

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

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Received 28 July 2006; received in revised form 27 September 2006; accepted 18 October 2006

Available online 13 December 2006

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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Keywords: UV-curing; Organosilicate glasses; Elastic behaviour; Fracture; Thermal conductivity

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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From Theory to Practice in Multi-Agent Systems Barbara Dunin-Keplicz, Edward Nawarecki, 2003-08-03 This volume contains the papers selected for presentation at CEEMAS 2001 The workshop was the fourth in a series of international conferences devoted to autonomous agents and multi agent systems organized in Central Eastern Europe Its predecessors were CEEMAS 99 and DAIMAS 97 which took place in St Petersburg Russia as well as DIMAS 95 which took place in Cracow Poland Organizers of all these events made efforts to make them wide open to participants from all over the world This would have been impossible without some help from friendly centers in the Czech Republic England France Japan and The Netherlands DIMAS 95 featured papers from 15 countries while CEEMAS 99 from 18 countries A total of 61 papers were submitted to CEEMAS 2001 from 17 countries Out of these papers 31 were selected for regular presentation while 14 were qualified as posters The motto of the meeting was Diversity is the core of multi agent systems This variety of subjects was clearly visible in the CEEMAS 2001 program addressing the following major areas of multi agent systems Organizations and social aspects of multi agent systems Agent and multi agent system architectures models and formalisms Communication languages protocols and negotiation Applications of multi agent systems Agent and multi agent development tools Theoretical foundations of Distributed AI Learning in multi agent systems The richness of workshop subjects was ensured thanks to the CEEMAS 2001 contributing authors as well as the keynote speakers

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