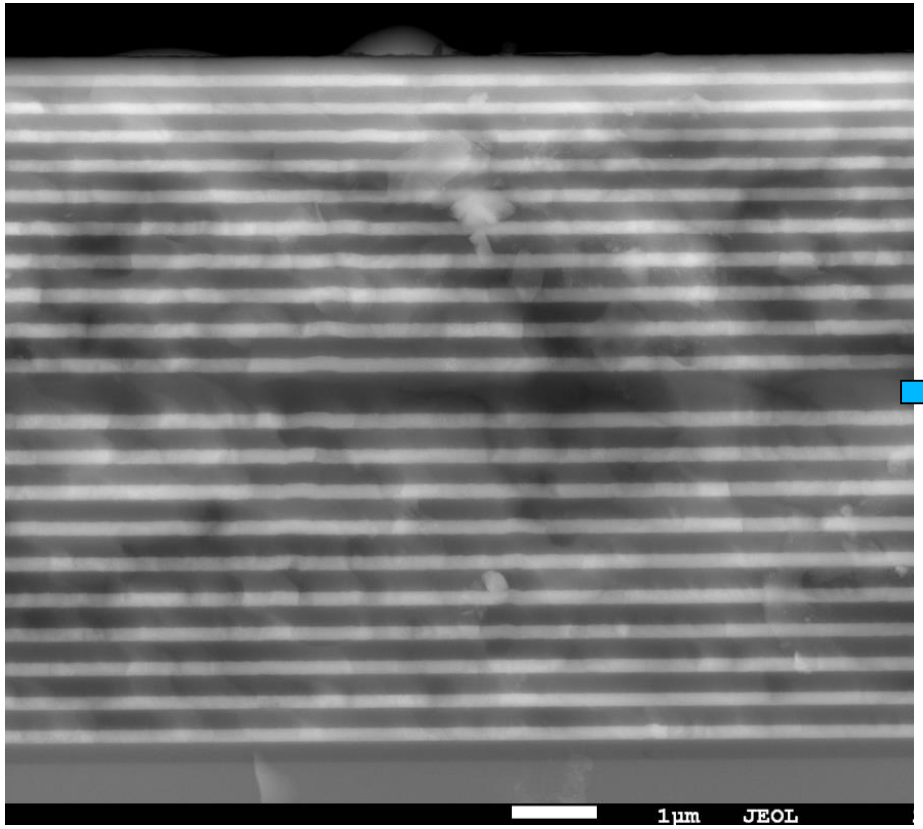
SiO_2 + Er Target



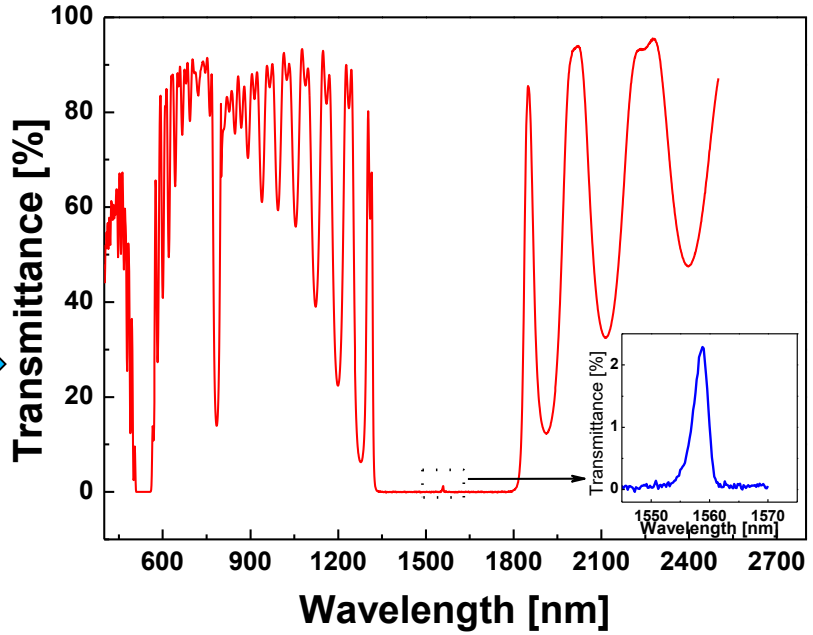
Substrate: v-SiO_2, dim. 7 x 3cm

Deposition is performed by sputtering alternatively the targets of silica and titania. The depositions were tailored to reach the appropriate thicknesses to obtain a cavity resonance centred at 1.5 μm

