Dimensional and Defectivity Nanometrology of sub-20 nm line arrays prepared by directed self-assembly

C. Simão,[a] W. Khunsin,[a] A. Amann,[b] M. A. Morris[c,d] and C. M. Sotomayor Torres[a,e]

[a] Catalan Institute of Nanoscience and Nanotechnology ICN2, Campus de la UAB, Barcelona 08193, Spain;
[b] School of Mathematics and the Tyndall National Institute, UCC, Cork Ireland;
[c] School of Chemistry and the Tyndall National Institute, UCC, Cork Ireland;
[d] Centre for Research on Adaptive Nanostructures and Nanodevices, TCD, Ireland;
[e] Catalan Institute of Research and Advanced Studies, Barcelona 08010 , Spain;

claudia.simao@icn.cat

One-dimensional nanostructures are a class of elements of key technological importance in many areas including electronics, lithography, self-assembly templates, x-ray gratings, photonic crystals, etc. Directed self-assembly (DSA) of block copolymers (BCP) appears in the ITRS roadmap as a potential bottom-up lithography solution for the 11 nm node. [1] The success of the implementation of block copolymer lithography in industry relies not only on the fabrication but also requires specialized nanometrology tools to control the quality of the fabricated structures.[2] The key for success of a production-compatible nanometrology system is based on an inspection tool which is reliable, applicable to large-areas, inline and robust to assure the quality of the fabricated nanostructures. Our image analysis work on colloidal crystal structures and block copolymers hexagonal patterns, a positive correlation between the "opposite partner" concept and transmission spectroscopy confirmed our method to assess three-dimensional ordering.[3] Here we present an extension of this concept to self-assembled nanowires from BCPs, thus 1D features, with feature sizes below 20 nm. Our method can be used in nanowires samples of phase-separated BCPs as an inline technique.

High □ BCP system polystyrene-*b*-polyethylene oxide (PS-PEO) line patterns on silicon substrates with different surface treatment were analysed with our full operational software. The output, which is time-efficient (< 1 minute), consists of morphology-related statistical data, such as length and number of lines, quantification of defect density and alignment. Defects are identified as dislocations, branching points, lone points and turning points which are depicted in histograms and sorted out statistically according to type. Furthermore, pitch and linewidth variations are estimated.

The morphology analysis, i.e., defect and alignment quantification of linear patterns, makes this method probably unique, while the fast response and simplicity of operation positions this technique as a highly promising nanometrological tool to standardize DSA characterization.

The research leading to these results received funding from the European Union Seventh Framework Program ([FP7/2007-2013] project LAMAND under grant agreement n° [245565]) and by the Spanish Ministry of Economics and Competitiveness under contract no. MAT2012-31392 (Plan Nacional de I + D + I (2008-2011). The contents of this work are the sole responsibility of the authors.

References

1. M. Salaun et al, *J. Mat. Chem. C* 2013, 1, 3544–3550; D. Borah et al, *Eur. Polym. J.* 49 (11), 3512–3521.
2. H.N. Hansen, et al, *CIRP Annals - Manufacturing Technology*, 55 (2006) 721
3. W. Khunsin, et al, *Adv. Funct. Mater.*, 22 (2012) 1812.

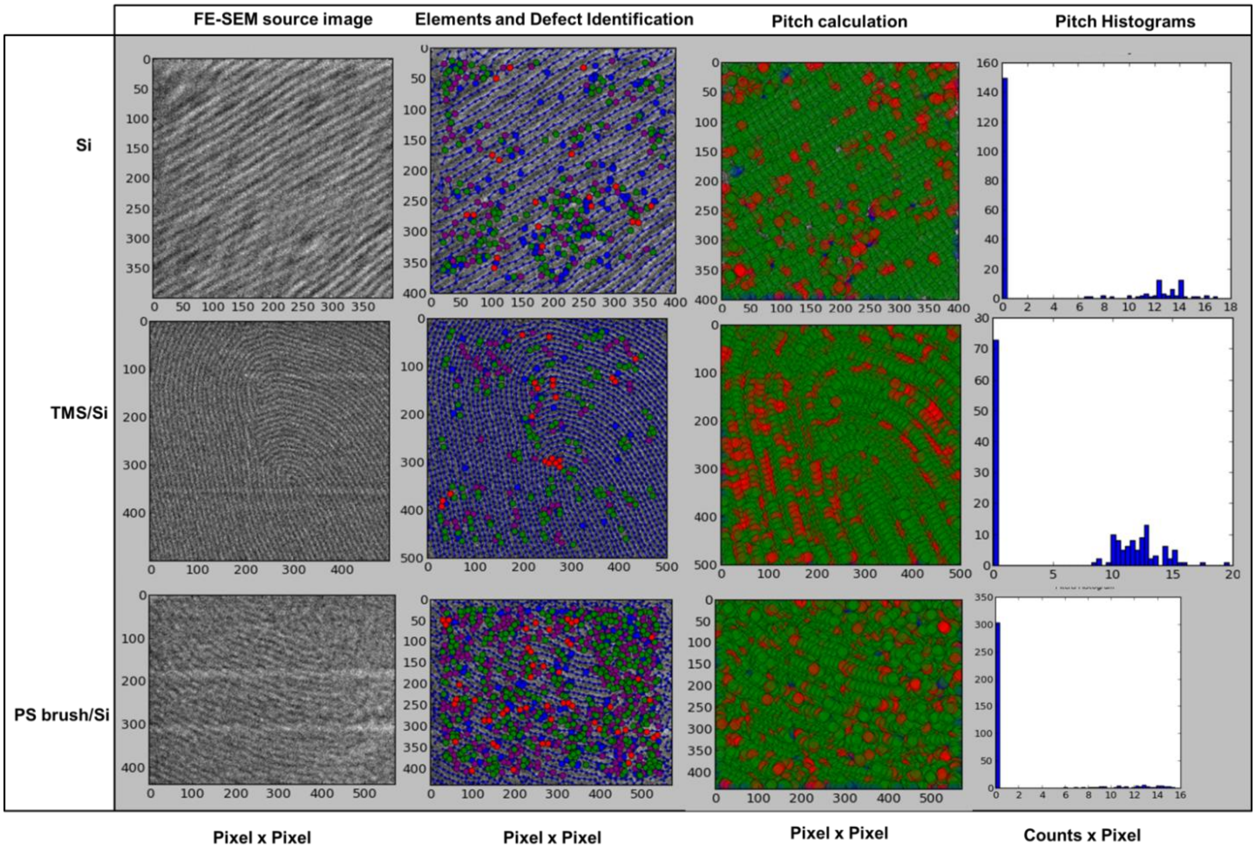

Figure 1. Analysis of PS-b-PEO line patterns on Si substrates subjected to different surface treatment by the pattern analysis software: the source SEM images are used as input and analyzed by identifying elements and defects, pitch calculation and related statistical data.