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PRODUCTION OF FEMTOSECOND LASER MICROMACHINING DEVICES USING MEH-PPV FILMS

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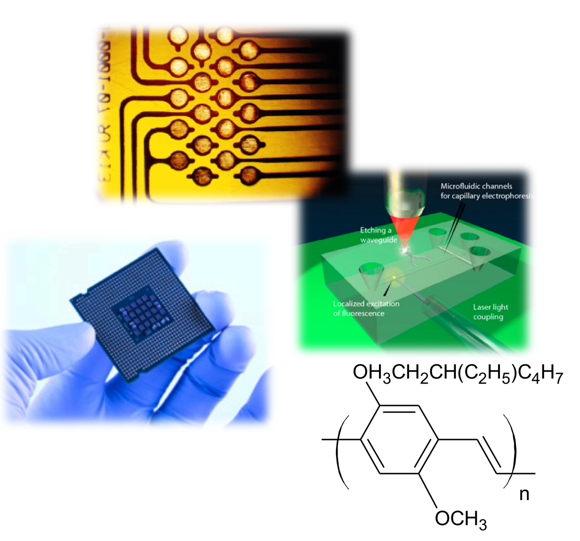
Abstract - In recent year due to their interesting properties for device applications, polymers have been the objective of several studies. On the other hand, with the considerable advances in the photonic field, micromachining laser technologies have also become very popular. In this work, we investigated the use of a femtosecond laser to micromachining the conjugated polymer poly[2-methoxi-5-(2'ethylhexy-loxy)-p-phenylenevinylene] (MEH-PPV). The results obtained provide important information regarding fs-laser micromachining, which can lead to more detailed parameters for the development of applications in polymeric-based devices. The samples were analyzed with optical, fluorescence, scanning electron and atomic force microscopy. Finally, we studied the dc Current-Voltage characteristics of the produced microstructured device.

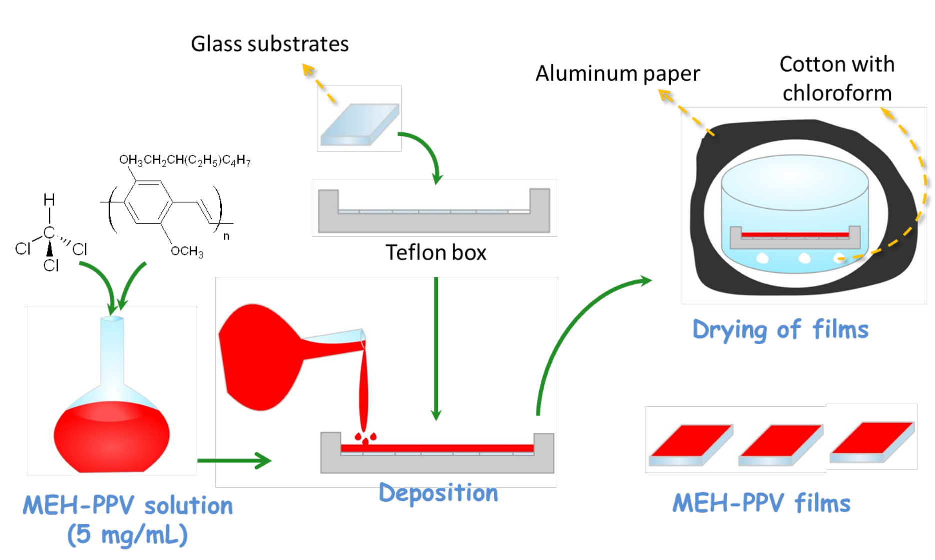
Motivation



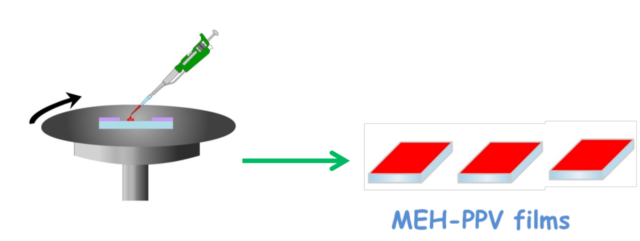
Polymers are considered great materials for fabricating devices, especially due to its interesting optical and electrical properties. In particular, the poly[2-methoxi-5-(2'ethylhexy-loxy)-p-phenylenevinylene] (MEH-PPV) has such versatility, that can be used for fabricating optoelectronic devices such as organic light-emitting diodes, chemical sensors and flexible displays.

