

Exotic structured laser light for enhanced societal applications: towards THz sensing, data processing, biophotonics

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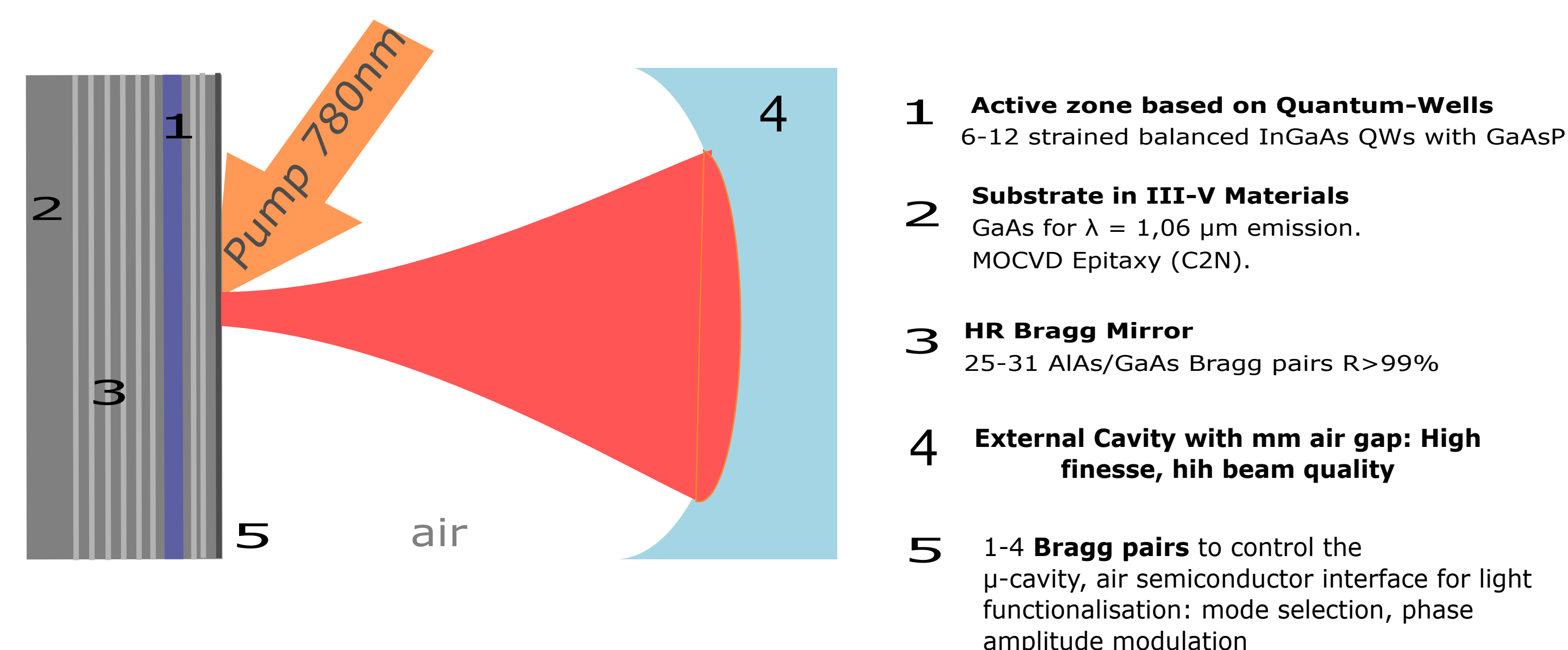
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GOALS

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.

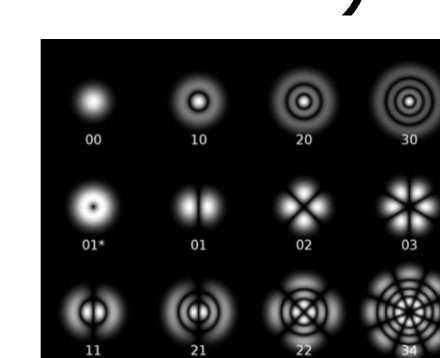
VECSEL TECHNOLOGY

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

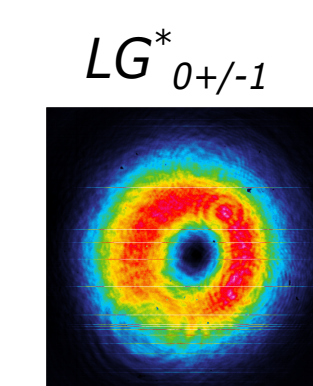


Advantages for Optical Trapping

- 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:

