OPTICAL TWEEZERS FOR BIOLOGY-HEALTH APPLICATION BASED ON A STRUCTURES LIGHT PHOTONIC SOURCE IN INTERACTION WITH NANOCRYSTALS

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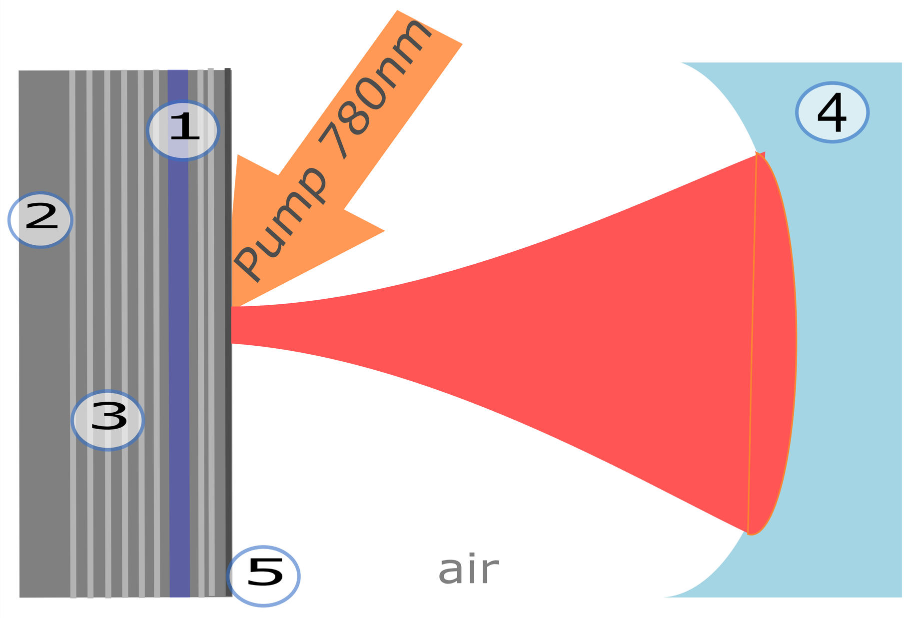
GOALS

Nanophotonics has great potential to control, structure and multiplex the 3D spatial wave functions of the laser field. We propose to overcome the limitations of optical tweezers mode for biophotonics by developing a new instrument coupling a photonic source and innovative nanocrystals for biological studies.

VECSEL TECHNOLOGY

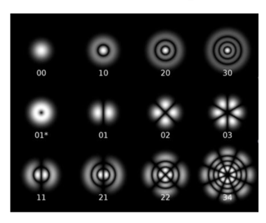
(VERTICAL EXTERNAL CAVITY SURFACE EMITTING LASER) of a plano-concave cavity



1. **Active zone based on Quantum-Wells** 6-12 strained balanced InGaAs QWs with GaAsP
2. **Substrate in III-V Materials** GaAs for λ = 1,06 µm emission. MOCVD Epitaxy (C2N).
3. **HR Bragg Mirror** 25-31 AlAs/GaAs Bragg pairs R>99%
4. **External Cavity with mm air gap: High finesse, hih beam quality**
5. 1-4 **Bragg pairs** to control the µ-cavity, air semiconductor interface for light functionalisation: mode selection, phase amplitude modulation

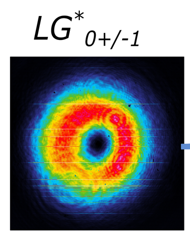
Advantages for Optical Trapping

- **Single Frequency and transverse mode operation**
- **High spatial coherence to focus wavefront to the wavelength**
- Linear Polarization along [001] axis
- Allow selection of high order Laguerre-Gauss transverse (with OAM) modes:



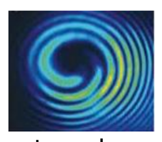
in particular:

