**Novel Optical Nanoprobes for Material Science and Nanotechnology: Nanoscale Femto Spectroscopy and Optical Nanostructuring**

The challenge to develop new tools for the investigation and the manipulation of organized materials and systems in the nanoscale, induced us to design and implement a novel optical facility able to perform nanoscale imaging, nanoscale ultrafast spectroscopy and nanoscale nanostructuring and photolithography.
The facility is based on the concept of confocal microscopy and the sample must emit light. A schematic view of confocal principles is reported in figure 1.

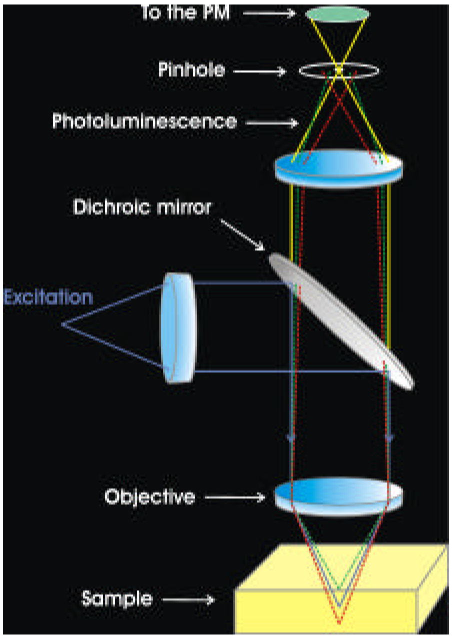


**Fig. 1** Working principles of confocal microscopy.
In plane photoluminescence selected by the pinhole.

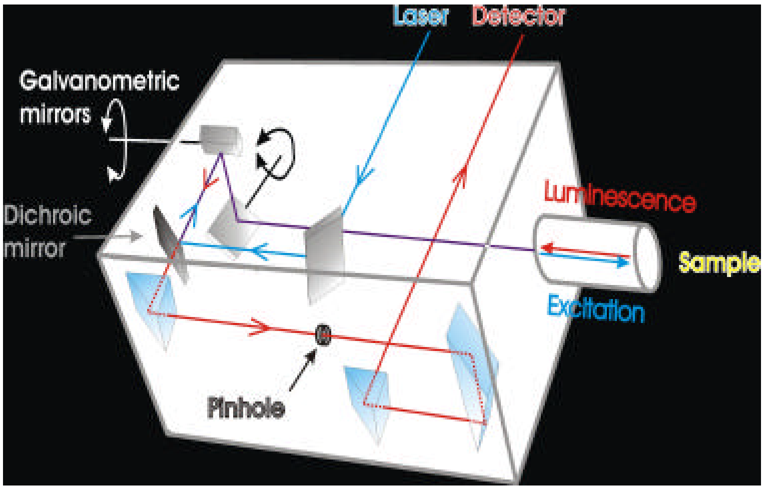


**Fig. 2** Schematics of the scanning head with the galvanometric mirrors. The incoming laser beam is reflected by the dichroic mirror (DC), and directed towards the sample by the two galvanometric mirrors. The sample photoluminescence is transmitted by DC and spatially selected by the pinhole before reaching the detector.

In ordinary one-photon (linear) configuration the confocal configuration allow to obtain a lateral resolution of 230 nm compared to 380nm for standard optical microscopy when working at an emission wavelength of 600nm and the use of galvanometric mirrors in order to scan the laser beam on the sample surface (Fig.2) allows PL imaging at the selected focal plane, permits large area and fast image acquisition and prevents photodegradation. The lateral resolution can reach better that 100nm in the case of multi-photon set-up (nonlinear).