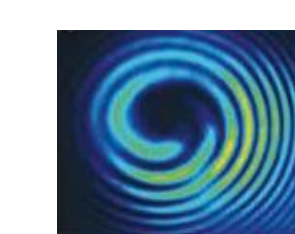


in particular:



Ideal for optical trapping

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



vortex phase

Innovation for our optical tweezers application, will rotate particles

OPTICAL TWEEZERS

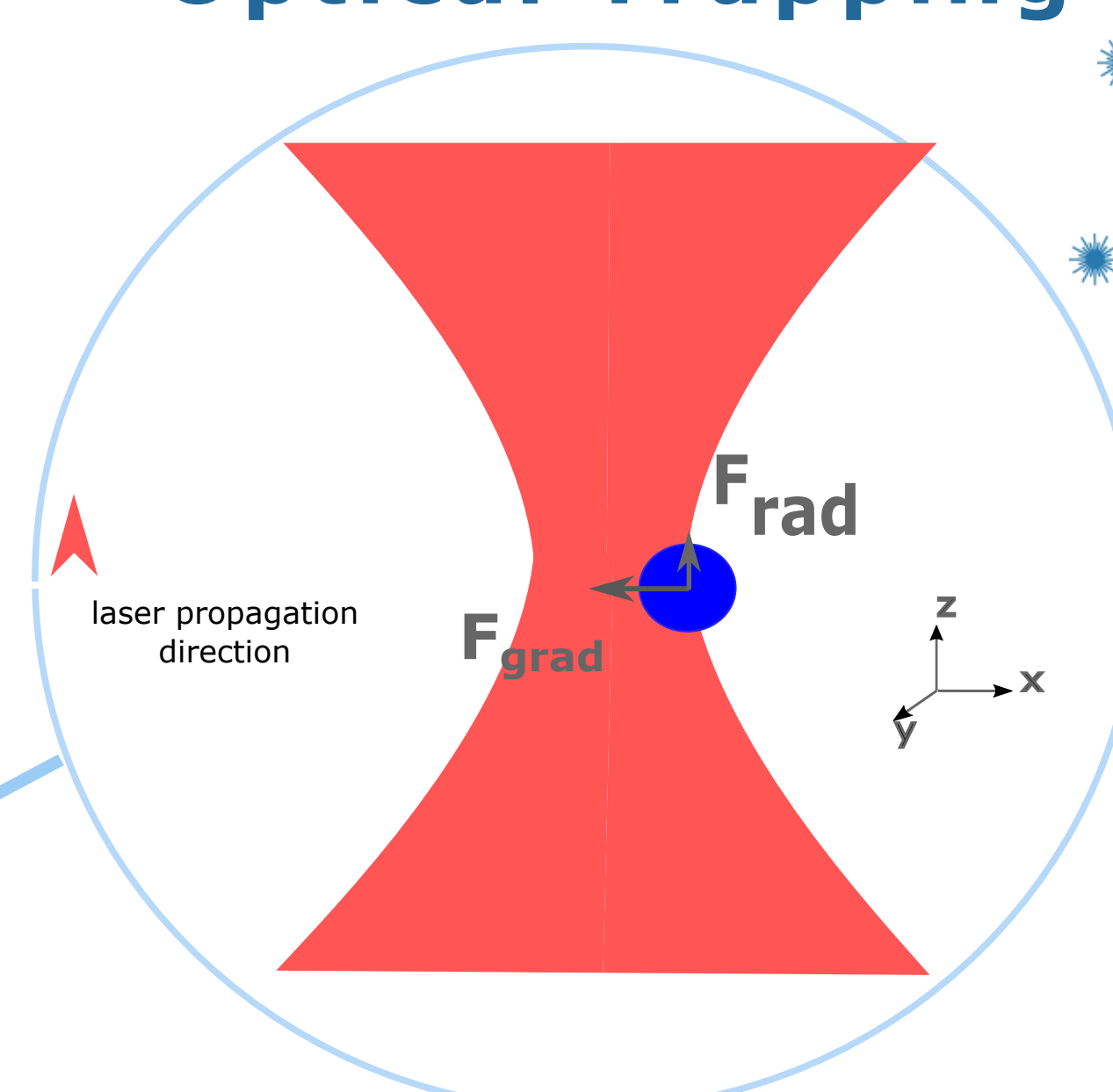
Allow the manipulation, control and measure of biological objects at the nanometric scale in a non-destructive way, by exploiting the various photonic forces of lasers beams.

