Plasma-AssistedAtomic Layer Deposition of SiN_x

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The shrinking device dimensions in integratedcircuits combined with the introduction of 3-D device architectures has createda need for novel atomic layer deposition (ALD) processes for a variety ofmaterials including Si-based dielectrics such as SiN_x .Development of new ALD techniques that can meet the demands for semiconductormanufacturing requires an atomistic level understanding of the surface reactionprocesses. In our lab, we have pioneered the use of *in situ* opticaldiagnostic techniques including highly surface sensitive attenuated totalreflection Fourier transform infrared spectroscopy and multi-wavelengthellipsometry to study the surface processes that occur during ALD.

In this presentation, I will discuss thelow-temperature plasma-assisted ALD of SiN_x films where oneof the key challenges has been to grow conformal films in high-aspect-rationanostructures such that the sidewall structure and composition is the same asthe top surface. I will discuss the surface reactions that occur during ALD ofSiN_x using chlorosilanes and aminosilanes as the Siprecursors with an NH_3 and N_2 plasma, respectively, asthe nitrogen source. The NH_3-plasma based processes show >95%conformality, but the wet-etch rate in dilute HF is much higher for thesidewalls compared to the planar surface. While N_2 plasma basedprocesses show a low wet-etch rate for both the sidewalls and the planarsurface, the conformality is ~50%. Based on these observations, we havedeveloped a new three-step ALD process for SiN_x growth usingSi_2Cl_6 followed by CH_3NH_2, and thenan N_2 plasma. I will show that in this three-step ALD processbecause nitrogen is supplied to the surface partially in a thermal stepfollowed by an N_2 plasma, the films are more conformal with asidewall wet etch rate that is intermediate between NH_3 and N_2plasma based ALD processes.

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