Structure of the microcavity

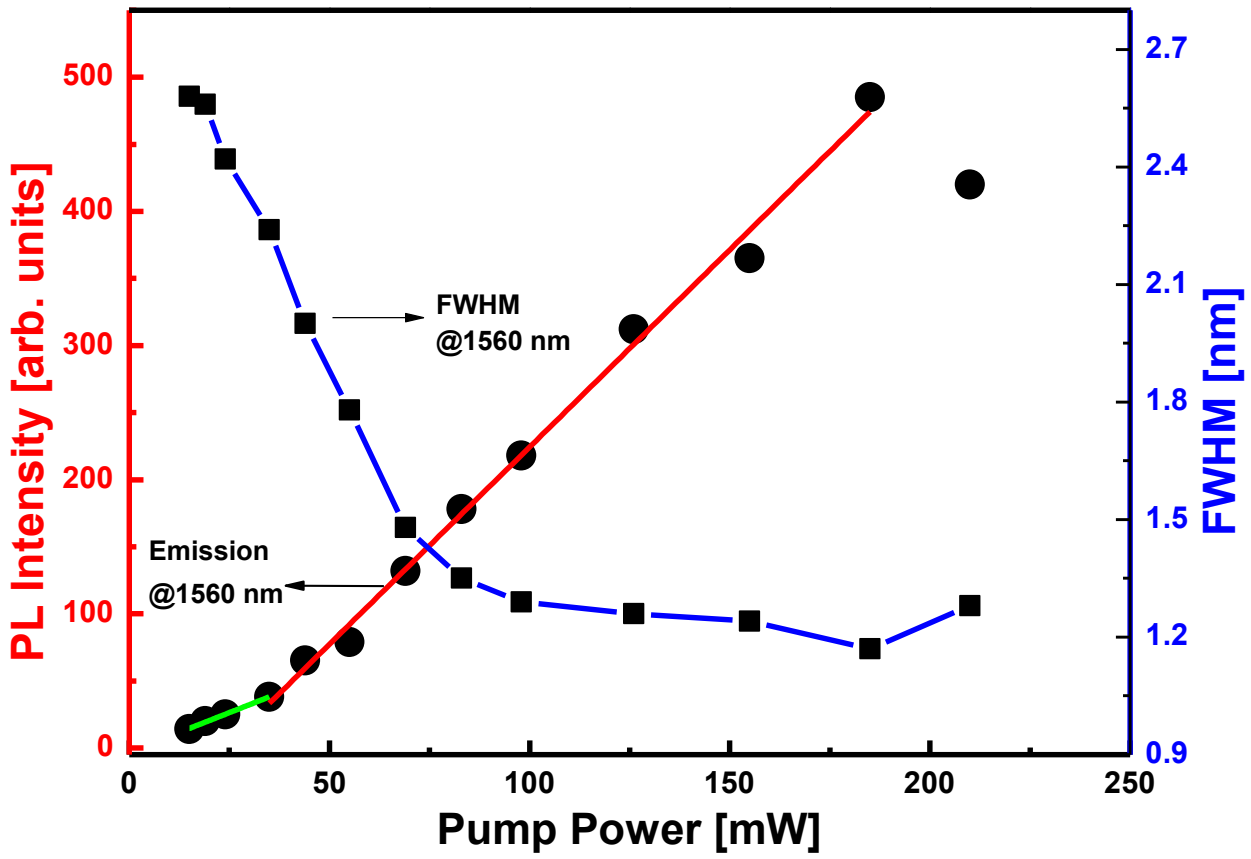


SEM micrograph of the Er^{3+} doped 1D dielectric microcavity cross section. The bright and dark region corresponds to TiO_2 and SiO_2 layers, respectively. The substrate is located on the bottom of the images and air on the top.



Transmission spectrum of the cavity with two Bragg mirrors, each one consisting of ten pairs of SiO_2/TiO_2 layers in the region between 450 nm and 2500 nm. The first order stop band ranges from 1300 nm to 1850 nm. The first order cavity resonance corresponds to the sharp maximum centered at 1559.2 nm.

Peak intensity and FWHM vs Pump Power
Exciting at 514.5 nm / 30°



$^4I_{13/2} \rightarrow {}^4I_{15/2}$ photoluminescence peak intensity and FWHM (blue line) at 1560 nm as a function of 514.5 nm pump power with 0 degree of detection angle and 30 degree of excitation angle. Red and green line are the results of linear fit while the blue line is a guide for the eyes.

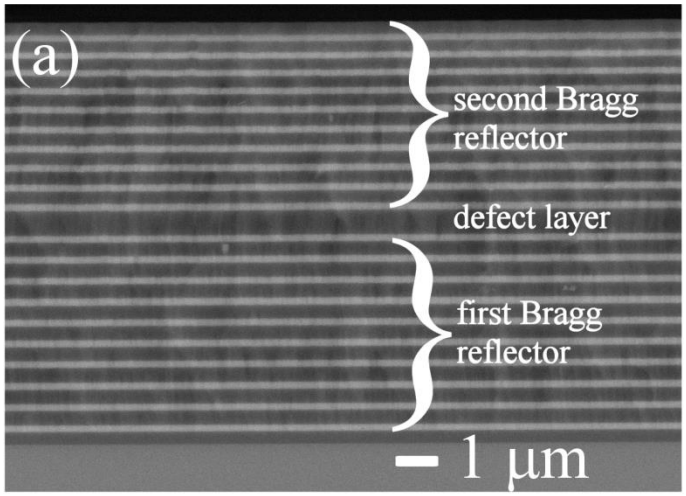
Improvement of the performance and decreasing of the pump threshold