Experimental details

Film Production

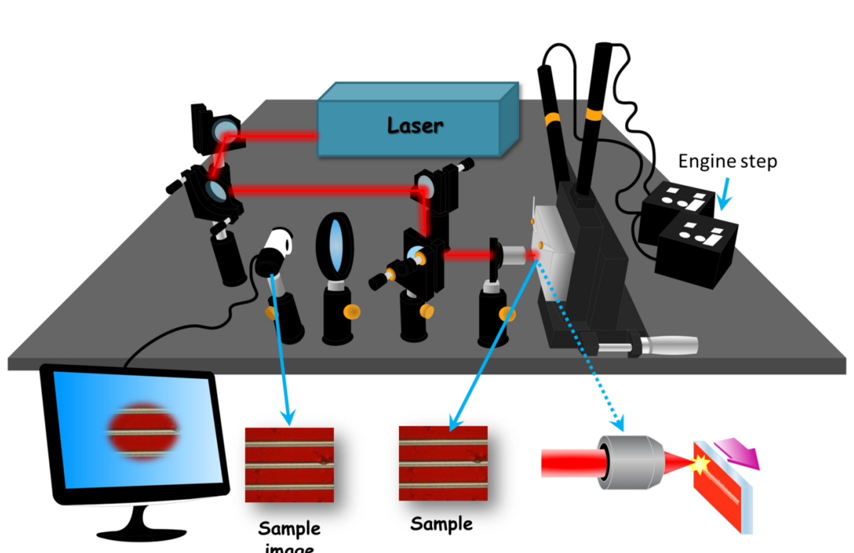


Production process of films MEH-PPV by method of decanting. The films obtained have a thickness of 14 μm.



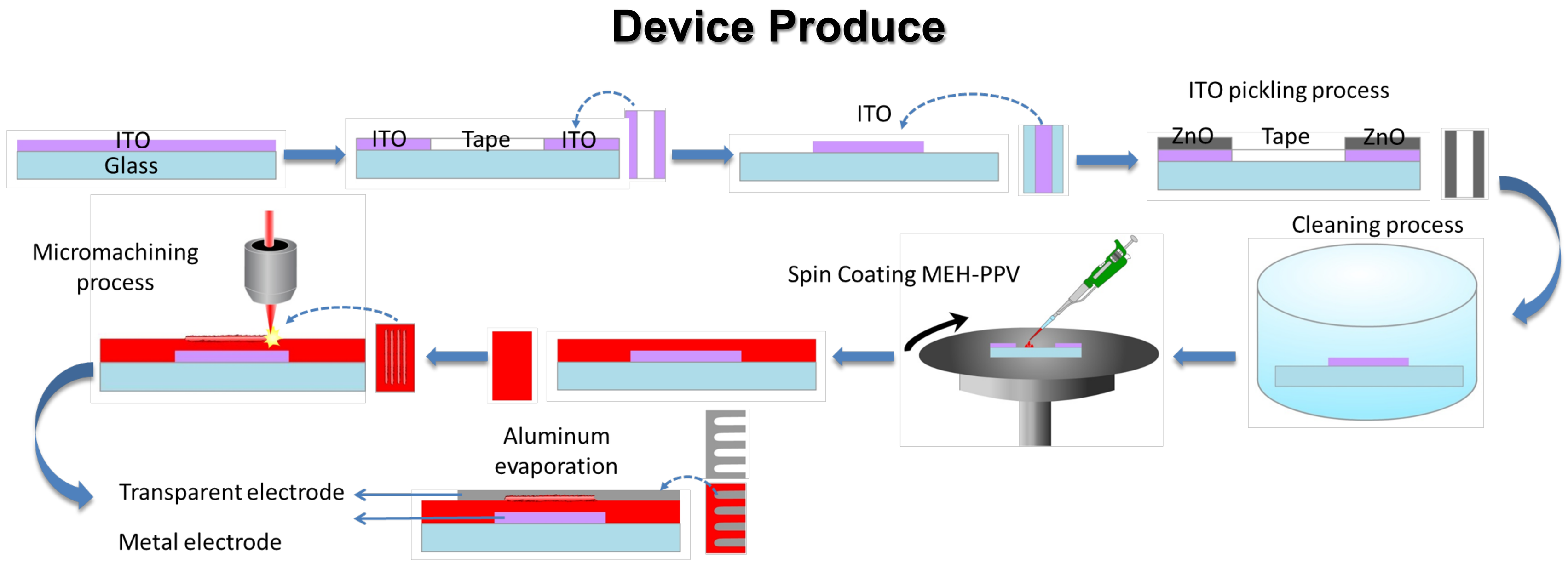
The MEH-PPV was dissolved in chloroform (in concentration 8 mg/ml). The solution was agitated for 20 minutes at 50°C. After have been filtered, the solution was deposited on glass substrates by spin coating method (optimized with 300 rpm for 30 seconds). Films were obtained with 280 nm.

