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Deposition and characterization of Ti-Al-N thin films deposited by plasma-assisted atomic layer deposition

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In modern ferroelectric device fabrication, diffusion barrier layers are used to inhibit oxygen transport between polysilicon and dielectric materials during subsequent high temperature processing steps.[1] Barrier layers are required to have high electrical conductivity, low contact resistance, high chemical and thermal stability, and to provide good adhesion with adjacent layers. Among diffusion barrier layers, $Ti_{1-x}Al_xN$ system exhibits high thermal stability with no evidence of phase decomposition following 1 h annealing at temperatures as high as 900℃.[2] In this experiment, we present O_2 barrier properties of Ti-Al-N films deposited by atomic layer deposition (ALD) technique.

Ti-Al-N films were synthesized from tetrakisdimethylamino-titanium (TDMAT, $Ti[N(CH_3)_2]_4$), NH_3, and trimethylaluminum (TMA, $Al_2(CH_3)_6$) at 180℃ using a hydrogen plasma. The hydrogen plasma was used as a reducing agent for TMA and to improve film quality. One cycle of Ti-Al-N deposition consisted of TiN and Al steps, and the Ti-Al-N cycles were then repeated until the desired thickness was obtained. The growth rate was saturated at 0.35 nm/cycle, which made it easy to control the film thickness concisely. Ti-Al-N films had excellent surface morphology and good step coverage on a patterned structure, which resulted from the self-limiting surface reactions. Ti-Al-N films are polycrystalline with a hexagonal $Ti_3Al_2N_2$ structure and good oxidation resistance when O_2 annealed at 700℃ from 30 min.

[References]

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Al/$Ti_{1-x}Al_xN$ (0<x<0.2) model diffusion-barrier structure" J. Vac. Sci. Technol. A, 11, 11 (1993).

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