Confocal Laser Scanning Microscopy as a tool for microscale characterization of luminescent materials.

S. Lattante, [1] A. Perulli, [1] M. Anni, [1]

[1]Dipartimento di Matematica e Fisica "Ennio De Giorgi", Università del Salento, Italy

Confocal Laser Scanning Microscopy (CLSM) [1] is a powerful tool for characterizing the morphological and luminescence properties of several different fluorescent systems, from biological tissues [2] to polymeric blends [3]. One of the great advantage of this technique is the lack of any particular preparation process on the investigated sample, unlike other standard techniques like electron microscopy or optical microscopy. We have used a Nikon Eclipse C1 inverted CLSM in order to study and characterize several samples of different nature, in particular polymer or polymer blends in the form of thin films [4–6] or nano-fibers [7].

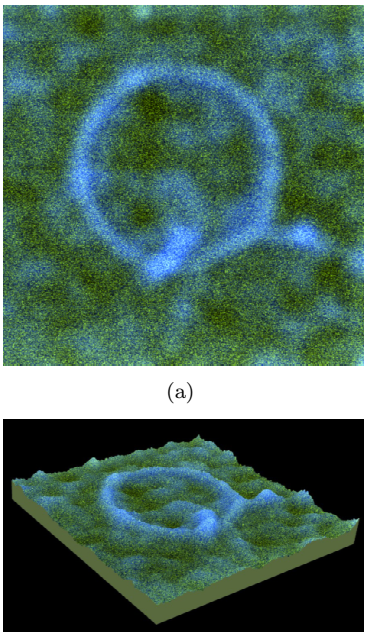
For instance, the CLSM has been used to study and characterize the phase separation between the so called glassy phase and the βphase in films of poly(9,9-dioctylfluorene) (PFO) [8] deposited by our Department colleagues by Matrix Assisted Pulsed Laser Evaporation (MAPLE) [6] as a function of the various deposition parameters. An example image is plotted in fig. 1 where the photoluminescence (PL) map along with its three-dimensional PL intensity distribution are reported.

The separation of the two phases in the film is evidenced by the different emission wavelength detected over the sample area (green and blue in the picture), allowing for a quantitative and qualitative characterization of the film morphology to be correlated with the deposition parameters.

We have characterized also micro-patterned luminescent polymeric surfaces. One example can be visualized in fig. 2, where a thin patterned film of a blend of PFO and Poly(styrene)-*block*-poly(acrylic acid) is reported. The micropatterning has been realized through the breath-figures method [9].

The CLSM characterization technique allowed in this case a fast and simple method for checking how the variation of a deposition parameter influences the final structure of the film, thus accelerating all the required optimization process towards the final goal of the particular research activity.

As last example, we report also some brief



(a)

(b)

Figure 1. CLSM image of MAPLE deposited PFO film. Different phase inside the film emits at different wavelengths (evidenced by the blue and green colors). Image 84 μm x 84 μm, 0.16 μ m/px.

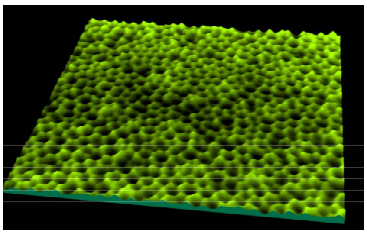
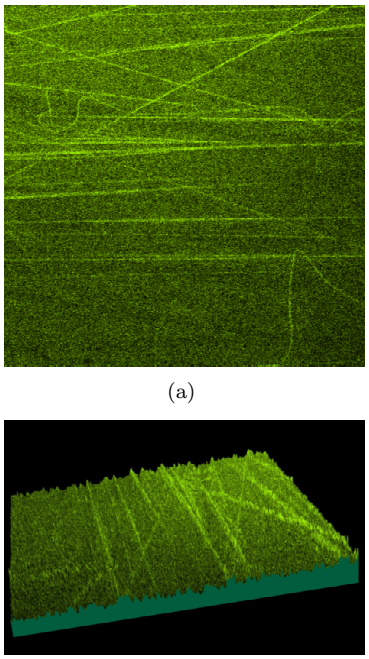


Figure 2. Quasi honeycomb-like structured luminescent polymeric blend. 30 μm x 30 μm, 0.06 μm/px.



(a)

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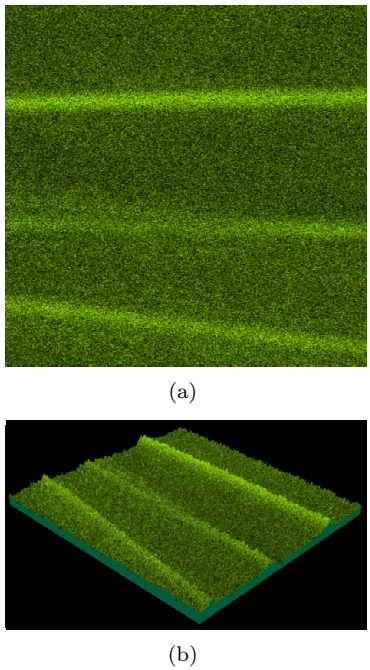
Figure 3. Ordered luminescent polymeric nanofibers deposited by electrospinning. a) 320 μm x 320 μm, 0.62 μm/px., b) 3D PL intensity map.



(a)

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Figure 4. Zoomed region of fig. 3. a) 13 μm x 13 μm, 0.02 μm/px., b) 3D PL intensity map.

results on the characterization of polymeric luminescent fibers obtained by electrospinning [7]. Electrospinning is a versatile method for the production of polymer fibers with diameters ranging from nanometers to microns. Fibers produced in this manner have a wide range of applications and with the introduction of emissive materials they are of particular interest as nano-photonic light sources [10]. The electrospinning process works by the formation of a charged jet of polymer solution which is accelerated towards a grounded plate where the fibers are collected. During transit the solvent evaporates and dry fibers are collected on a substrate above the ground plate [11]. This process normally yields a randomly oriented "web" of fibers due to the inherent instabilities in the path of the jet. However, oriented fibres can be produced by changing the collection geometry [12–14].

The photo-physical properties of the fibers were examined by CLSM. CLSM images of aligned fibers are shown in fig. 3 and 4, while in fig. 5 is reported a fluorescence image of a different sample with less aligned fibers and emission on a different wavelength, which shows that the dye was evenly distributed along the fiber. In order to check for a possible polarization of the light emitted from the fibers, a rotating polarizer inserted through the optical path of the collection signal has been used. Anyway no preferential polarization of the PL was detected, indicating that the dipoles of the dye molecules are randomly oriented.

In conclusion, we have used Confocal Laser Scanning Microscopy (CLSM) for the characterization of the morphology and optical properties of various polymeric systems.

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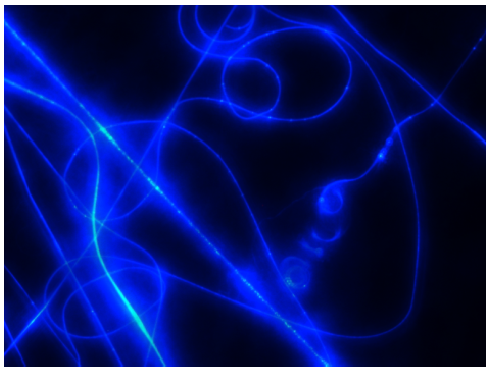

Figure 5. Fluorescence image of non-ordered luminescent polymeric nano-fibers deposited by electrospinning, 220 μm x 160 μm, 0.17 μm/px.

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