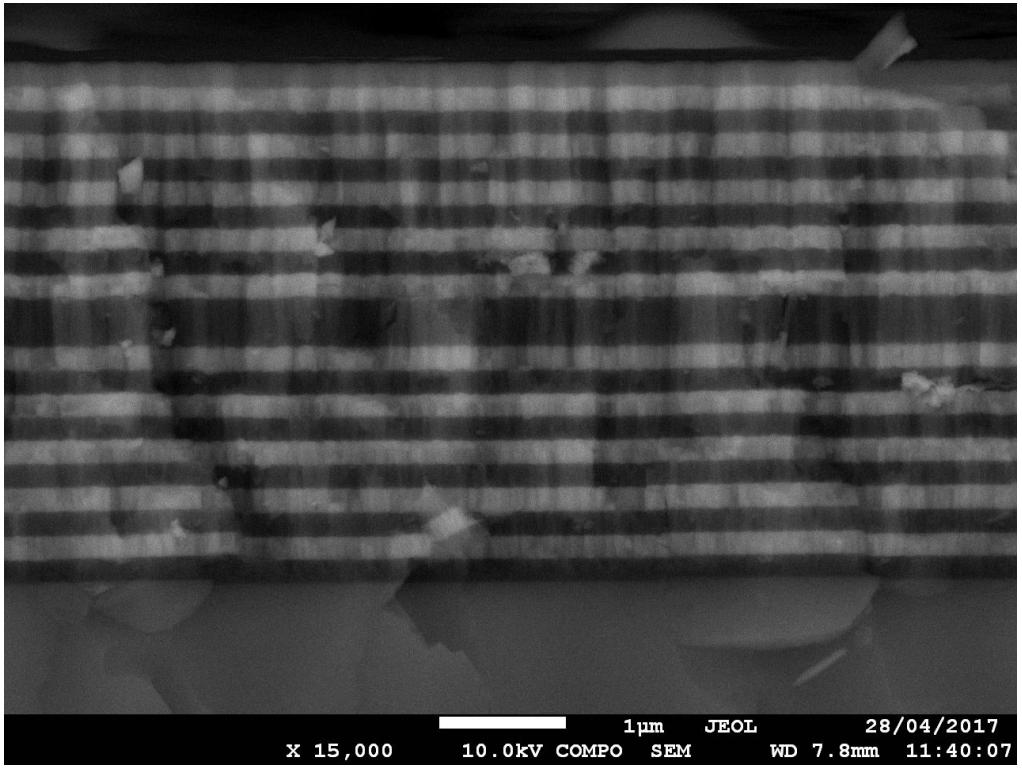
- Rare-Earth concentration optimization
- Improvement of the thicknesses reproducibility
- Co-Activation and different pumping scheme
- ….
- Geometry optimization

Structure of the microcavity

NEW approach

Conventional approach



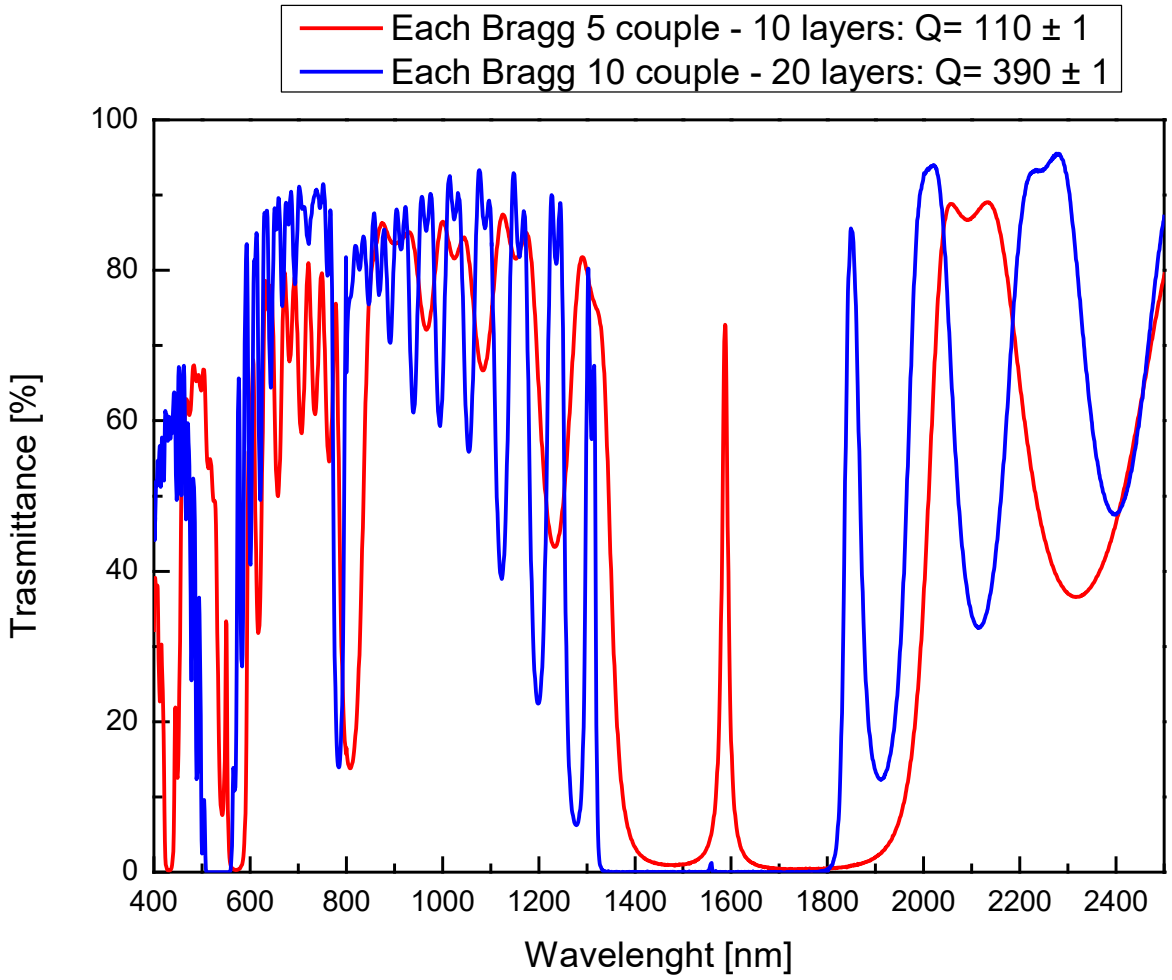


Active Bragg Mirror: 10 alternated quarter wave layers TiO_2 (172 nm) and SiO_2 (262 nm) activated with 0.2 mol % of Er^{3+}.

