

## On the design of neural structured scaffolds using conducting polymers by direct interference laser patterning

Mulko, Lucinda<sup>1</sup>, Bongiovanni, Silvestre<sup>2</sup> Soldera, Marcos<sup>1,5</sup>, Bouchard, Felix<sup>1</sup> Acevedo, Diego<sup>4</sup> y Lasagni, Andrés<sup>1,2</sup>

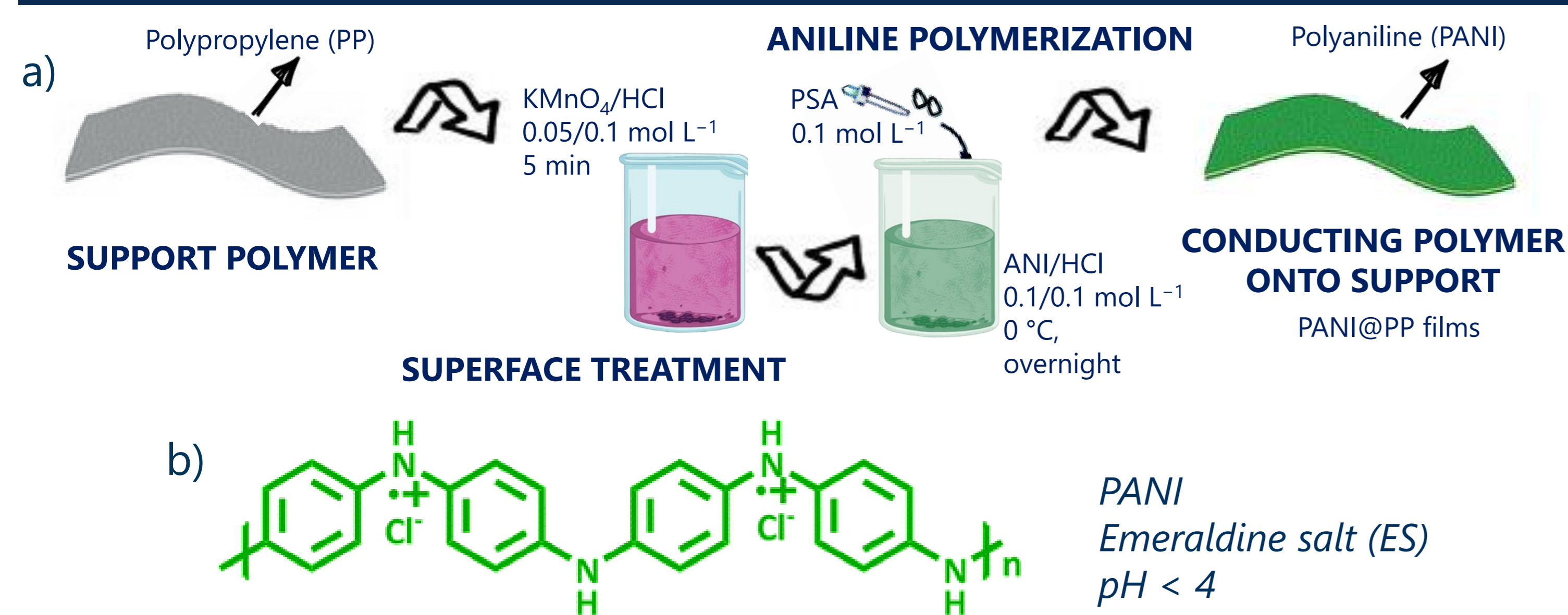
<sup>1</sup> Institut für Fertigungstechnik, Technische Univ. Dresden, George-Bähr-Str. 3c, 01069 Dresden, Germany – <sup>2</sup> Fraunhofer-Institut für Werkstoff- und Strahltechnik IWS, Winterbergstr. 28, 01277 Dresden, Germany – <sup>3</sup> Research Institute for Mat. Sci. and Tech., INTEMA (UNMdP-CONICET), Av. Colón 10850, 7600, Mar del Plata, Argentina - <sup>4</sup> Instituto de Investigaciones en Tec. Energ. y Mat. Avanzados (IITEMA), UNRC, Río Cuarto, 5800, Argentina – <sup>5</sup> PROBIEN-CONICET, Dto. de Electrotecnia, Univ. Nac. del Comahue, Buenos Aires 1400, Neuquén 8300, Argentina

