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In situ stress evolution during reactive and unreactive magnetron sputtering of polycrystalline metal thin films

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Intrinsic stress during polycrystalline growth of metal thin films has been the subject of intense research in the last years, especially with the implementation of atomic-scale sensitive multiple beam optical stress sensor (MOSS) technique. If the case of Volmer-Weber growth of high mobility metals like Ag or Al has been largely investigated, mainly during thermal evaporation, the case of low-mobility materials like transition metal (Ti, Ta, Zr, Mo or W) remains largely unexplored. In particular, no systematic study has been reported during magetron sputtering, where the contribution of the more energetic incoming particles may significantly alter the elementary growth processes.

We present here some results on the stress evolution of various metals grown by magnetron sputtering, either in pure Ar plasma discharge (unreactive mode) or in mixed $Ar+N_2$ plasma discharges (reactive mode), using a MOSS wafer curvature technique. For the case of Mo films grown on Si susbrate, importance of interfacial effects and phase transformation on the tensile stress evolution in the early growth stages will be demonstrated [1]. Similar evolutions are also found for W, while for Ta, Zr or Ti a steady-state compressive stress is observed. Variation in the growth rate and working pressure was used to understand the origin of the compressive stress.

For Ti films, stress will be compared in reactive and unreactive modes. For pure Ti films, we will show that the MOSS technique can be used to probe adsorption of reactive gases like O_2 or N_2. For TiN films, stress gradients are revealed with increasing thickness, as the result of two competing contributions: atomic peening induced compressive stress and intercolumnar attractive forces inducing tensile stress [2]. Examples will be also given for alloy films during co-sputtering.

[1] A. Fillon, G. Abadias, A. Michel, C. Jaouen, P. Villechaise, submitted to Phys. Rev. Lett.

[2] G. Abadias, Ph. Guerin, Appl. Phys. Lett., 93, 111908 (2008)

Keywords

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