Active layer: half wave (525 nm) SiO_2 activated with 0.2 mol % of Er^{3+}.

The dark regions corresponds to SiO_2 and the white regions corresponds to TiO_2

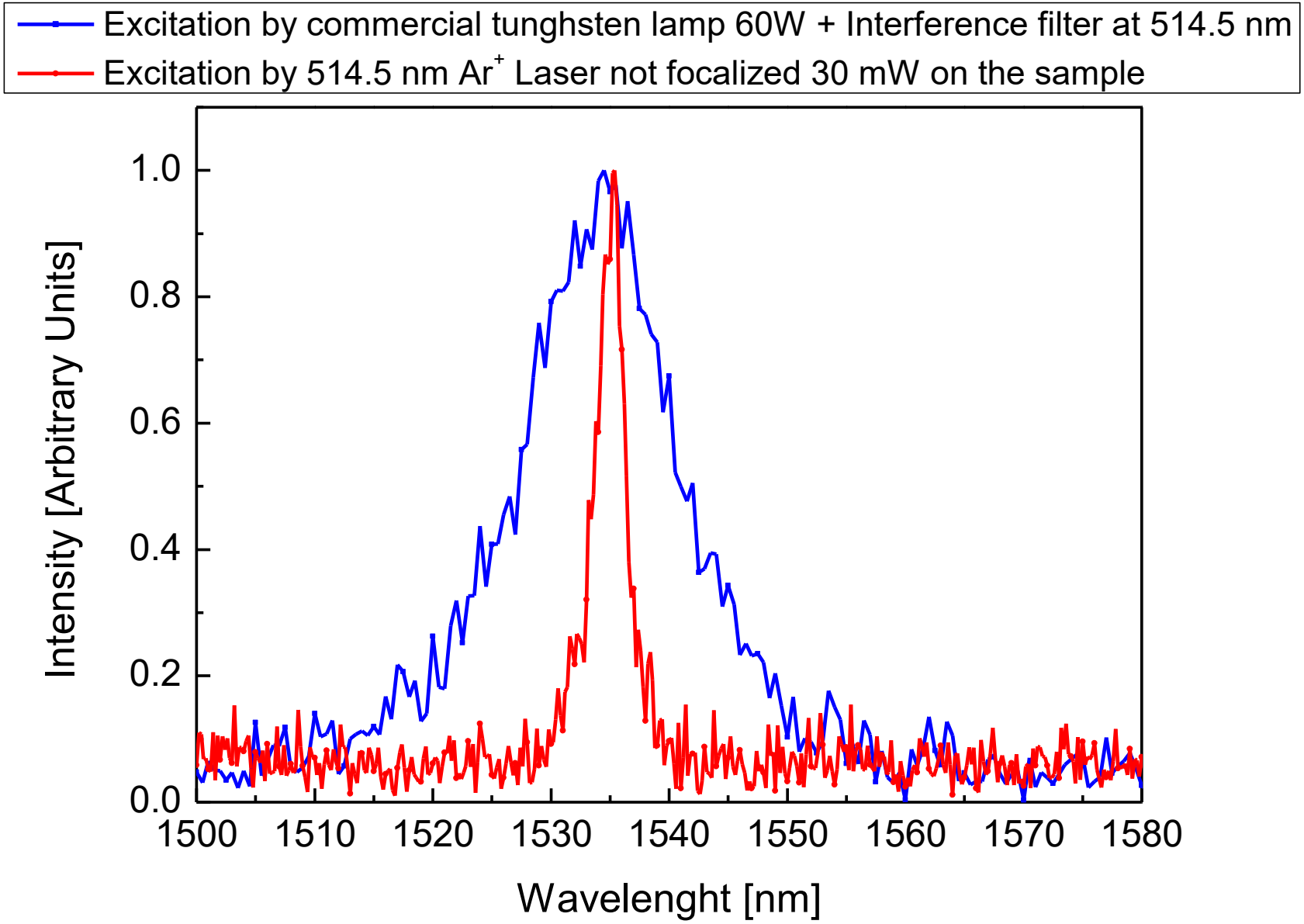
Transmittance



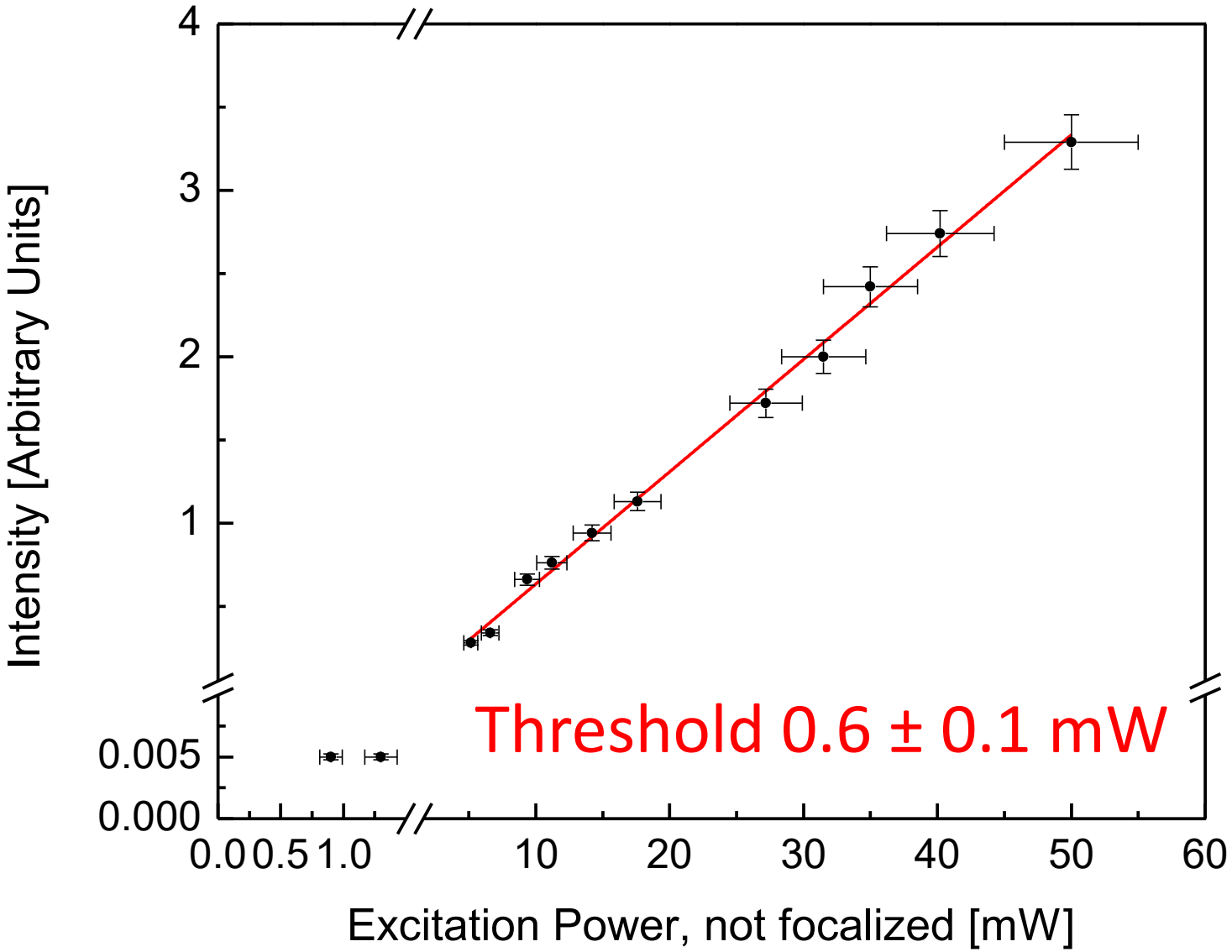
- Stop Band: 1300nm – 1800nm
- Resonance: 1559.2 nm, width 14nm
- Third order resonance: 536 nm
- Q = 110