$LG^{*}_{0+/-1}$



→ Ideal for optical trapping

- **Meta-surface technology** : Photonic Crystal made by E-Beam lithography. Modulate Round-trip phase (<< 2п) in order to lift degeneracy of modes to **create artificial phase morphology**



vortex phase

→ Innovation for our optical tweezers application, will rotate particules

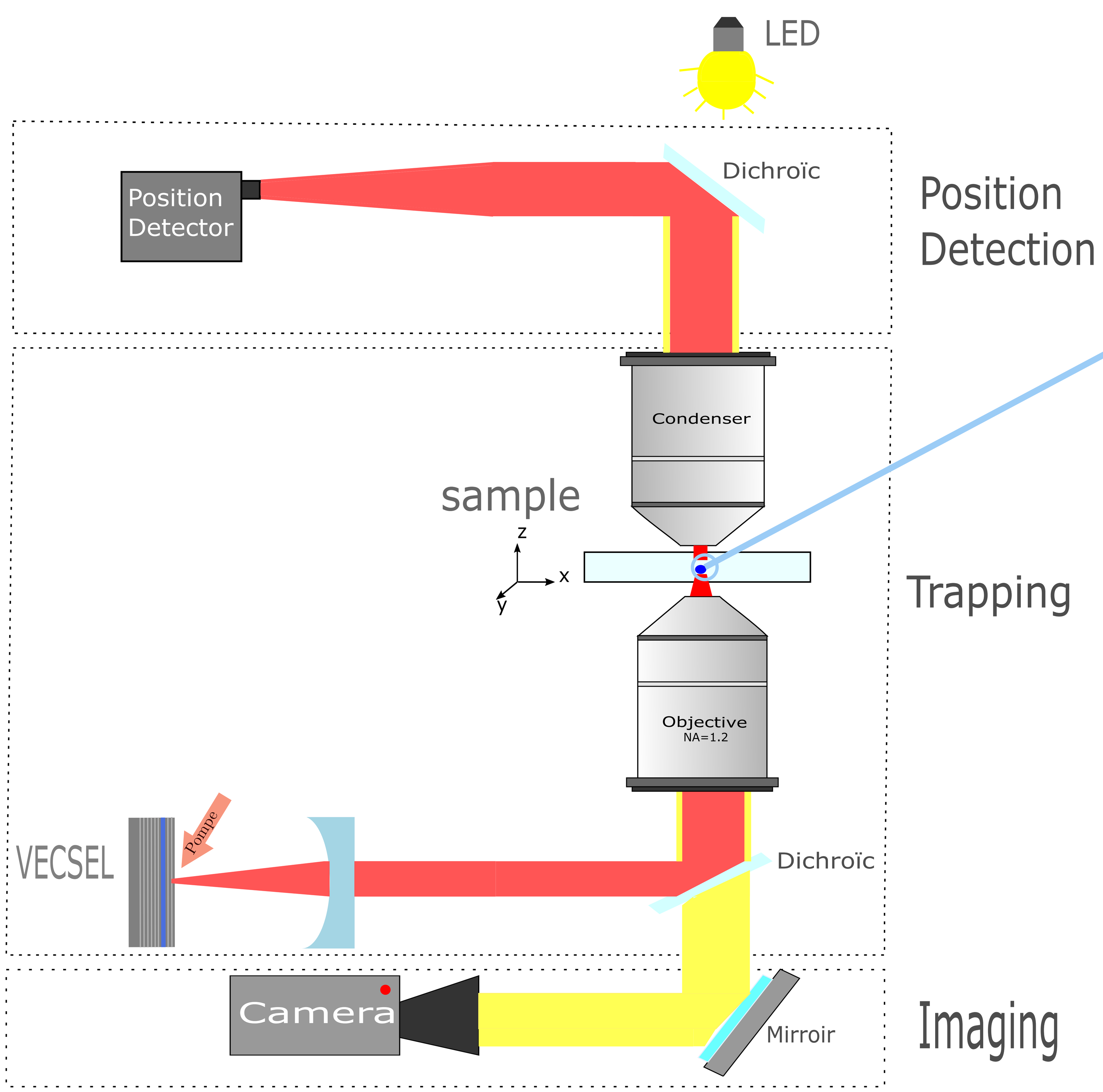
OPTICAL TWEEZERS

Allow the manipulation, control and measure of biological objects at the nanometric scale in a non-destructive way, by exploiting the various photonic forces of lasers beams.

