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Ho, Caroline and Dehoux, Anita and Alexis, Joël and Lacroix, Loïc and Dalverny, Olivier and Châtel, Sébastien and Faure, Bruce Understanding mechanisms of adhesion of SiO2 thin films evaporated on a polymeric substrate. (2016) In: 43th International Conference on Metallurgical Coatings and Thin Films (ICMCTF), 25 April 2016 - 29 April 2016 (San Diego, United States). (Unpublished)

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Understanding Mechanisms of Adhesion of SiO₂ Thin Film Deposited on a Polymeric Substrate

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Abstract: A better understanding of mechanisms of adhesion between a 200 nm thick silicon dioxide layer and a 4.5 µm thick polymeric hardcoat is indispensable for an efficient adhesion at the interface. To reach this purpose, focus is placed on two axes: finding an applicable and effective method to quantify adhesion and in parallel, characterizing mechanical properties of materials composing the system. The second axis is needed to obtain data to feed modeling codes, enabling a better analysis of the adhesion experiment. Modulus of modified SiO₂ was found to be roughly 20% higher than reference SiO₂, by nanoindentation. AFM experiments showed no difference between modified and reference SiO₂. Currently, an investigation to detect cracks at the interface of interest for micro-tensile test is ongoing. Adhesion tests, such as micro-compression will be performed as well.

Context

To improve wearers’ experience, ophthalmic lenses made of plastic polymeric substrates are coated with functional treatments, bringing anti-scratch and anti-reflective properties. These treatments are composed of 5 to 15 layers, ranging from micrometers to nanometers.

First Results

Micro-tensile test

To anticipate and prevent delamination, understanding mechanisms of adhesion between Hardcoat and Anti-Reflective Stack is crucial. First micro-tensile experiments suggest that most noticeable cracks are located at the hardcoat/substrate interface. This was determined by EDS on fractured areas, after tensile stress.

Modulus of modified SiO₂ was found to be roughly 20% higher than reference SiO₂, by nanoindentation. Considering the high standard deviation of moduli measured by AFM, no significant difference between moduli of modified and reference SiO₂ was observed by AFM. However, an important difference between moduli of SiO₂ on lens and on Si wafer was observed. This exposes unexpected influence of substrate on mechanical measurements using AFM, which has been hypothetically attributed to impact of Peak Force high frequency oscillations on viscoelastic substrates. Currently, an investigation to detect cracks at the interface of interest after micro-tensile test is ongoing. Other adhesion tests, such as micro-compression will be performed as well.

Methodology

Adhesion between SiO₂ layer and HardCoat

Evaluating Practical Adhesion

Characterization of Bulk Mechanical Properties of Constituents Composing the System

Nano-indentation

AFM

Modulus of SiO₂ by Nanoindentation

Conclusion and prospects

First micro-tensile experiments suggest that most noticeable cracks are located at the hardcoat/substrate interface. This was determined by EDS on fractured areas, after tensile stress. Modulus of modified SiO₂ was found to be roughly 20% higher than reference SiO₂, by nanoindentation. Considering the high standard deviation of moduli measured by AFM, no significant difference between moduli of modified and reference SiO₂ was observed by AFM. However, an important difference between moduli of SiO₂ on lens and on Si wafer was observed. This exposes unexpected influence of substrate on mechanical measurements using AFM, which has been hypothetically attributed to impact of Peak Force high frequency oscillations on viscoelastic substrates. Currently, an investigation to detect cracks at the interface of interest after micro-tensile test is ongoing. Other adhesion tests, such as micro-compression will be performed as well.