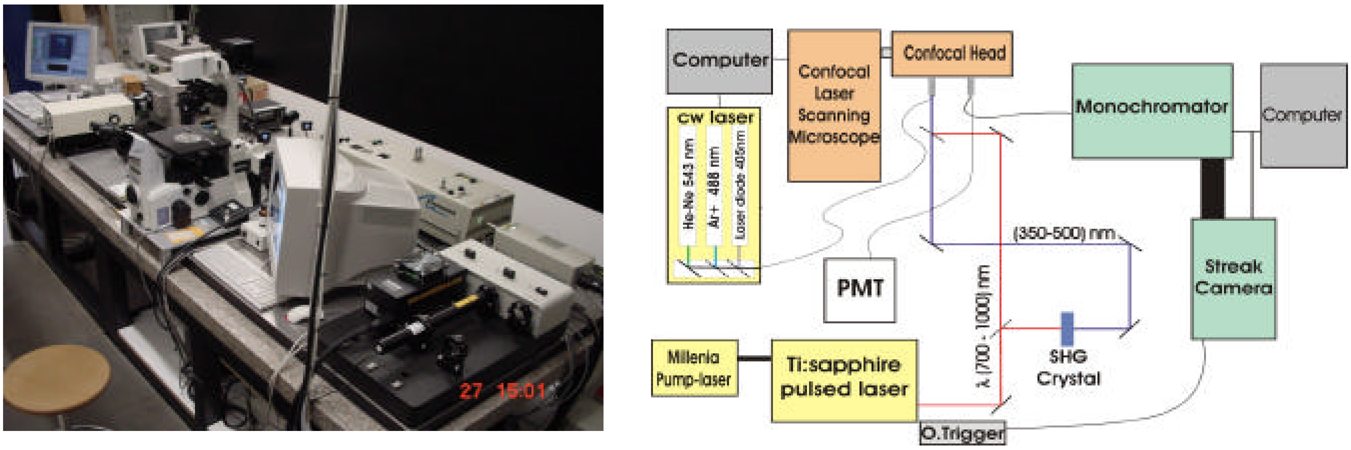


**Fig. 3** The optical nano probe designed and developed at our Institute. The left-side shows a picture of the real system and the right-side a block diagram.

We have designed and developed a single and multiphoton femtosecond laser excitation coupled to a Laser Scanning Confocal Microscope and to a photon counting Streak Camera detection allowing to perform photoluminescence spectroscopy with in-plane spatial resolution of up to 120 nm and temporal resolution of 2 ps (Fig. 3). The facility combines high performance imaging capabilities in 3D (z-scanning resolution of 25 nm and optical volume resolution of 100nm) with high sensitivity spectroscopic detection of time-resolved photoluminescence (PL). Imaging and spectroscopy are performed on the same spatial position thus allowing a direct correlation of the morphological features with the spectroscopic properties. An example of imaging obtained with the one-photon configuration on a microstructured ultra thin film of Tris(8-oxyquinoline)aluminum (III) (a prototypical material of organic light emitting diodes) is reported in figure 4.

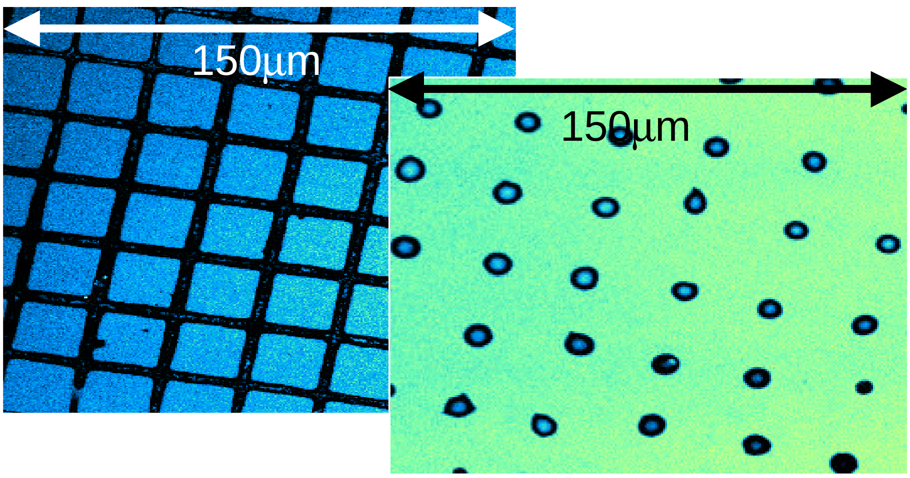


**Fig. 4** Confocal laser scanning images of microstructures of Tris(8-oxyquinoline)aluminum (III) on silicon oxide. Exc. 405 nm.