Micromachining Technique

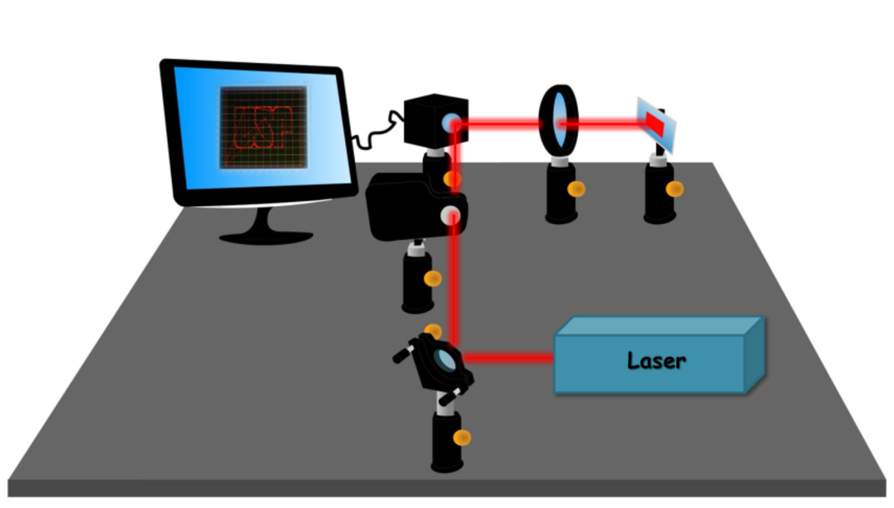


The MEH-PPV films were micromachined using an Ti:Sapphire laser delivering 50 fs pulse, centered at 800 nm (100 nJ and operating at a 5.1 MHz repetition rate). The beam was focused through a microscope objective (40x) onto the surface of a MEH-PPV film, which was translated at a constant speed, controlled using a computer-controlled xyz stage, with respect to the laser beam.