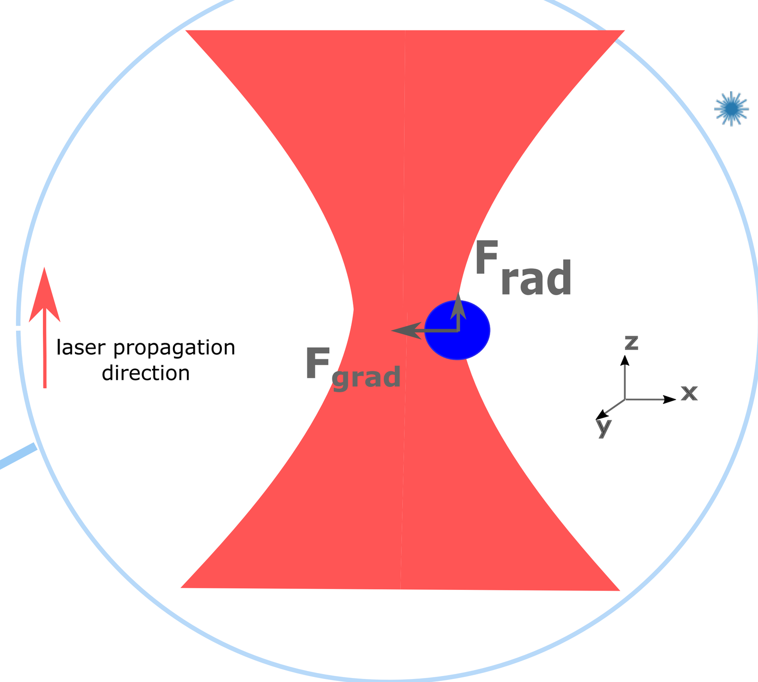
The optical force generated by a highly focus laser beam has two components:

-**Gradient force, F_{grad},** oriented in the direction of higher intensity

-**Force of radiation pressure, F_{rad},** oriented toward the direction of laser propagation



Optical Trapping

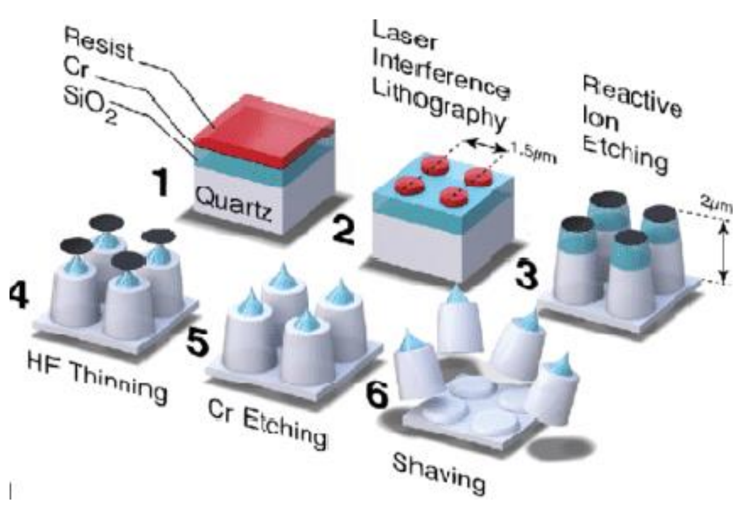


- In optical trapping,the gradient force is dominant
- Key element in optical trapping is the **high numerical aperture objective,** typically 1.2 for water immersion. A high NA generates an important intensity gradient, the focus beam is less than 1 um in this configuration the gradient force is dominant and the particle is optically traped.

A wide Variety of Particules can be trapped

Atomes, molecules, bacteries and sythetic particules can be trapped in optical tweezers microscopes

Cylindrical nanocrystals will be fabricated in the clean room by **laser interference lithography** and **trapped in an optical tweezers** in order the image the surface of a biological cell



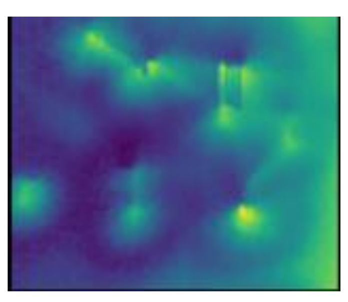
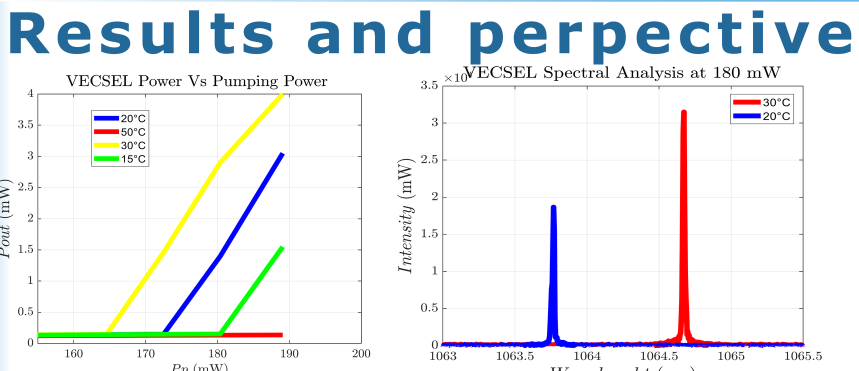
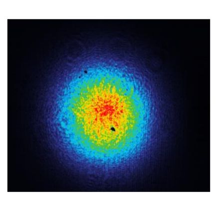