New approach: Lower Q, higher transmittance

Emission Features – Bragg reflectors with 10 layers

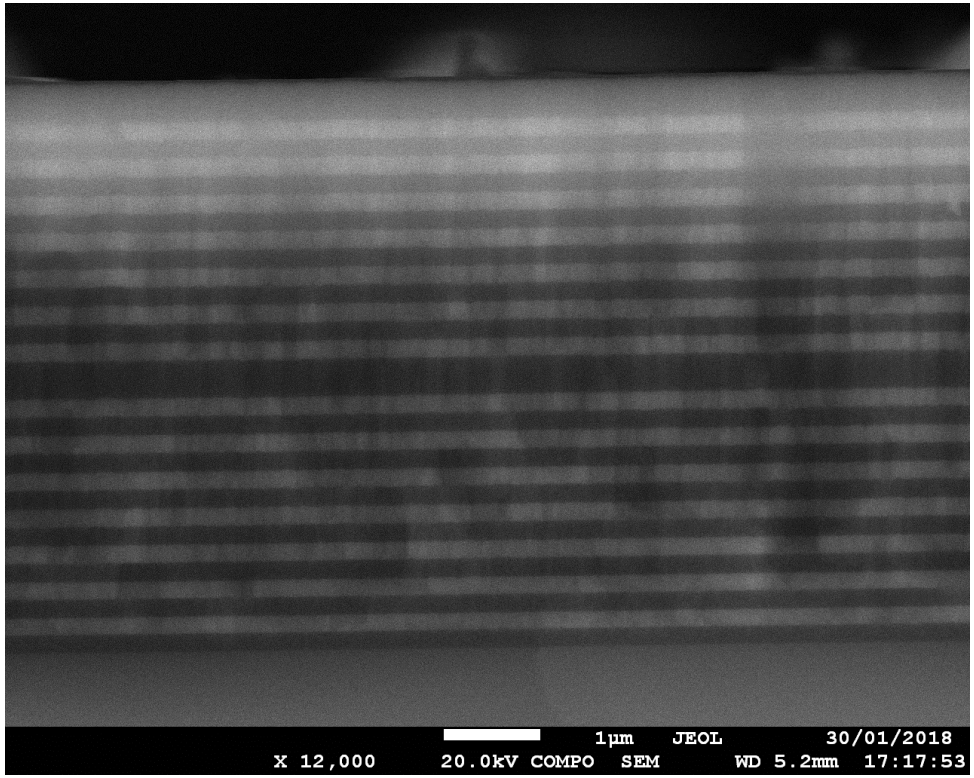


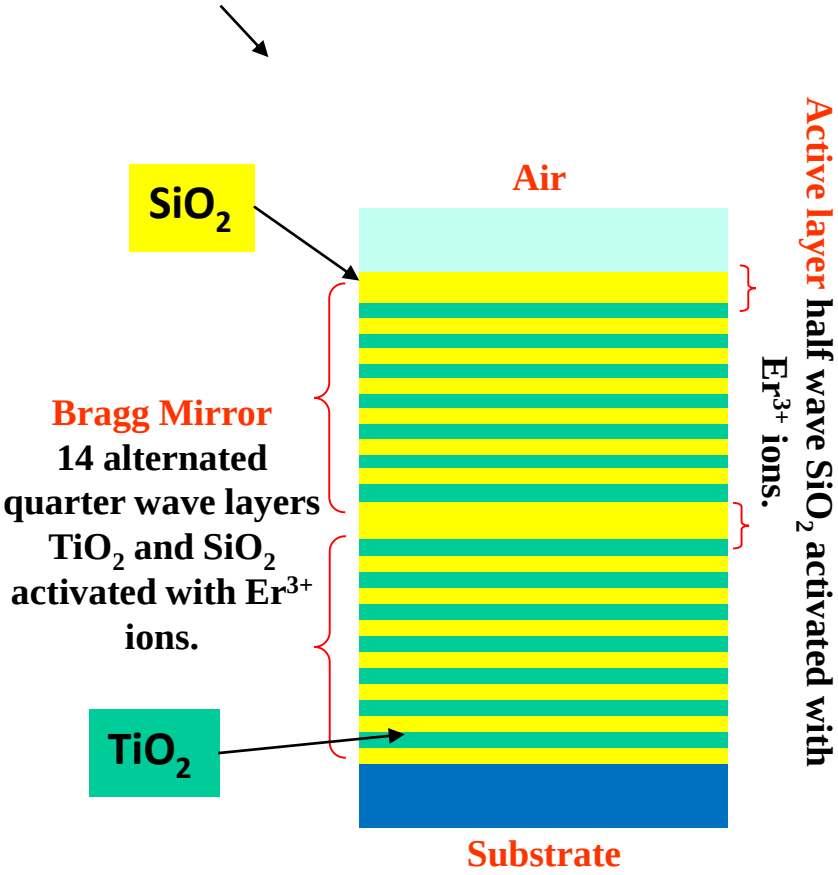
Emission Features – Bragg reflectors with 10 layers