Device Produce

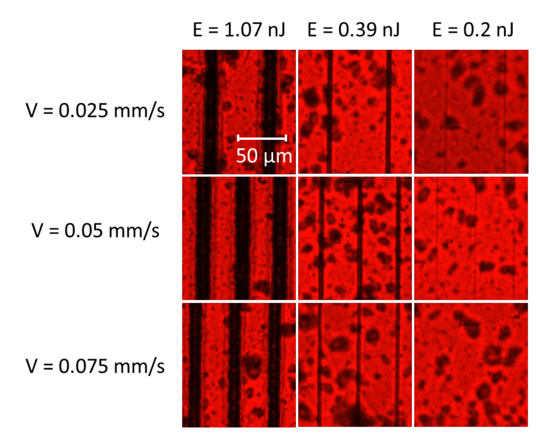


Micromachining Technique

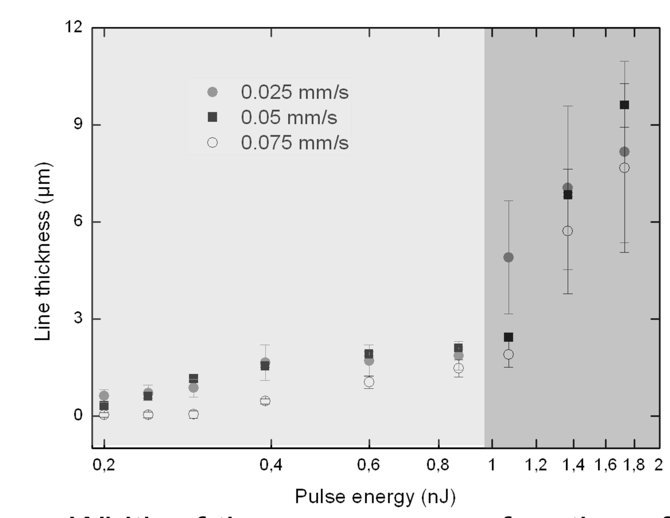


The beam was focused through a lens onto the surface of a MEH-PPV film.
Using galvanometer scanning mirror, whose movements are controlled by software, the laser beam was moved at a constant speed in relative the sample, producing acronym of University of São Paulo (USP). The acronym were produced with pulse energy of 16 nJ and the translation speed 1.0 mm/s.

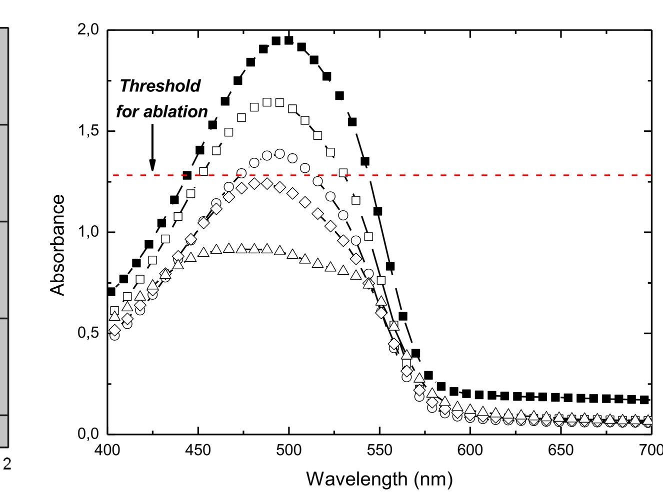
Results



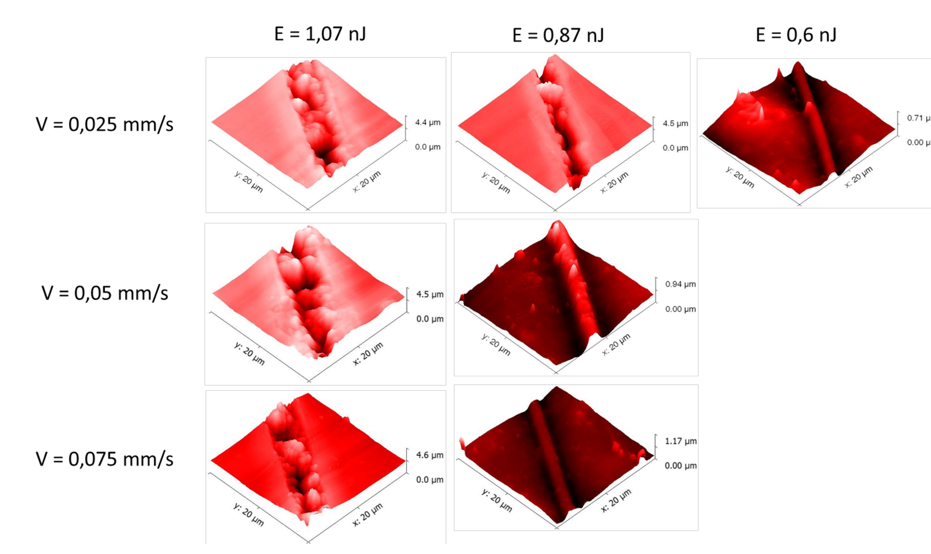
Optical microscopy images of line micromachined in MEH-PPV film using different pulse energies and translation speed.



