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Sol-Gel-Derived Hard Coating on Polymeric Substrate:

The Effect of Chemical Composition

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The many attractive properties of plastics such as light weight, formability, high impact strength, and ductility have allowed them to be widely used in many optical applications. However, plastics have poor abrasion resistance, allowing them to be readily scratched. This leads to decreased optical transparency. However, this shortcoming can be alleviated by depositing a hard film on the plastic. Ceramic oxide films derived by sol-gel processing is a low-cost means of attaining such a protective coating. Furthermore, this method offers easy manipulation of chemical compositions leading to a variety of different coatings.

Silicon oxide films with thicknesses less then 200 nm were deposited on plasma enhanced polyester substrates. Nanoindentation using the Hysitron TriboScope® was employed to characterize the mechanical properties of these films.

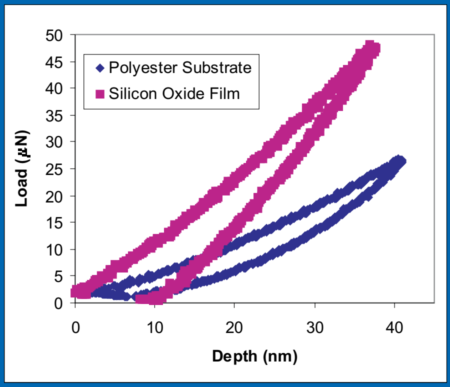

Figure 1: Example of indentation curves for sol-gel derived silica film and polyester substrate. The film exhibits a 3-fold increase in hardness and elastic modulus over the substrate, as measured by the Hysitron TriboScope®.

Example

When 150 nm thick sol-gel-derived silica films are deposited on polyester substrates, a significant improvement in mechanical properties over the uncoated substrate is observed. The hardness and elastic modulus were characterized at a contact depth of 20 nm using the Hysitron TriboScope®. As shown by the indentation curves in Figure 1, the sol-gel-derived silica film is clearly harder than the polyester substrate. On average, the silica film has a hardness of 1.45±0.08 GPa and an elastic modulus, of 14.2±0.3 GPa (corrected for substrate effect). Comparing to a hardness of 0.53±0.02 GPa exhibited by the substrate, the increase in the sol-gel-derived film is almost three-fold.

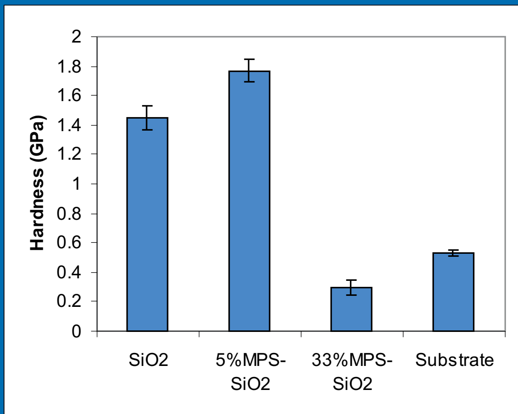

Figure 2: Effect of MPS addition on the hardness of sol-gel-derived silica films.

The effect of incorporating 3-methacryloxy-propyl-trimethoxysilane (MPS) in the silica sol is also investigated. By adding the correct amount, it is believed that the MPS would promote film densification by collapsing the sol-gel network, hence improving the mechanical properties of the film. Nanoindentation measurements by the Hysitron TriboScope® at a contact depth of 20 nm reveal that there is an improvement in both hardness and elastic modulus with a 5% MPS addition, as shown in Figures 2 and 3. This improvement is due to a denser film brought about by the addition of MPS. However, with a 33% addition, the mechanical properties of the film are dramatically decreased. This softening effect is due to too much organic replacing the silica in the resultant network leading to a more polymer-like film.

Conclusion:

As measured by the Hysitron TriboScope®, sol-gel-derived silica films increase the surface hardness and stiffness by as much as three-fold over the polyester substrate. These mechanical properties are further improved by the addition of 5%MPS.

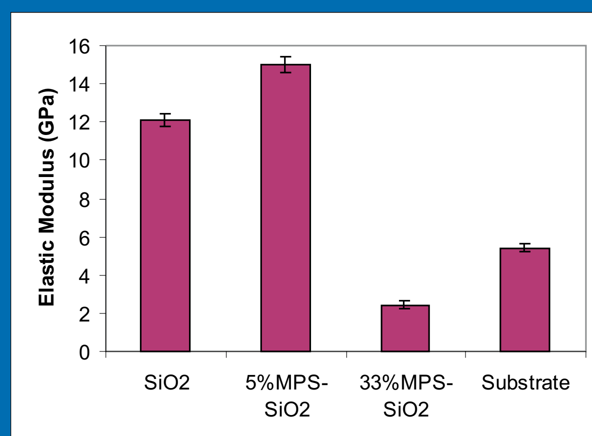

Figure 3: Effect of MPS addition on the elastic modulus (substrate corrected) of sol-gel derived silica films.

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