- Excitation angle: 30°
- Detecton angle: 0°

Bragg reflectors need to be optimized





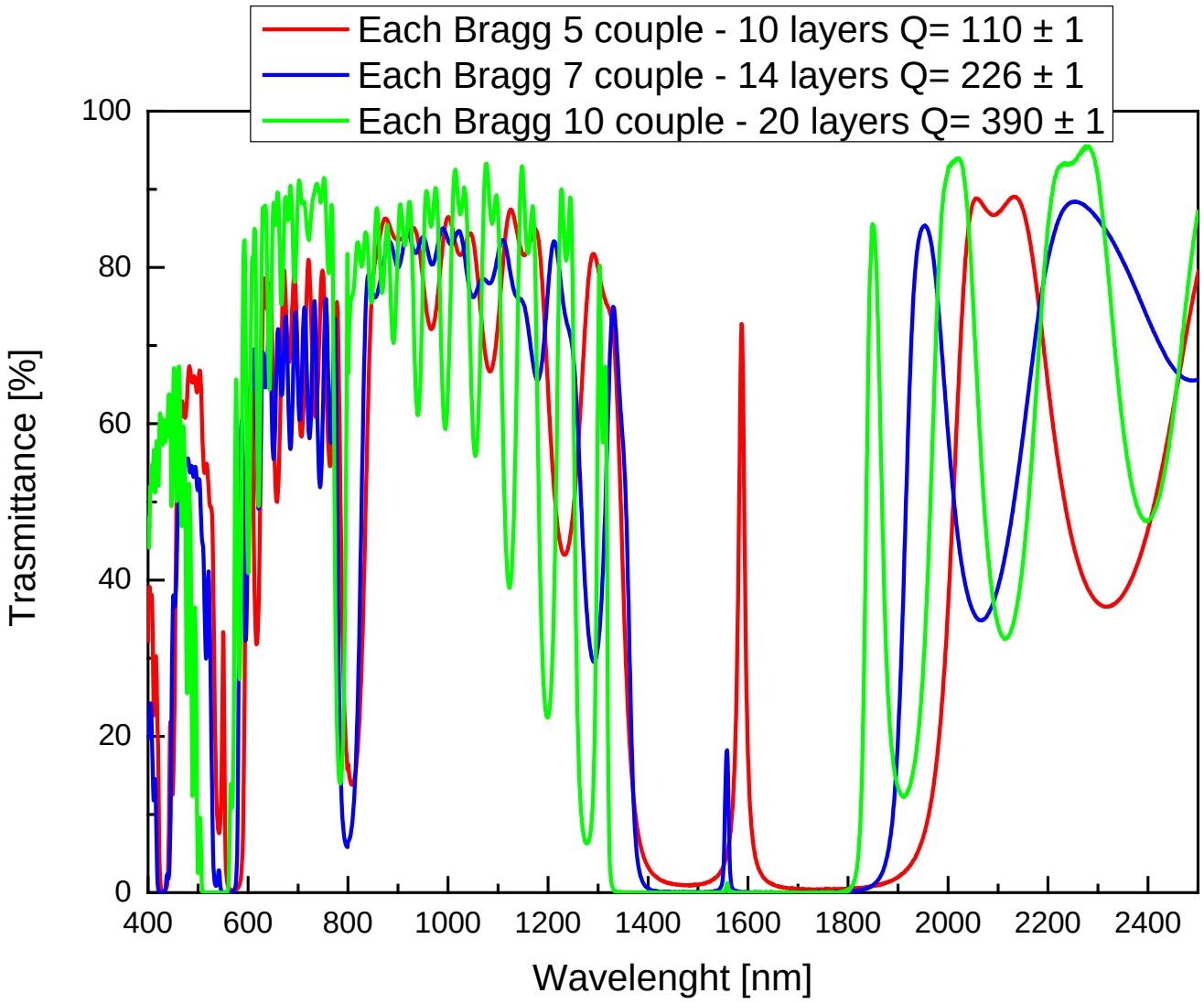
Active Bragg Mirror: 14 alternated quarter wave layers TiO_2 (172 nm) and SiO_2 (262 nm) activated with 0.2 mol % of Er^{3+}.

