Control of plasma-surface interactions is essential for successful application of low temperature plasmas to materials processing. We briefly review three examples of recent from our laboratory: First, formation of an ultrathin (~1nm) delaminated graphitic layer by two-step plasma processing of methacrylate-based polymer that utilizes the interaction of VUV photons and ion bombardment in low pressure plasmas with the polymer. Second, use of low pressure plasma surface interaction mechanisms aimed at achieving atomic precision in etching materials in the semiconductor industry. We show that by employing steady-state Ar plasma in conjunction with periodic injection of a defined number of C₄F₈ molecules and synchronized plasma-based Ar⁺ ion bombardment 1/10 of a nanometer precision in etching of SiO₂ is possible. This is due to the temporal variation of the chemically enhanced etch rate of SiO₂ for Ar⁺ ion energies below 30 eV as a function of fluorocarbon surface coverage. Third, studies of plasma-surface interactions related to application of a non-equilibrium atmospheric pressure plasma jet (APPJ) for modification of model polymers and biomolecules will also be discussed. Measurements of the changes in surface chemistry and biological activity of biomolecules exposed to the APPJ plume/effluent in a controlled environment clarify how jet chemistry and interaction of plasma with the environment impact the consequences of APPJ-biomaterial-surface interactions.

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