Contact: lucinda\_emma.mulko@tu-dresden.de

### Introduction

This work aims to design and develop a composite film consisting of a nanocoated conductive polymer polyaniline (PANI) bonded to the flexible bioinert polymer polypropylene (PP) acting as a support polymer and structured by direct laser interference patterning (DLIP) using two different approaches. On the one hand, by directly structuring the PANI@PP films by DLIP using ps-laser at 355 nm (Fig. 2) On the other hand, indirectly structuring a stainless-steel metal template using DLIP ps-laser at 1064 nm, which in a second step, by means of hot-embossing plate-to-plate (DLIP-P2P) will be used to mould the patterning on the PANI@PP films (See Fig 3). The ultimate goal is to use this material as a neural scaffold for biomedical applications.

### Obtention of the PANI@PP films

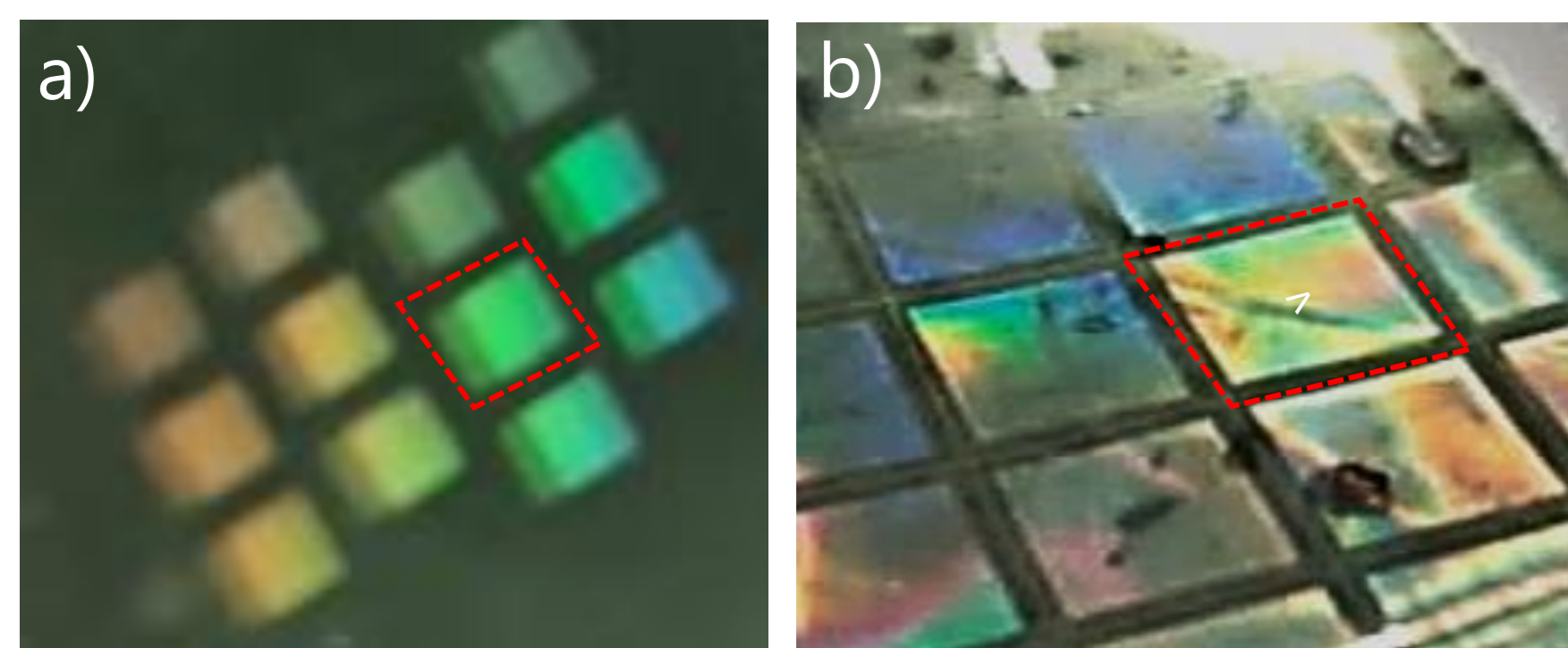


**Fig. 1:** a) Representative scheme of the PP surface treatment and PANI polymerization procedure onto PP support to obtain the final material (PANI@PP). b) Structure of PANI in the conductive state (emeraldine salt) as was herein resulting.

### Surface topography characterization

PANI@PP-DLIP

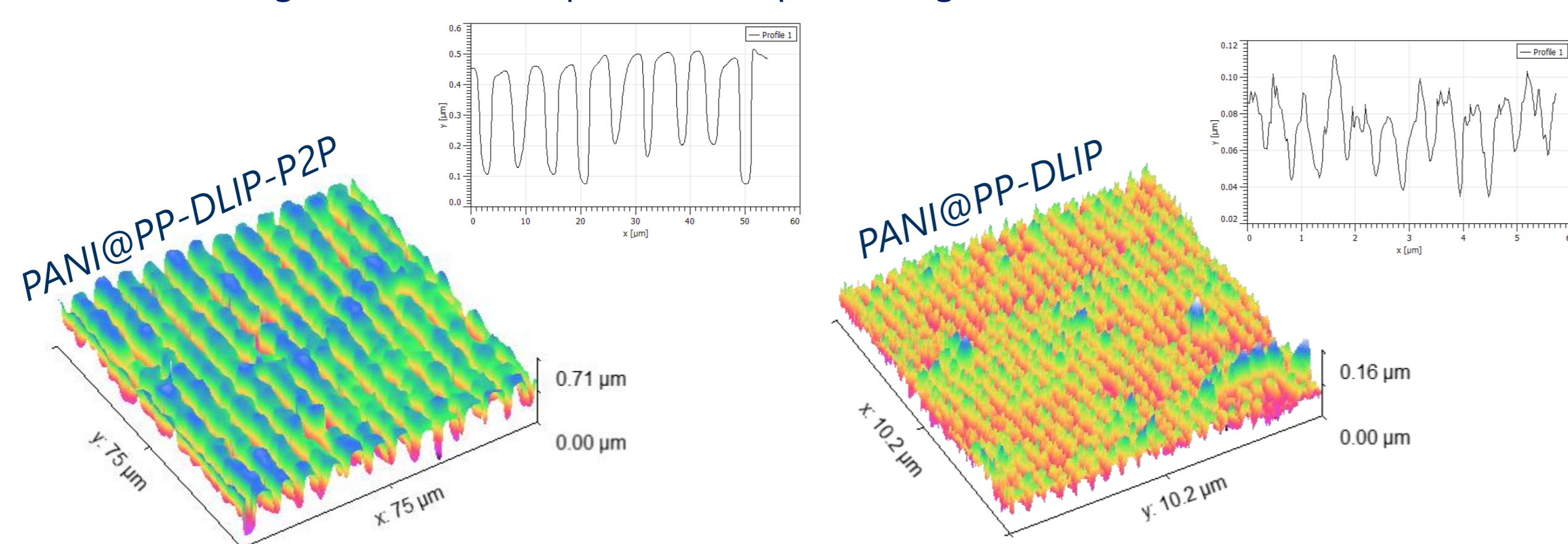
PANI@PP-DLIP-P2P



**Table 1:** Structure conditions of the PANI@PP films (---). The structure periods shown are the classical ones achieved by this type of technique at the working wavelengths. For 1064 nm: ~ 6 µm, at 355 nm: ~ 1 µm.