Active layer: half wave (525 nm) SiO_2 activated with 0.2 mol % of Er^{3+}.

The final layer SiO_2 is a defect layer (525 nm)

The dark regions corresponds to SiO_2 and the white regions corresponds to TiO_2

Transmittance



Different number of layers

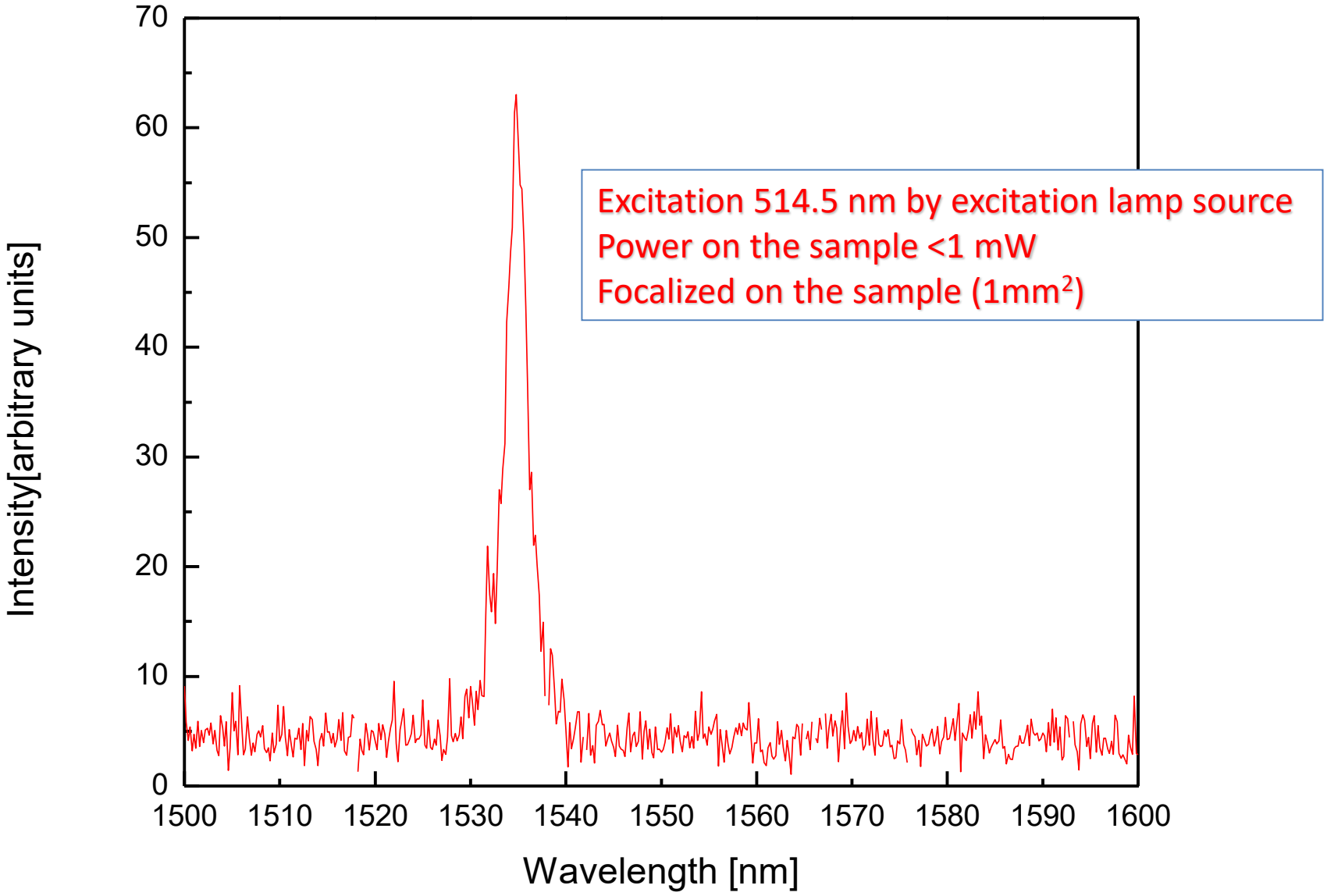
↓

High number → High Q

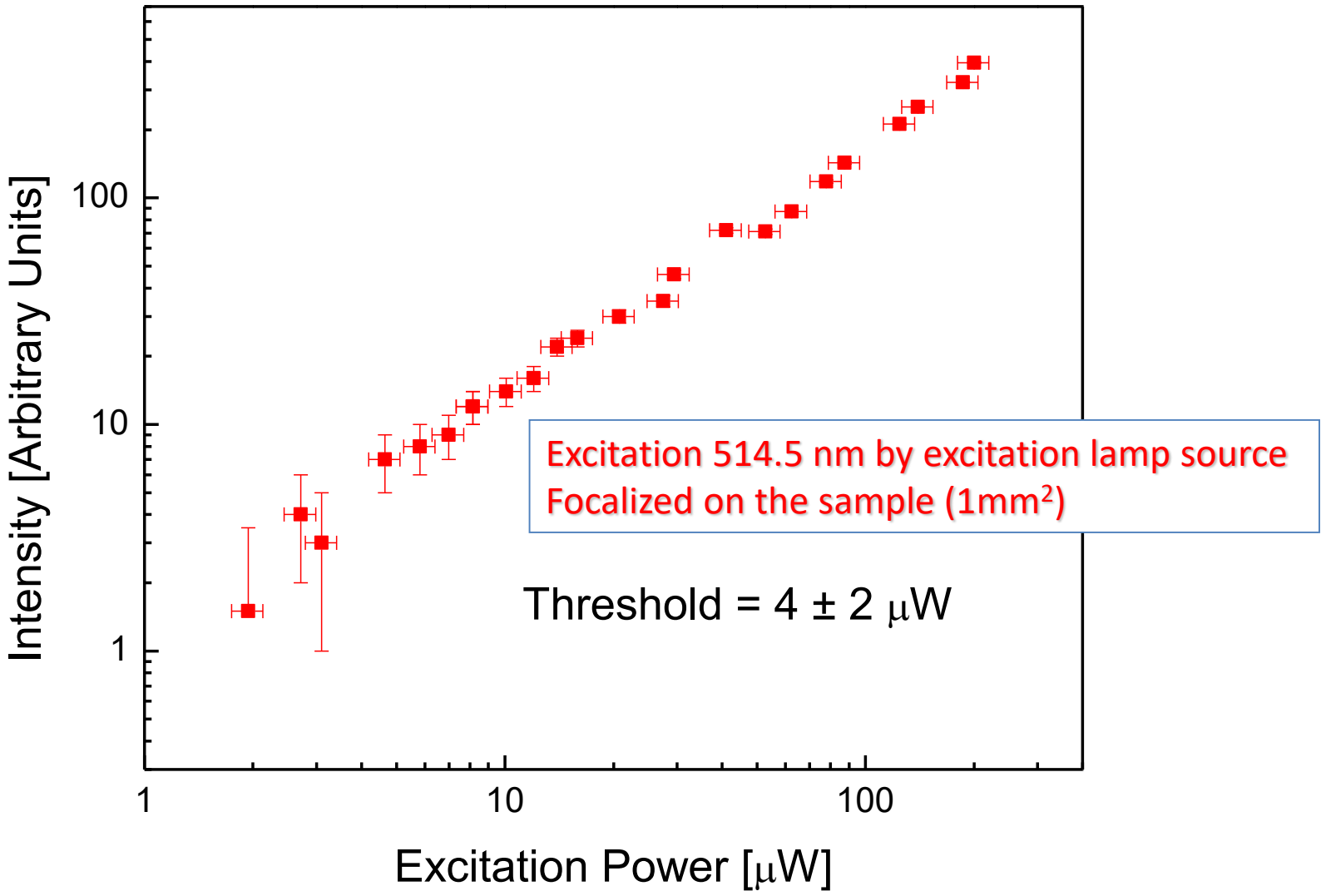
↓

High number →
Low Transmittance

Emission Features – Bragg reflectors with 14 layers



Emission Features – Bragg reflectors with 14 layers



- Excitation angle: 30°
- Detecton angle: 0°

CONCLUSIONS

- The cavities are designed to present a cavity resonance at 1.5 μm at 0° of detection that correspond to the $^4I_{13/2} \rightarrow {}^4I_{15/2}$ Er^{3+} ions emission and a third order resonance placed at around 514 nm with 30° of incidence from the normal of the sample that is used to pump the sample at 514,5 nm.
- The behavior of the emission intensity at emission wavelength of 1535 nm as a function of different 514.5 nm excitation powers, with a detection angle of 0° and an excitation angle of 30°, is nonlinear.
- The FWHM is limited by a spectral resolution of our experimental set up with a threshold of 4μm in the case of the cavity made up with Bragg reflectors with 10 layers.
- High resolution measure is in progress.
- Deposition directly on the tip of the fiber in progress.

ACKNOWLEDGEMENTS

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