Polymer Molecular Weight Governs Feature Size During Tip-Based Fabrication of Polymer Nanostructures

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Tip-based nanofabrication (TBN) can produce polymer nanostructures smaller than 100 nm[1]. These polymers can have electrical or chemical functionality[1,2], or can be used as a masking layer for further nanofabrication[3]. While there has been a number of publications that describe the applications of TBN polymer nanostructures, only a few publications investigate the underlying physics of polymer TBN and how these physics govern the speed and resolution at which polymer nanostructures can be fabricated[4].

Here, we investigate polymer deposition from a heated atomic force microscope (AFM) cantilever tip, and in particular we investigate how polymer molecular weight affects the feature size of the polymer nanostructures. The polymer is poly methyl methacrylate (PMMA) of molecular weight (MW) either 15 kg/mol or 75 kg/mol. The 15 kg/mol PMMA is near the threshold for polymer entanglement, while the 75 kg/mol PMMA is well above the entanglement threshold. We achieved fabrication of highly uniform polymer nanostructures for the high MW polymer, while the lower MW polymer produced somewhat less even nanostructures. The high MW polymer produced polymer nanostructures narrower and taller than the low MW nanostructures, with the smallest nanostructures as small as 50 nm. The polymer flow and resulting nanostructures can be understood using appropriate rheological models. The ultimate goal of this work is to understand the relationship between polymer properties and the nanostructures that can be fabricated.

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