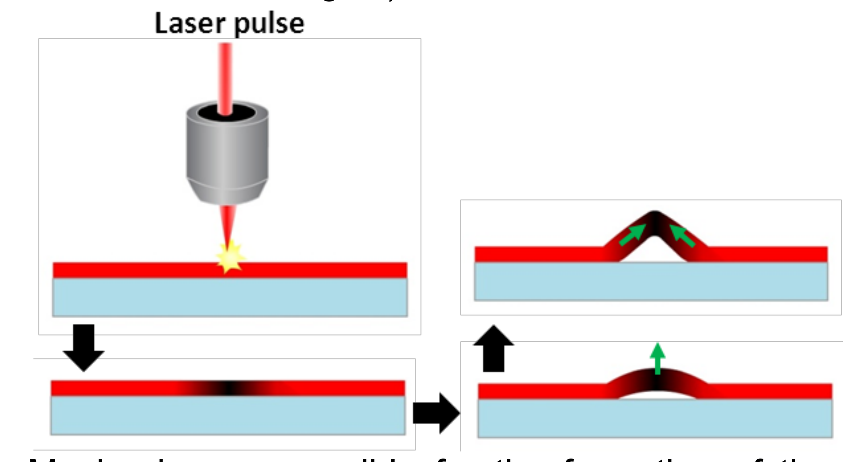
Width of the grooves as a function of the pulse energy for a translation speed of 20 mm/s.



Absorbance spectra for a MEH-PPV film not microstructured (solid squares) and after microstructured with 0.6 nJ (open squares), 0.8 nJ (open circles), 1.0 nJ (open rhombus) and 2.0 nJ (open triangles).

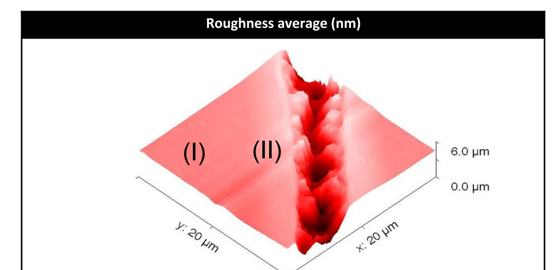


Atomic force micrograph the MEH–PPV films.



Mechanism responsible for the formation of the bulge in the film of MEH-PPV.

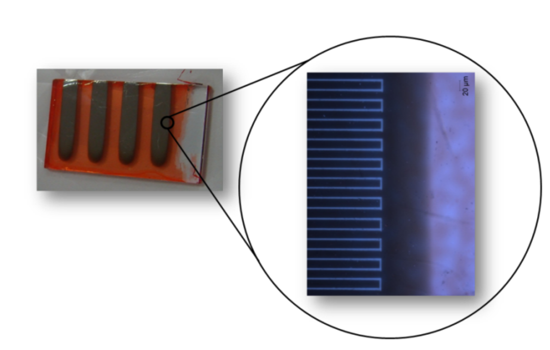
Roughness average (nm)



Region on film	Sample					
	a	b	c	d	e	f
I	24	9	33	11	35	11
II	66	17	70	25	78	29

*O filme de MEH-PPV não microfabricado apresentou cerca de 9,0 nm de rugosidade.

The lines was micromachined with speed translation and pulse energy of: (a) 0.025 mm / s and 1.07 nJ; (b) 0.025 mm / s and 0.87 nJ (c) 0.05 mm / s 1.07 nJ (d) 0.05 mm / s 0.87 nJ (e) 0,075 mm / s and 0.87 nJ , (f) 0,075 mm / s and 1.07 nJ.



Photograph of an MEH-PPV device with a transmission optical image of lines micromachined.

