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XXXVII Cycle

Fabrication and electrical measurements of metallic nanowires based on BCP

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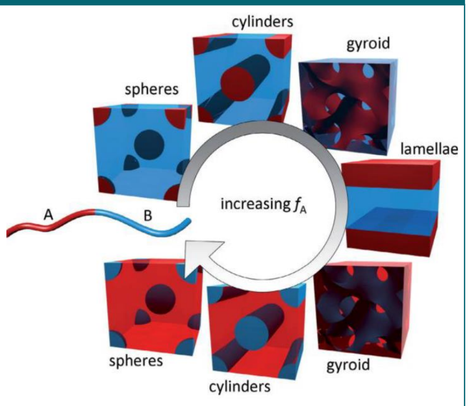
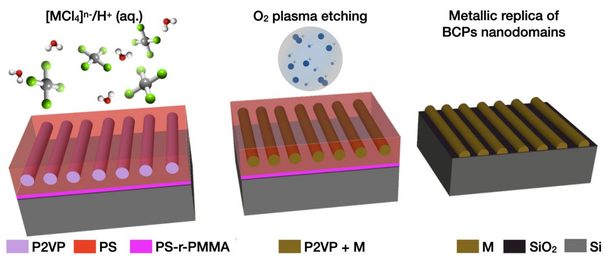
Supervisors: Prof F. Pirri, Dr F. Ferrarese Lupi, Dr N. De Leo

Research context and motivation

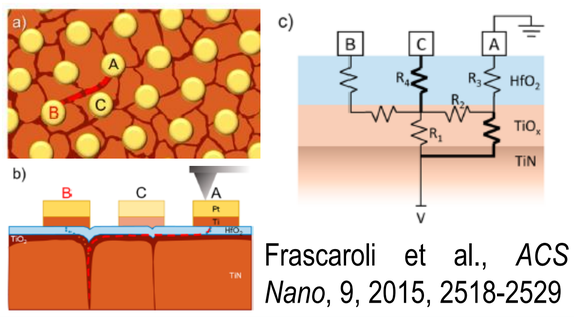
Block Copolymers (BCPs) have gained much interest thanks to their natural tendency to self-assemble into a variety of periodic morphologies at the nanoscale, which can be infiltrated by metallic materials to realise nanometric systems and devices with intriguing optical and electrical properties.





Metal/metal oxide networks at the nanoscale could serve as bio-inspired devices to mimic the neuronal behaviour in the brain, thanks to their memristive functionalities. The great interest into these structures rises from the possibility of reaching high interconnectivity and reducing the power consumption for data processing.

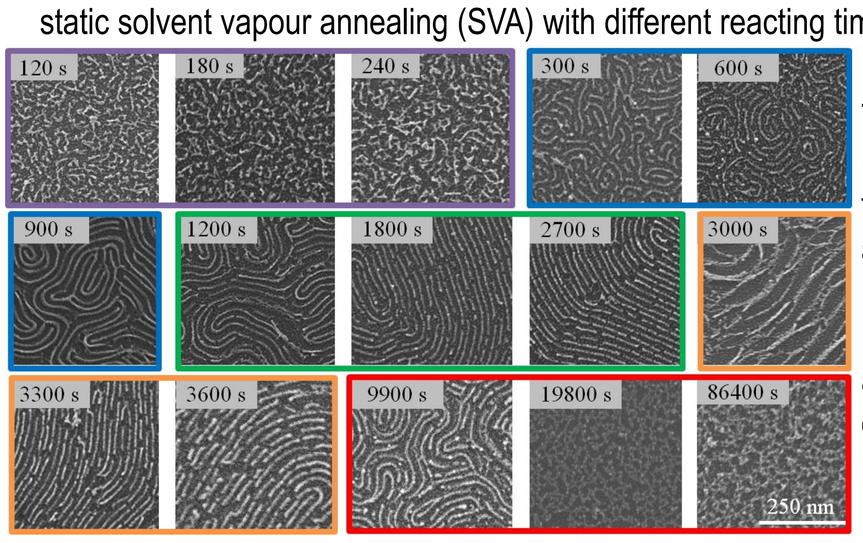
Shaping the BCPs self-assembly through the fabrication parameters and combining it with the conventional lithographic techniques paves the way to the fulfilment of the device miniaturisation imposed by Moore's law.



