



Thermomechanical properties of thin organosilicate glass films treated with ultraviolet-assisted cure

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Abstract

Ultraviolet (UV)-assisted cure has recently been reported as an efficient method to enhance the mechanical properties of organosilicate glasses (OSG) at the expense of only minor film densification. In this work we show that, depending on the OSG material, the effect of UV-cure on fracture and thermal conductivity properties can vary to a large extent even through the same extent of stiffness enhancement is obtained. When the increase of elastic modulus is mostly due to the rearrangement of the silica matrix into more stable silica bonds, the film cohesion strength and thermal conductivity are also improved. Conversely, these properties remain unaffected when the dominant UV-cure mechanism is the increase of matrix connectivity. In the latter case, film adhesion is enhanced. The dominant UV-cure mechanism depends on the initial degree of cross-linking and on the mobility of the OSG matrix.
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1. Introduction

Organosilicate glasses (OSGs), also known as C-doped oxides (SiOC:H), are lower density materials than SiO₂ since the silica backbone is interrupted by –CH₃ functional groups, making the matrix less dense (and lowering connectivity). Because of the lower density and also thanks to the lower polarizability of Si–CH₃ bonds as compared with Si–O [1], OSG films have a significantly lower dielectric constant than SiO₂. The need for on-chip interconnects structures with extremely low dielectric constant (approach-

ing 2.0 and below) has prompted the synthesis of OSG films with substantial degrees of porosity. The drastic reduction in film density is very effective in reducing film permittivity [2], whereas thermal and mechanical properties of such dielectric materials tend to degrade as density decreases. The film elastic modulus E is expected to decrease when film density ρ is reduced with a power law [3], where C is a constant that can be approximated to 1 in most cases, and the exponent n is expected to vary between 1 and 3 [4]:

$$E/E_m = C(\rho/\rho_m)^n \quad (1)$$

Cohesive film strength is also expected to drastically decrease with decreasing mass and thus bond density. In a similar way, the thermal conductivity λ tends to decrease

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