Ultrathin Silicon Oxynitride Gate Dielectrics Scaling

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Ultrathin silicon nitride and oxynitride films are becoming increasingly important in the semiconductor industry [1,2]. These films find applications for use in gate dielectric stacks, polysilicon sidewall spacers and diffusion barriers for logic and memory devices. Oxynitride films are currently employed as a gate dielectric, a key element of MOSFETs in VLSI devices. As the physical thickness of gate dielectrics shrinks below 2 nm, a number of fundamental issues (such as tunneling currents, reliability, etc.) arise and these issues will be discussed in the presentation.

Then we will focus on processing aspects and electrical properties of ultrathin oxynitride films on Si. Specifically we will compare the growth kinetics, nitrogen composition and profile, morphology and electrical characteristics of silicon nitrides and oxy-nitrides prepared by several techniques. These techniques include rapid thermal (RT) processes such as N_2O [3], NO, $NO+O_2$, and NH_3 (oxy)nitridations as well as ultra-thin LPCVD and RTCVD and nitride and oxy-nitride deposition processes and films deposited by plasma-assisted methods. The following measurement techniques [4] were used to characterize these films: ellipsometry, nuclear reaction analysis (NRA), medium energy ion scattering (MEIS), atomic force microscopy (AFM) and C-V and I-V electrical characterization of poly-Si gated devices. With a thorough understanding of the growth behavior, and material properties of ultra-thin silicon (oxy)nitride films grown by different techniques, we can tailor the film thickness, nitrogen concentration and profile to optimize the materials diffusion barrier and electrical properties for desired applications. Finally, scaling trends will be discussed.

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