Frascaroli et al., *ACS Nano*, 9, 2015, 2518-2529

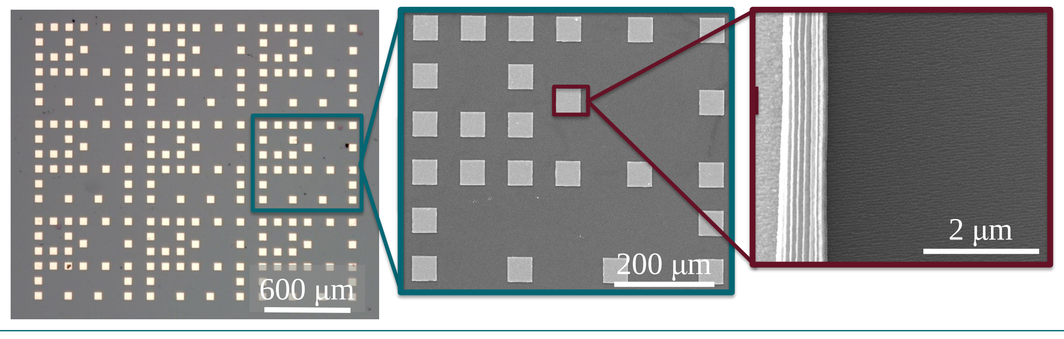
Addressed research questions/problems

- Control of the structural order of lamellae-forming PS-*block*-P2VP BCP, self-assembled by static solvent vapour annealing (SVA) with different reacting times.

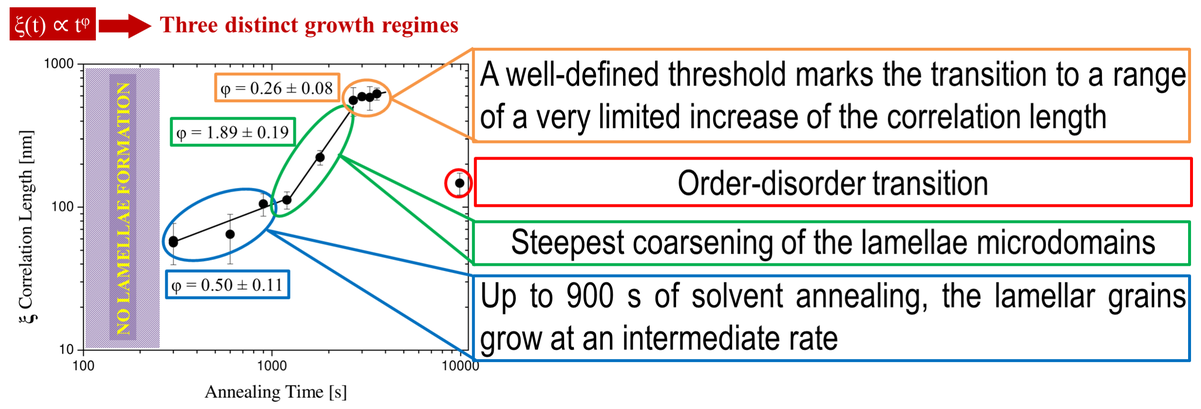


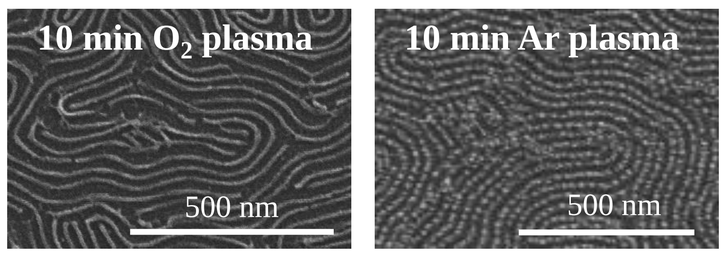
The adopted liquid phase infiltration method and the following metal reduction are key factors in the realisation of the final metallic nanostructures and are being investigated to be optimised for distinct properties and applications.

- Electronic transport properties at the nanoscale, in collaboration with the University of Warsaw (realisation of gold electrodes on Si/SiO2 substrates patterned with Pt nanowires assembled from PS-*block*-P2VP cylinders, aligned *via* laser zone annealing (LZA)).



