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Sara Coppola

Manipulation of Multiphase Materials for Touch-less Nanobiotechnology

A Pyrofluidic Platform

Doctoral Thesis accepted by
ISASI CNR—Institute of Applied Sciences and Intelligent Systems of Naples, Pozzuoli, Italy

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Publications Related to This Thesis

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J2. V. Vespini, S. Coppola, M. Todino, M. Paturzo, V. Bianco, S. Grilli, P. Ferraro, "Forward electrohydrodynamic inkjet printing of optical microlenses on microfluidic devices", *Lab on a Chip - Miniaturisation for Chemistry and Biology* **16**, 326–333 (2016).
J3. S. Coppola, L. Mecozzi, V. Vespini, L. Battista, S. Grilli, G. Nenna, F. Loffredo, F. Villani, C. Minarini, P. Ferraro, "Nanocomposite polymer carbon-black coating for triggering pyro-electrohydrodynamic inkjet printing", *Applied Physics Letters* **106**, 26, 261603 (2015).
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Supervisor's Foreword

One of the emerging paradigms for the future of *micro and nanotechnology* is flexibility. Flexibility means the capability of new fabrication techniques and procedure to be adaptable to different industrial and scientific needs. For the fourth revolution it is required that all processes involved be simple, easy, fast, low-cost, green, versatile, and smart with the aim to give to users a lot of degree of freedom. A number of investments have been done and are currently in progress worldwide to create novel methods to reach the *flexibility*. Priorities in prominent research groups are to find and invent disruptive strategies for obtaining in single or a limited number of steps a desired micro-device. To accomplish that, one should be able to use the matter, especially minute amount of matter, at the desired resolution but at the same time with extreme care to avoid damage. It is not often possible to find in the literature the word "manipulation." Manipulation originates from the Latin word *manus* (i.e., hand) and gives the idea that promises to fulfill the two requirements. Various physical forces can be adopted for manipulating matter but priority is given to forces that can exert the required action on the matter in no-contact and no-invasive modality. With this aim electric forces have good chance to make the right work with a high degree of flexibility.

The idea behind Sara Coppola's thesis was to develop a novel way for manipulating matter. The basic factor is adoption and functionalization of a polar dielectric crystal exhibiting the pyroelectric effect through which the electro-hydrodynamic (EHD) fields can be generated and fully controlled. Starting from this substrate, during her work with the team at Institute of Applied Science and Intelligent Systems (ISASI-CNR) in Pozzuoli, Sara was able to develop and demonstrate many exciting possibilities to exploit the pyro-EHD from 2D self-assembling to a new revolutionary concept for 3D lithography. The pyro-EHD approach has demonstrated to be flexible and adaptable to different situations by handling for many purposes several liquids and polymers. The major remarkable results have been reached by using pyro-EHD, such as polymers self-assembling, printing, and multi jets liquid dispenser, fabricating 3D microstructures for significant application in photonics, high-resolution patterning of biomaterials for

tissue engineering, and fabrication of biodegradable microneedles for drug delivery applications. All the demonstrated applications are *flexible* and have significant advantages over other methods to manipulate the matter. The most important results from Sara Coppola's interdisciplinary work have been published in top-ranked journals such as Nat. Nanotech, PNAS, Adv Funct. Mat., Chem. of Mat., and Lab On A Chip, and all are highly cited. Overall, Sara has contributed to the publication of 30 papers in peer-reviewed journals, two international patents, and more than 30 contributions to international conferences during her thesis work. Furthermore, she was the winner of the Best Poster student presentation at two international conferences (*NanoBioTech-Montreaux* conference at the Frontiers of Micro and Nanotechnology developments for Biological, Chemical and Medical applications, November 18–20, 2013 and *SPIE Photonics Europe Bruxelles,* April 14–17, 2014). Her work was highlighted twice in the SPIE Newsroom 2012 and was selected as the Best in *Optics & Photonics News* 2011 by the Optical Society of America. Furthermore, her thesis was awarded the Best Thesis by IEEE Photonics Society, Italian Chapter in 2014.

On the basis of the above considerations, I can say without doubt that Sara has done excellent work and I am very proud of her. Definitively, I can assert that Sara Coppola's research work has contributed substantially in the development to conceive a completely original "pyro-nano-bio-platform" that can play a role in nano-bio-technologies and that maybe could revolutionize different fields of application in the future.

Pozzuoli
January 2016

Dr. Pietro Ferraro

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Contents

About the Author

Sara Coppola received the degree in Biomedical Engineering with full marks and cum laude from the University of Naples "Federico II," Naples, Italy, on May 21, 2008, and the Ph.D. degree from the Department of Materials Engineering and Production studying alternative methods for processing biomaterials from the same university in 2014. Since 2008 she has been involved as assistant researcher at the CNR and is currently Researcher at the Institute of Applied Sciences and Intelligent Systems ISASI-CNR, in Pozzuoli, Italy. Her research interests include microfluidics and dispensing, manipulation of liquid and high-viscous polymers for electronic, photonic, and biomedical applications. In 2015 she received the IEEE Award "Best Doctoral Thesis in Optoelectronics." She is co-author of more than 30 articles, published by international peer reviewed journals (recognized by ISI Web of Knowledge); she holds 2 patents and has published 3 book chapters.