A-8

Determination of thickness and optical properties of fluorocarbon *thin film on aluminum by a variable angle spectroscopic* ellipsometry

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Introduction

Teflon-like organic thin films are the subject of great interest from a practical point of view due to their utility in numerous applications. These materials impart unique properties to the surfaces on which they are coated. For example, the diffusion of vapors can be controlled, surface energy lowered, and improvements made in the friction and wear properties of the interface by molecularly thin Teflon-like organic thin films. In this study, the ellipsometric parameters Ψ and Δ, which depend on both the thickness and the optical properties of the fluorocarbon film, were measured using a variable angle spectroscopic ellipsometry in the photon energy from 1.55eV to 4.13eV. The thickness and optical properties of fluorocarbon thin film on aluminum were determined, also, by a variable angle spectroscopic ellipsometry. Lorentz oscillator model was used to characterize the thickness and the optical properties because it is powerful in modeling unknown materials. The optical properties of Teflon were analyzed as a reference.

Experimental

Aluminum coated wafers were cut into 13 mm × 19 mm. Samples were activated in a solution mixture of 73% H_3PO_4, 4% HNO_3, 3.5% CH_3COOH, and 19.5% DI water. After the wet etching, wafers were rinsed in DI water and dried with N_2. Teflon was cleaned in a pure acetone and rinsed in DI water. FC722 (solute, 98% C_6F_{14} with 2 % proprietary fluoropolymer) and FC40 (solvent, $C_{12}F_{20}$) were provided by 3M Co. as source liquids for the deposition of fluorocarbon films. FC chemicals were vapor phase (VP) deposited on the surface of aluminum coated wafer. For the VP deposition, 1000 μl of 1:5 mixture of FC chemicals was placed in a vacuum oven. The temperatures of substrates and chemicals were set at the same temperature. Data of thickness and optical properties were acquired using a J.A. Woollam Company VASE ellipsometer using a white light of photon energy from 1.55eV to 4.13eV and an incident angle of 70°. Optical modeling and data analysis were done using a Woollam Company WVASE32™ software package.

Results

The thickness of the fluorocarbon thin film using Lorentz oscillator model was 41.14±0.472nm with 3.72 MSE(Mean Square Error) value in 90% confidence limits. The optical properties such as refractive index and extinction coefficient of the fluorocarbon thin film were also determined; refractive index was changed from 1.22 to 1.43 and extinction coefficient was changed from 0.13 to 0.28 as the photon energy. A good correlation of the optical data was observed between fluorocarbon thin films and Teflon. The thickness was reciprocally related to the optical properties in this analysis as expected from the theory. It was shown that the differences between the thin film and the bulk material in the lower photon energy region. However, there was a good correlation between the thin film and the bulk material in the higher energy region.

References

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