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 μm in this configuration the gradient force is dominant and the particle is optically trapped.

A wide Variety of Particules can be trapped

Atoms, molecules, bacteria and sythetic particles 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

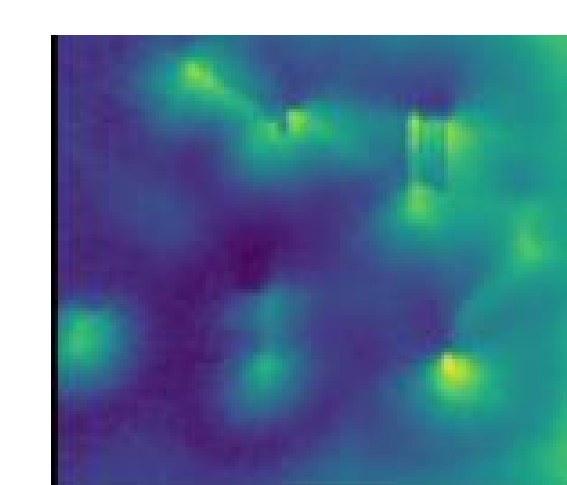
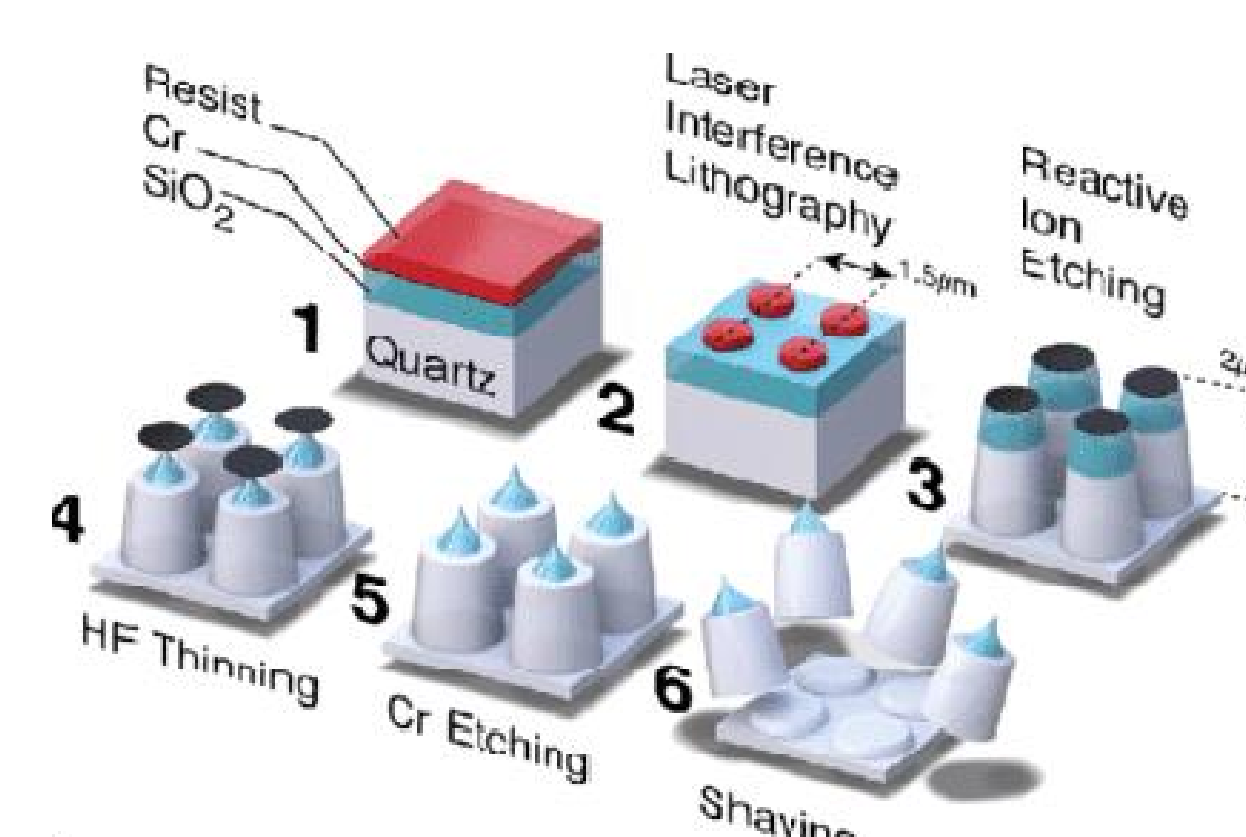
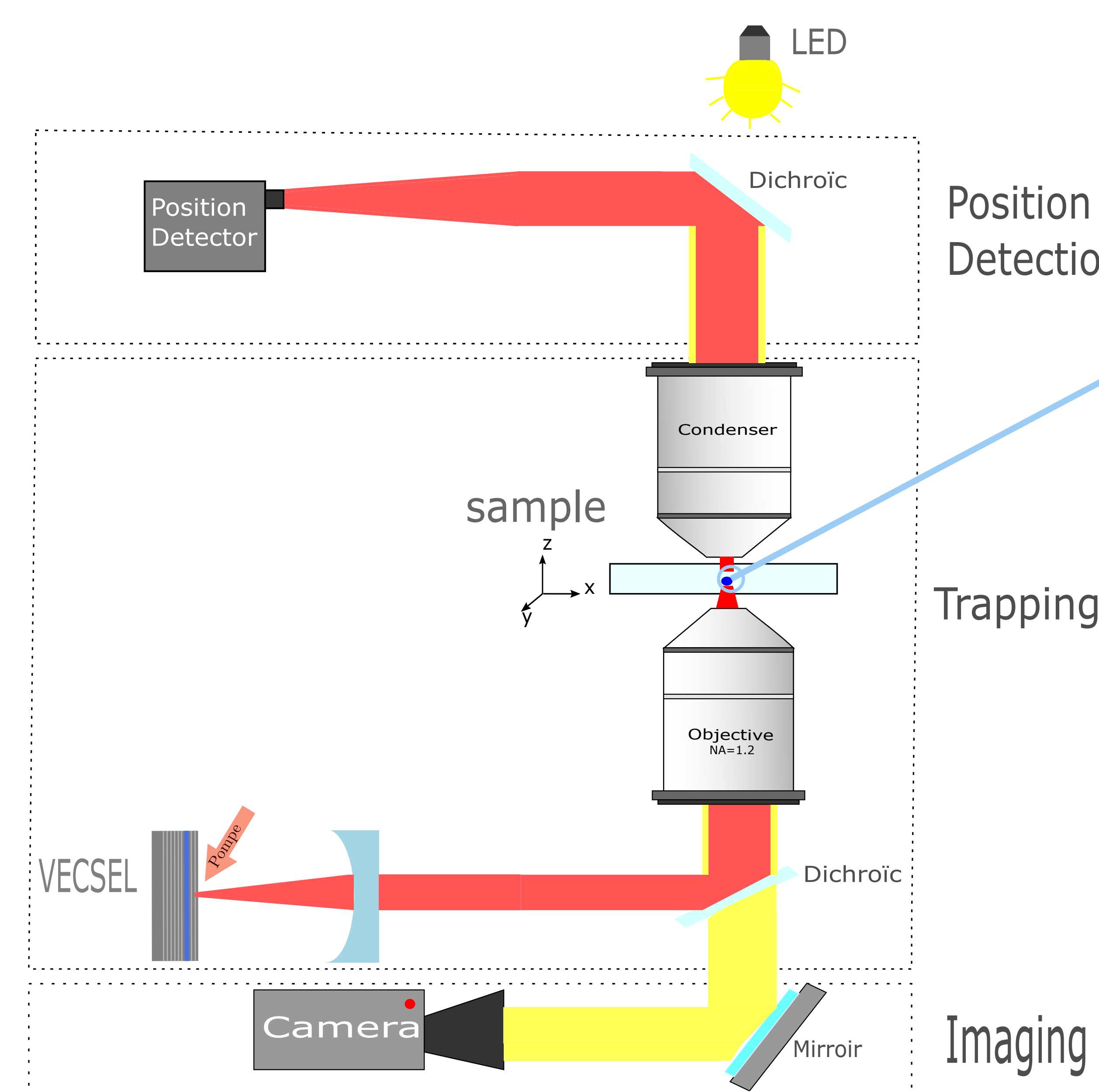
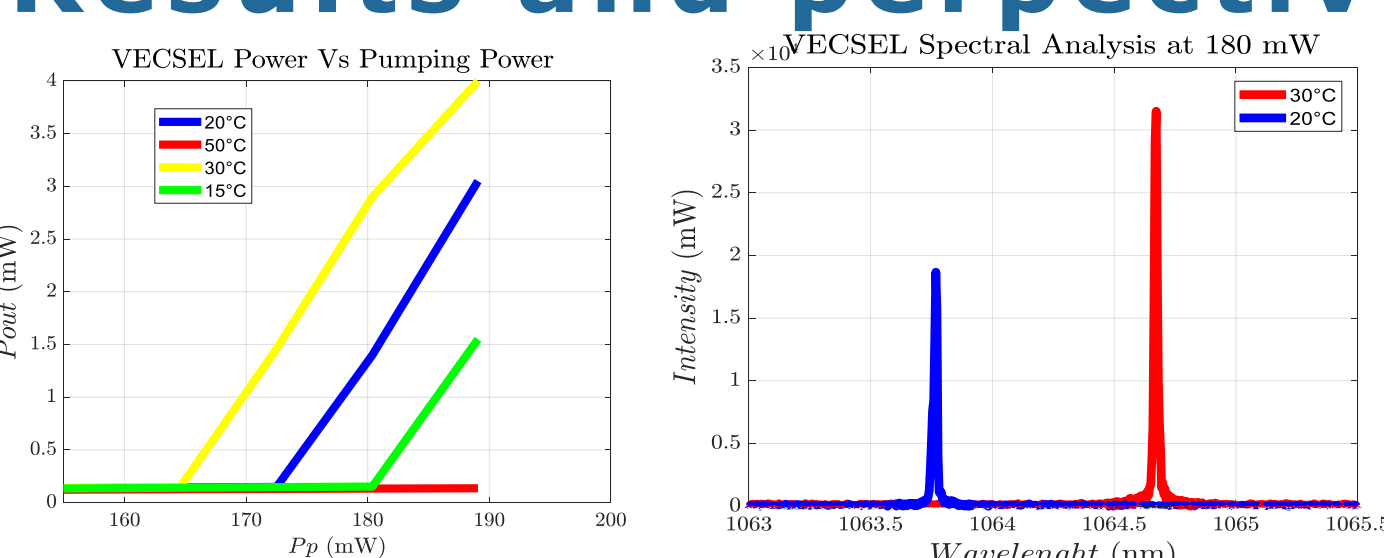