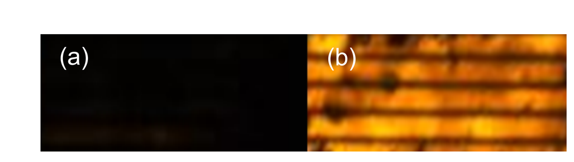
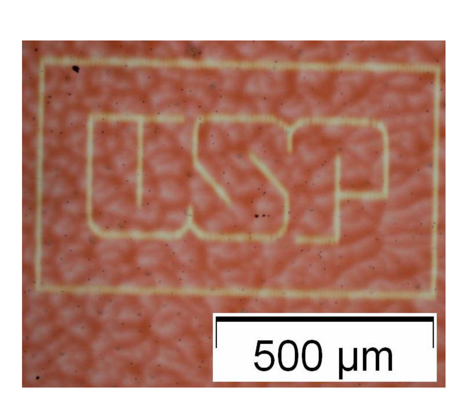
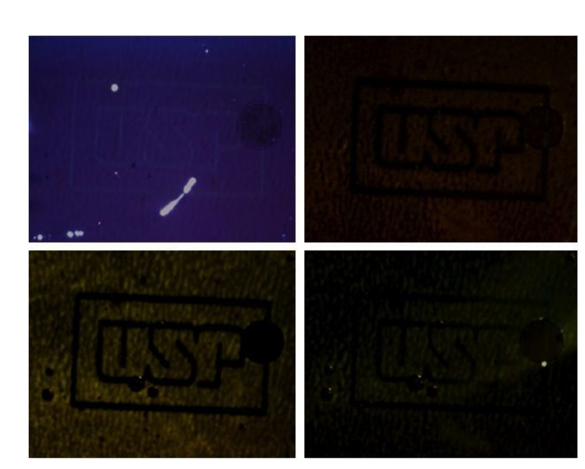


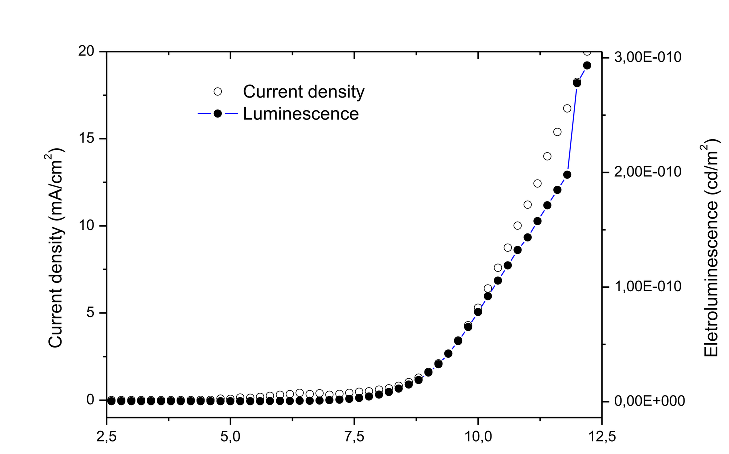
Image of the region micromachined in device: (a) without light emission and (b) with light emission.



Optical microscopy image of the name of the University of São Paulo in MEH-PPV film



Images of the device of MEH-PPV (a) just before applying the voltage, (b) after 30 sec (c) is after 43 (d) after 55 s.



Measurement of current and electroluminescence as a function of applied voltage on the device ITO /MEH-PPV / microstructure / Al.

Conclusion

- The width of micro grooves increases with pulse energy.
- The optical properties of the polymer were not changed after micromachining.
- The interaction of fs laser pulses with the polymer has two regimes: ablation threshold which occurs for high energies, resulting in visible changes produced in the film surface and structural change threshold, which occurs for low energies, resulting in only structural changes.
- For a translation speed of 0.075 mm/s, the threshold energy to cause structural changes on the surface of the film approximately above 0.29 while that for speeds 0.05 and 0.025 mm/s is below of 0.20 nJ.
- The process microfabricated does not alter the characteristics device, been that he continues with behavior of the diode and luminescence accompanies the behavior of the electrical current, showing that they are correlated. We see that the device starts shine with a voltage of about 8 V.
- The results presented here provide the experimental conditions for fs laser micromachining of MEH–PPV, which can lead to more detailed parameters for the development of applications in polymeric-based photonic devices.

Acknowledgments

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