Nanostructured pattern replication on transparent polycarbonate by plastic injection

Jordi Fraxedas[1], Daniel Ruso[1], Francesc Perez-Murano [2], Carles Colominas [3] and Andrés García-Granada [4]

[1] Institut Catala de Nanociencia i Nanotecnologia (ICN2), Campus UAB (Bellaterra), Barcelona; [2] Instituto de Microelectrónica de Barcelona (IMB-CNM, CSIC), Campus UAB (Bellaterra), Barcelona; [3]FLUBETECH, S. L., Terrassa (Barcelona); [4]IQS-Universitat Ramon Llull, Barcelona

Contact *jfraxedas@cin2.cat*   Website *www.aim4np.eu*

Introduction

Micrometer-sized motifs have been patterned by focused ion beam (FIB) on diamond-like carbon (DLC)-coated stainless steel mould surfaces and replicated to surfaces of polycarbonate (PC) pieces by plastic injection.

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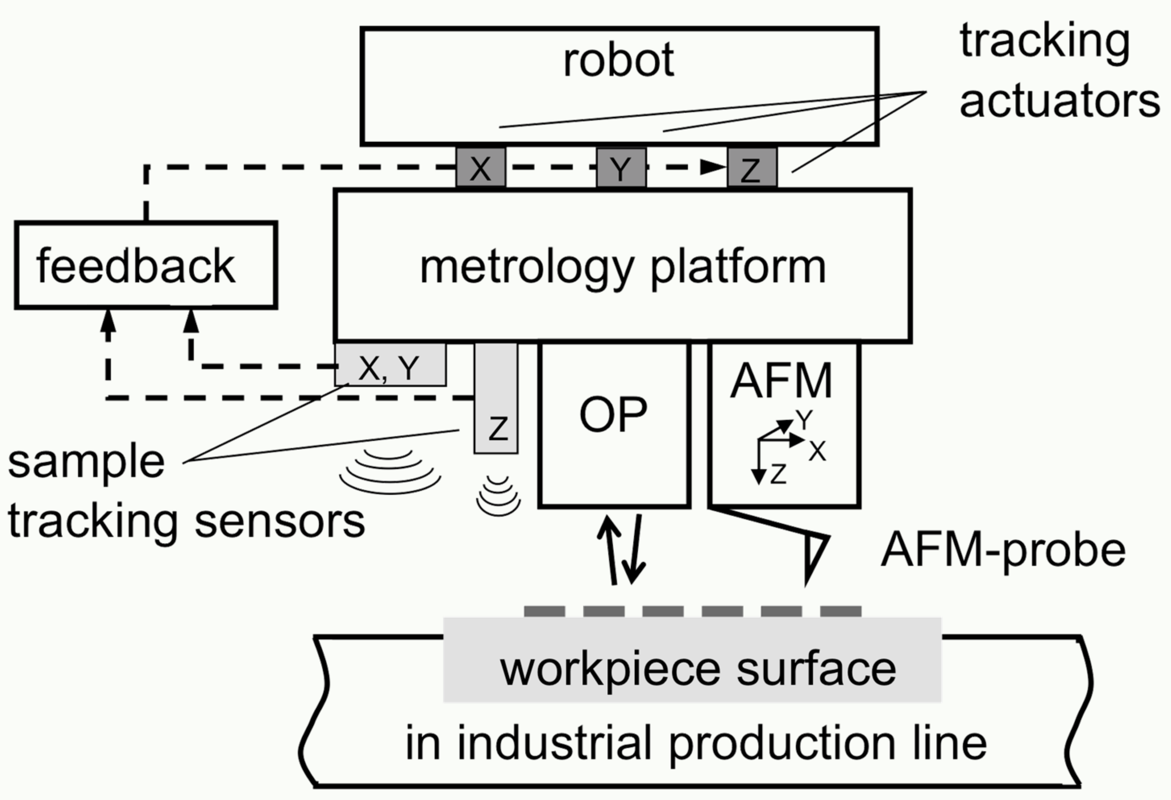
Knowing the mechanical properties of workpieces and machine-tools at the nanometre scale is an absolute necessity for efficient nanoscale production. Current technologies are lacking the flexibility and robustness needed for measuring in a traceable way such key parameters as topography, morphology, roughness, adhesion, or micro- and nano-hardness in a production environment. The project *aim4np* strives at solving this problem for nano-roughness measurements by combining atomic force microscopy and white-light interferometry with novel control techniques from mechatronics and procedures from traceable metrology. The basic concept is to constantly measure and actively stabilize the distance between the surface of the workpiece and the mounting/reference base of the metrology heads, leading to an artificially stiff link between the two parts, which allows measuring the topography of the workpiece with nanometre resolution.



