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Modeling the evolution of rough profiles of polymeric substrates during plasma etching: The interaction between surface charging and roughness

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The interaction of plasma with polymeric substrates induces surface roughness on the substrates. In the semiconductor industry, the surface roughness (line edge roughness, LER) of polymeric masks, induced or enhanced during plasma etching process, was and still is an artifact. In other fields, the surface roughness of polymeric substrates may be beneficial for a variety of applications related to the wetting behavior and the interaction of surfaces with cells. Surface charging of rough polymeric substrates is inevitable during plasma etching as all prerequisites are present: The directionality difference of positive ions and electrons impinging on the etched surface, the dielectric property of the substrates allowing charge accumulation, and finally the surface morphology, facilitating the local imbalance of positive and negative charges. Towards the understanding and, ultimately, the manipulation of plasma-induced surface roughness, the interplay between surface charging and microscale surface roughness of polymeric substrates is investigated by a modeling framework consisting of a surface charging module [1], a surface etching model, and a profile evolution module [2]. The evolution of initially rough profiles during plasma etching reveals, on the one hand, that the charging contributes to the suppression of roughness and, on the other hand, that the decrease of the roughness induces a decrease of the charging potential. The effect of charging on roughness is intense when the etching yield depends solely on the ion energy and it is mitigated, when the etching yield additionally depends on the angle of ion incidence. The effects of ion reflection and secondary electron emission on the evolution of rough profiles are also investigated. [1] G. Memos and G. Kokkoris, Plasma Processes Polym. 13, 565 (2016). [2] G. Kokkoris, A. Tserepi, A. G. Boudouvis, and E. Gogolides, J. Vac. Sci. Technol. A 22, 1896 (2004).

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