	PANI@PP DLIP	PANI@PP DLIP-P2P
Structured material	PANI	stainless steel
Period	6.1 µm	1.3 µm
Aspect ratio period/depth	0.85	0.81
Laser λ	1064 nm	355 nm
Laser fluence	230 mJ.cm <sup>-2</sup>	105 mJ.cm <sup>-2</sup>

**Fig. 4:** Photograph of the PANI@PP film structured by a) DLIP each structured area 1 mm x 1 mm and b) DLIP-P2P each structured area 1 cm x 1 cm. The analysed structures are indicated by red dotted lines (---). The different structured areas correspond to different structuring conditions (e.g., laser fluence, focus distance and periodicity of structuring which will not be discussed in this work). The structured surface corresponds to the areas where diffraction colours are observed (due to the high-resolution periodic structure), the remaining material corresponds to unstructuring PANI@PP.

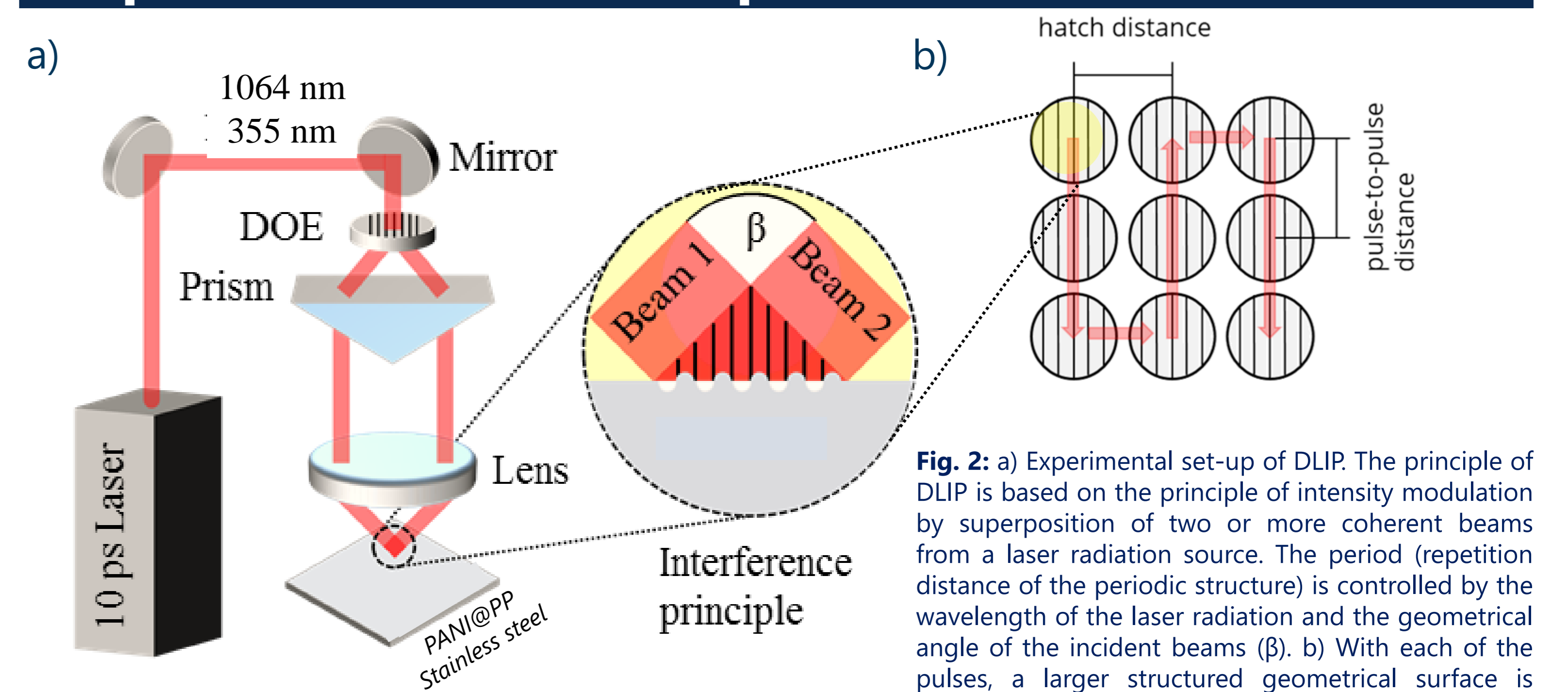


**Fig 5:** Confocal Laser Microscopy of (left) PANI@PP-DLIP (right) PANI@PP-DLIP-P2P films and respective surface profile. The image sizes were taken in such a way as to obtain at least 10 valley/ridge patterns in each image.