OP: optical probe, AFM: atomic force microscope

Measuring nanomechanical properties in a production environment is challenged by the inherent noise and vibration characteristic for such a setting. The locations of the measurements can be relatively far apart from each other. We address this by using a robot that carries a platform onto which the sensitive metrology tools are mounted. This metrology platform can be locked to the sample surface by means of sensors, actuators and a feedback controller.

Plastic Injection of Polycarbonate

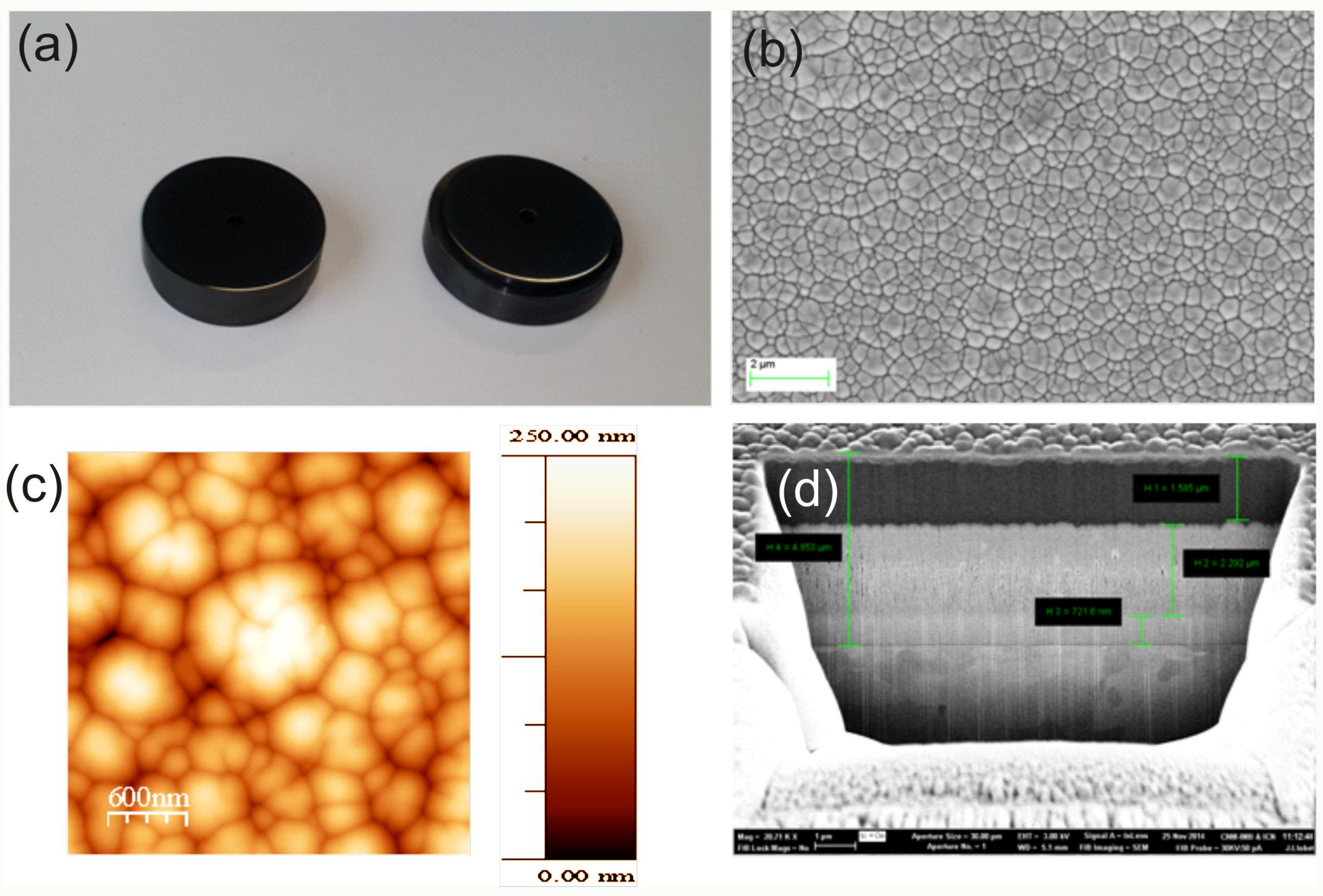


Fig.1. (a) DLC-coated parts of the mould, (b) SEM and (c) AFM images of the surface of the coating and (d) FIB cross section of the DLC coating on a steel mould. The overall coating thickness is 3.1 µm consisting of a gradient Cr-N-C adhesion multilayer and a 1 µm thick amorphous carbon layer with a hydrogen content of ca. 18 %.