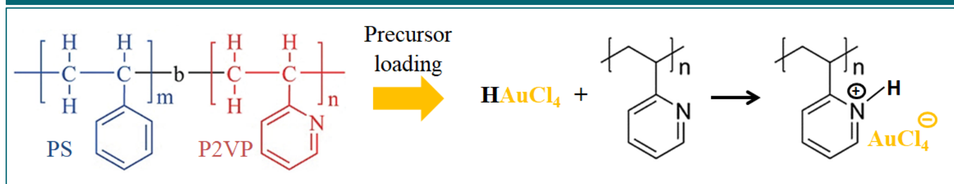
Novel contributions





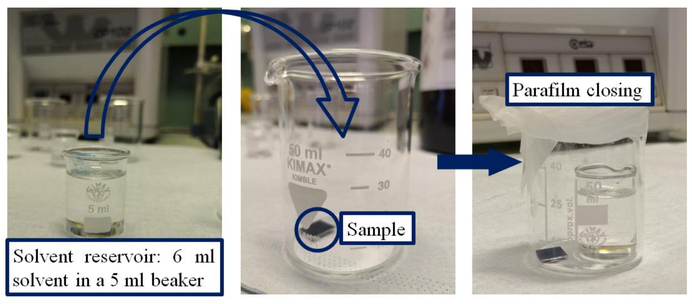
Different plasma gases for the polymer removal/gold reduction step produce different effects on the morphology and the structure of the metallic replica.

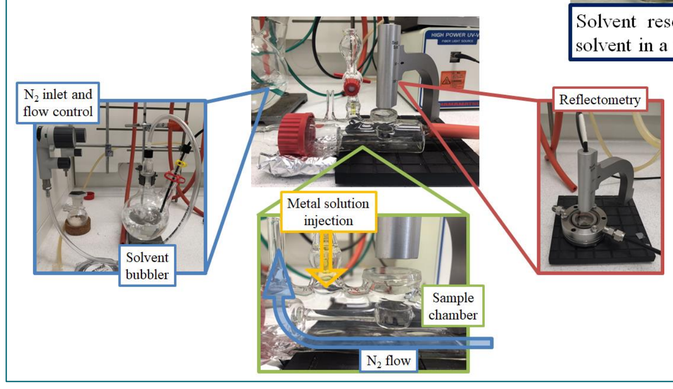
Adopted methodologies



Liquid phase infiltration (LPI)

Static solvent vapour annealing (SVA): the solvent slowly evaporates up to the saturation of the chamber.





Dynamic SVA to control the rate at which the solvent evaporates and block the swollen polymer morphology with the metal infiltration.

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Future work

- Comparison on the ordering transitions by both static and dynamic SVA
- Definition of the control on the order of the lamellae in terms of correlation length depending on the fabrication parameters with different set-ups
- Geometrical characterisation and traceable quantification of the metal deposition after selective infiltration of block copolymer-based substrates
- Electrical measurements of the resistivity/conductivity of metallic nanostructures with different morphologies
- Evaluation of the enhancement factor of plasmonically-active metallic nanostructures

External activities

- EUPOC Conference 2022 (Bertinoro - Italy, 15-19 May 2022) – Poster contribution: Baglieri, N., Murataj, I., Antonioli, D., De Leo, N., Boarino, L., Laus, M., and Ferrarese Lupi, F., *"Liquid phase infiltration of block copolymers self-assembled via static and dynamic solvent vapour annealing"*
- Experimental activity at DISIT – Università del Piemonte Orientale (Alessandria)
- RMG proposal related to the 21GRD01 OpMetBat project for hybrid metrology and SERS measurements with the X-Ray Radiometry group of PTB at BESSY II

Submitted and published works

- Murataj, I., Cara, E., Baglieri, N., Pirri, F., De Leo, N., and Ferrarese Lupi, F., *"Liquid phase infiltration (LPI) of block copolymers (BCPs)"*, Soft Matter - submitted

List of attended classes

- 01DMMKG – Impedance spectroscopy for electrochemical processes (9/2/2022, 20 h)
- 01DMLKG – Introduzione alla microscopia ottica – Scienza e tecnologia (24/3/2022, 20 h)
- 01SFVRV – Metamaterials: theory and multiphysics applications (8/4/2022, 20 h)
- 02SFURV – Programmazione scientifica avanzata in MatLab (21/4/2022, 30 h)
- 01UKGKI – Synthesis methods to tailor the surface and the structure properties of advanced materials (11/5/2022, 25 h)
- 01UNXRV – Thinking out of the box (12/11/2021, 1 h)
- 01UNVRV – Navigating the hiring process: CV, tests, interview (18/11/2021, 2 h)
- 01UNYRV – Personal branding (18/11/2021, 1 h)
- 01SWPRV – Time management (19/11/2021, 2 h)
- 01DOCRV– The Hitchhiker's Guide to the Academic Galaxy (16/6/2022, 20 h)

Total credits: Hard skills 175/200 points; Soft skills 26/40 hours

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