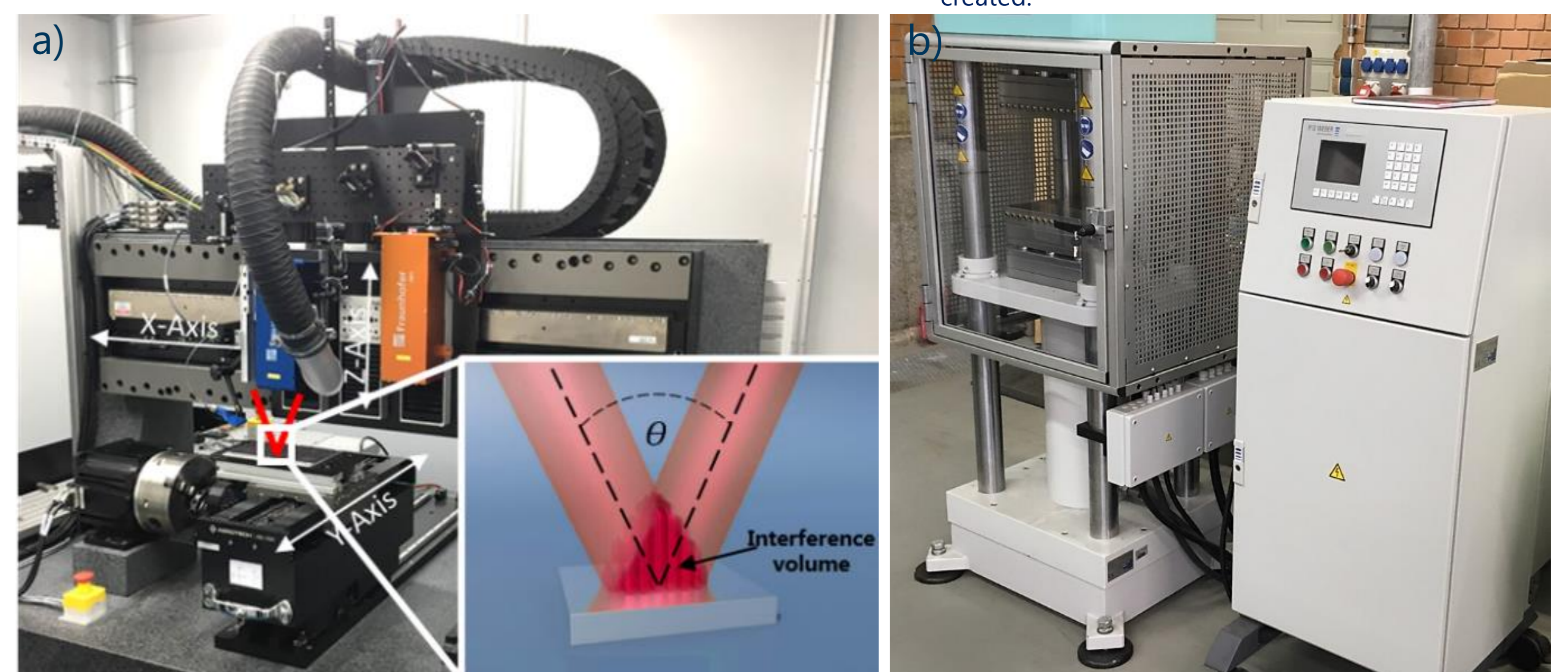
### Conclusion

It was possible to structure PANI@PP films by direct and indirect interaction of the laser on the surface. Using the indirect method (DLIP-P2P) the structured surface resulted more uniformly but it is ineffective to achieve structures close to the micron (limitation  $\lambda = 1064\text{nm}$ ). The direct structure (PANI@PP-DLIP) of the surface presented partial melting of the polymer, however it was possible to achieve smaller linear structures close to 1 micron which is better suited to the final application of using these surfaces as Neural Scaffolds. Chemical and electrochemical characterisation tests are being carried out to further investigate the DLIP surface modification of the polymeric surfaces.

### Experimental DLIP set-up

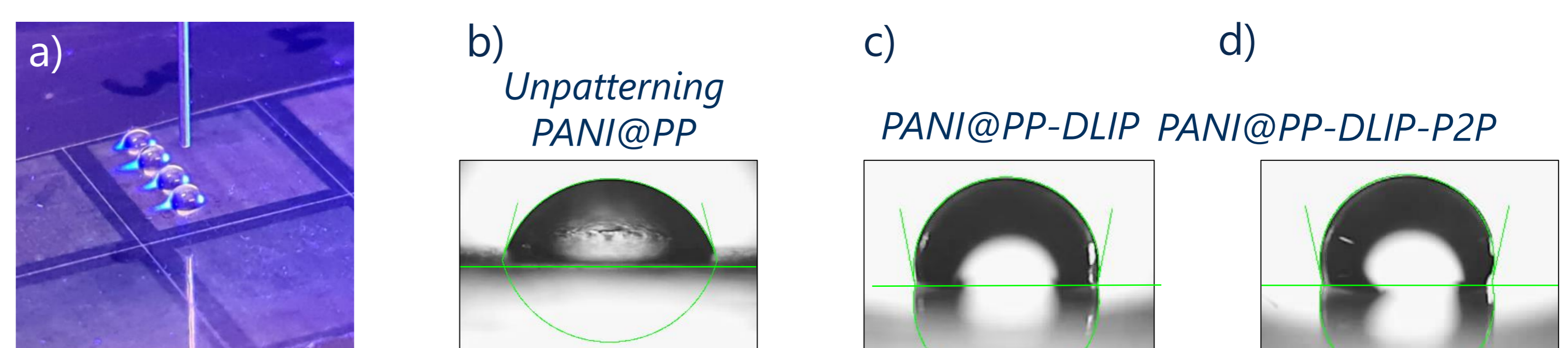


**Fig. 2:** a) Experimental set-up of DLIP. The principle of DLIP is based on the principle of intensity modulation by superposition of two or more coherent beams from a laser radiation source. The period (repetition distance of the periodic structure) is controlled by the wavelength of the laser radiation and the geometrical angle of the incident beams ( $\beta$ ). b) With each of the pulses, a larger structured geometrical surface is created.



**Fig. 3:** Experimental setups used for a) DLIP system designed and constructed by Chair for Large Area Laser Based Surface Structuring (TUD) and b) Hot-Embossing plate-to-plate (P2P) hardware.

### WCA wetting results



**Fig 6:** a) Photograph illustrating how WCAs were measured. b) PANI@PP-DLIP and PANI@PP-DLIP-P2P surface contact angles. The WCA is increased, hence the surface becomes more hydrophilic, by DLIP structure.

### References

1. Fu, M., et al. Sci. Rep., 2020, 10 (1), 1-11.
2. Saberi, A., et al. Biomolecules 2019, 9(9), 448.

### Acknowledgements:

This work was supported by the German Research Foundation (DFG), Excellence Initiative by the German federal and state governments to promote top-level re-search at German universities, and CONICET, Argentina.

Funded by:



In cooperation with:

