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Effect of strain on silica patterned thin films deposited on stainless steel due to an uplift process induced by plasma assisted nitriding

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Below 400 °C, a low temperature nitriding treatment of austenitic stainless steel produces high compressive residual stress induced by the introduction of a large amount of nitrogen. As a result, an expansion of the nitrided layer occurs from the initial surface of substrate in a direction perpendicular to the surface. This phenomenon, which is known as swelling or uplift, can be used for surface patterning or surface texturing. We already use this property to perform surface patterning by a selective diffusion of nitrogen using removable grids or fixed patterned silicon oxide layer as masks [1]. In the last configuration, interesting interactions between expanded austenite and the attached silicon oxide masks with several different shapes (circular and square dots) are observed. The purpose of this communication is to focus on the results gained by atomic force microscopy (AFM) observations on the silicon oxide masks deformed by the uplift effect. Patterned areas are selected and marked to monitor changes in topography over nitriding time. The variations in heights of both the stainless steel substrate and the silicon dots are measured by AFM in between two nitriding experiments. By doing so, we are able to quantitatively measure the local deformation of the silicon dots and to correlate it with the deformation of the surrounding stainless steel substrate. Strong dots distortions are obtained, particularly at the edges of the dots with a larger size. Some explanations will be proposed to justify such behaviour. The role of elastic strain, due to the expanded austenite phase formed by nitrogen diffusion under the mask will be highlighted.
Finally, some perspectives for the uplift effect induced by nitriding will be given in surface shaping and in the determination of the mechanical properties of thin films at micrometer scale.
[1] G. Marcos, S. Guilet, F. Cleymand, T. Thiriet, T. Czerwiec, “Stainless steel patterning by combination of micro-patterning and driven strain produced by plasma assisted nitriding”, Surf. Coat. Technol., 205 (2011) S275–S279.

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