A direct use of this Optical Nano Probe is in the spectroscopic investigation and imaging of the active areas of molecular electronic and optoelectronic devices such as OTFTs, OLEDs and PV cells. Morphology of active layers within working devices can be correlated to field distributions, charge flows, charge recombination and light emission.
Nanoscale spectroscopic analyses range from integrated light emission, steady state PL, time resolved PL, one and two photon excited PL, and one and two photon excitation profiles.

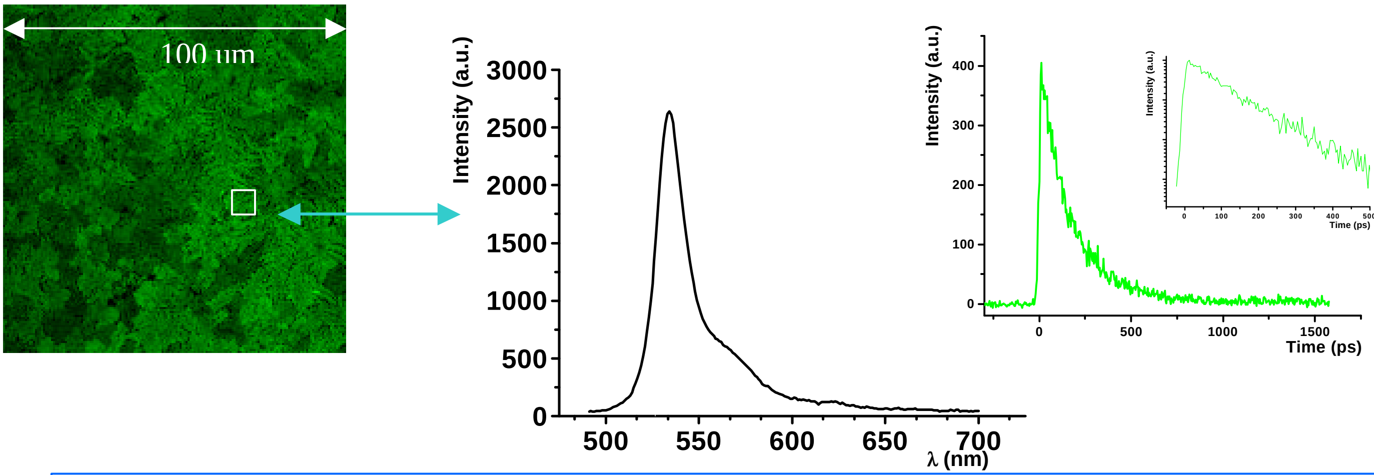


**Fig. 5** Left:confocal laser scanning image of a tetracene film grown by high vacuum sublimation. Exc. ~400 nm; Center: steady state PL of the film of Fig 4. Excitation 400 nm; Left: time-resolved photoluminescence at 525 nm. The inset shows the PL intensity in logarithmic scale.

The correlation of spectroscopical and morphological information at the nanoscale can provide a unique knowledge about the photophysical properties of nanostructured materials. In Figure 5 we present a correlated result obtained on a vacuum sublimed thin film of tetracene. The grown thin film can be imaged with a spatial resolution of few hundred of nanometers and simultaneously characterised both with energy and time-resolved spectroscopy.

The new Nanoscale Femto facility sheds light into phenomena which occurs at the nanoscale and may become an unprecedented tool in the evaluation of organic, hybrid and bio Nanostructures and Nanodevices