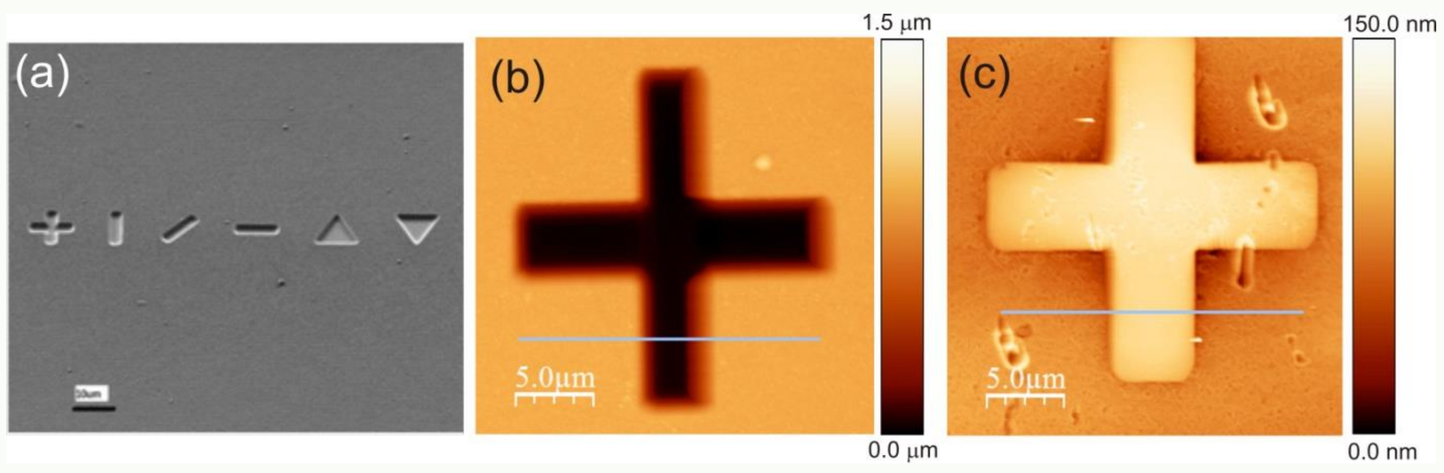


Fig.2. (a) Scanning Electron Microscopy image of the FIB patterns prepared on a DLC-coated mould. The overall coating thickness was 3.1 µm consisting of a gradient Cr-N-C adhesion multilayer and a 1 µm thick amorphous carbon layer with a hydrogen content of ca. 18 %. AFM images of (a) a cross patterned on the mould and (c) the transferred cross to the PC injected piece.

Conclusions

- Plastic Injection is suitable for the patterning of micrometer- and nanometer-sized features
- Surface roughness of injected parts is lower than that of the injection mould under the used experimental conditions

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