Image obtained by scanning the tip of the cylindrical nanocrystals on the surface of blood cell trapped in the optical tweezers set up

→ Similar to the AFM but adapted to soft materials because of it is noninvasive

Results and perpectives

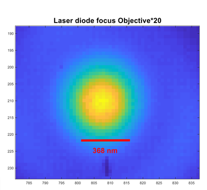




- VECSEL beam has a high spatial coherence, quality factor $M^2<1.2$
- Its efficiency is 17% at 25°C
- Single frequency and single transverse mode

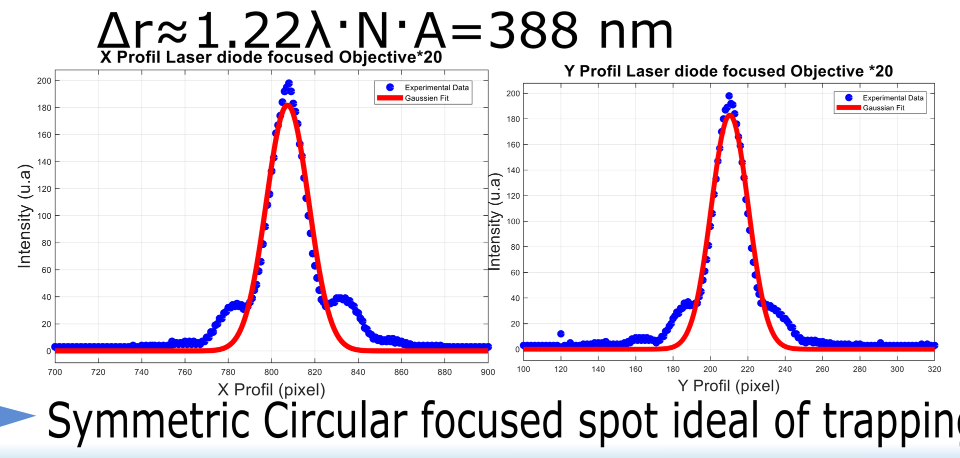
First image of focused red diode beam through x20 Na=0.5 objective

Experimental focused spot size=368 nm



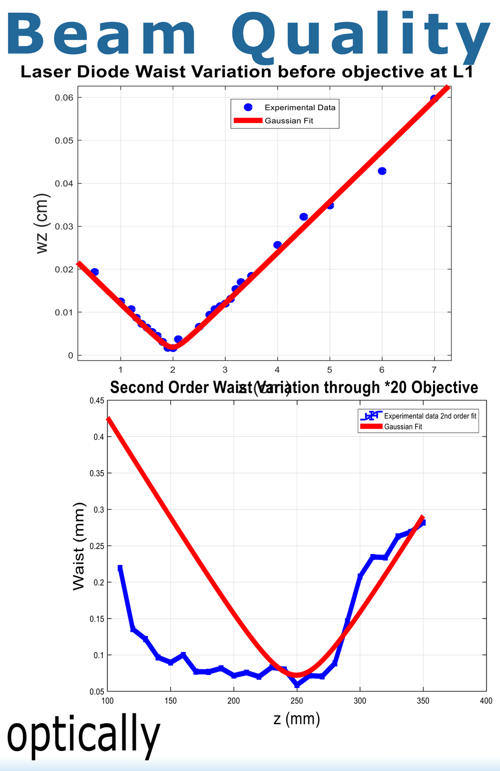
Theortical diffraction limited spot size

$\Delta r \approx 1.22\lambda \cdot N \cdot A = 388$ nm



→ Symmetric Circular focused spot ideal of trapping optically

Beam Quality



→ quality factor $M^2=1,08$ before focusing

→ working on improving the beam quality at the focal point

Future work

Integrated mutiplexed VECSEL light and concept of Vortex and high order transvers mode integrated in the optical tweezers set up in order to manipulate several particules at the same time