Image obtained by scanning the tip of the cylindrical nanocrystals on the surface of blood cell trapped in the optical tweezers set up

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

Results and perspectives

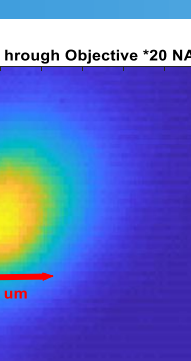
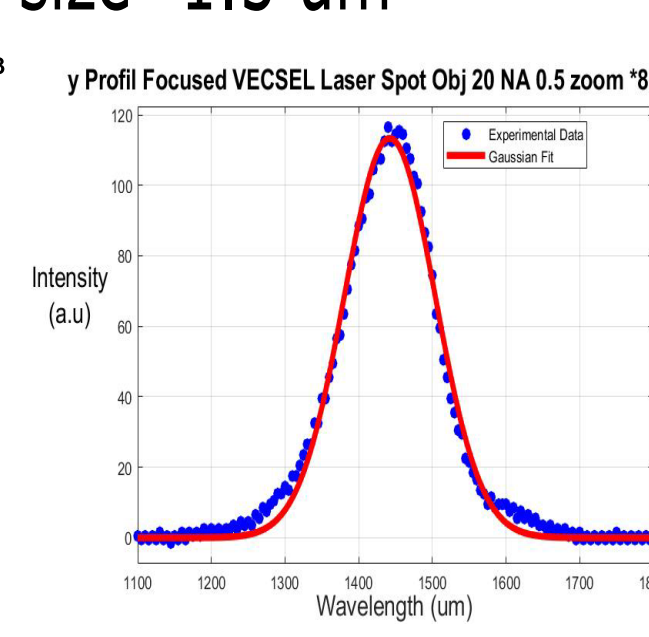
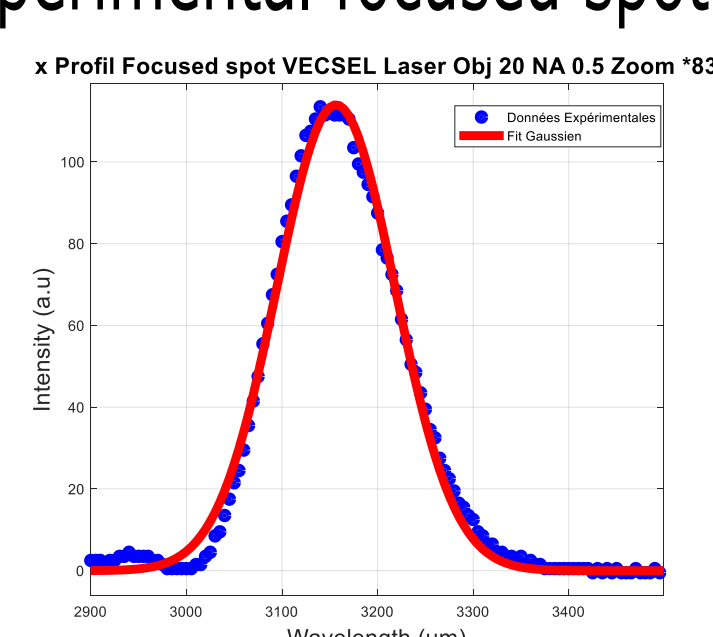


- VECSEL beam has a high spatial coherence, quality factor $M^2 < 1.2$
- Its efficiency is 17% at 25°C

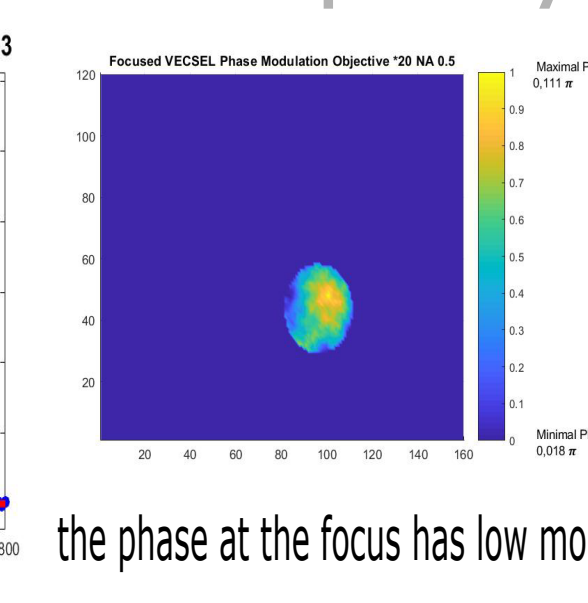
- Single frequency and single transverse mode

Gaussian Mode

Image of focused VECSEL beam through x20 NA=0.5 objective
Experimental focused spot size=1.5 μm



beam quality



the phase at the focus has low modulation 0.113 xλ

- Symmetric Circular focused spot ideal of trapping optically

Vortex Mode

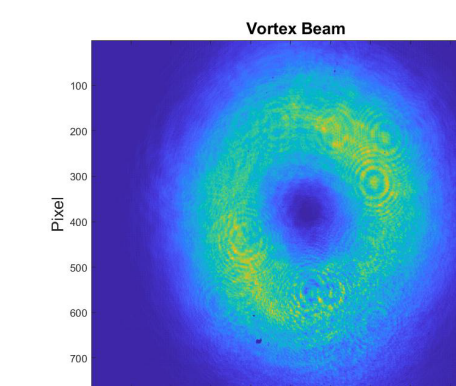


Image of the intensity profile of the Vortex beam before focalisation

Next Steps

Focalisation of the vortex mode beam in the microscope objective and optical trapping

Future work

Integrate multiplexed VECSEL light and focalisation of a high charge of Vortex mode in the optical tweezers set up in order to manipulate and rotate several particules at the same time