Enhancement of glass surface quality by sol-gel coatings

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Abstract:

Sol-gel techniques have long been used for the wet chemical processing of glasses, ceramics and organic-inorganic compounds. It is a low temperature processing with high homogeneity and purity, eco-friendly balance of low energy consumption and minimized air pollution, and the facility of precise control of complex chemical composition and physical structure. Ready preparation of thin films and coatings, nano-crystalline powders and hybrid materials as well as the availability of good optical qualities are advantageous for the development of novel functional materials by sol-gel processing. On glass substrates the most widespread commercial uses are in architecture, construction and solar power of reflective, coloured and AR coatings, partially with water repellent or hydrophilic surfaces.
The quality of commercialized sol-gel products, e.g. meeting the required optical and mechanical specifications depends besides control of designed deposition and curing processes on the quality of the glass surface. Surface quality of glass substrates is regularly addressed in terms of cleaning to ensure wettability of the coating solution and grafting to exposed silanol groups during the polymerization process.
The aim of the presentation is to illustrate effects of composition, curvature, roughness and flaws of glass surfaces with respect to the performance and protective character of the coating. In particular, examples and problems are highlighted to motivate discussion and to improve understanding of surface properties such as adhesion, homogeneity and mechanical resistance. For example adhesion of thin oxide films often depend on the mobility of network modifying cations in the near surface range (< 100 nm), while in case of TCO this mobility will decrease the materials conductivity substantially. Depending on the size ratio of surface flaws to coating thickness counteracting effects on product quality are evident. Large flaws can grow to visible defects decreasing productivity while small ones are covered by the coating increasing optical quality and mechanical resistance.
In view of 2025 concepts on mechanical protection and strength enhancement of glasses could include active coatings, i.e. self-healing of cracks by local release of organic molecules and controlling pH in the stress corrosion regime from sol-gel derived hybrid coatings.

Questions to be answered:

1.) What will be a topic stating an exceptional success to be published in a well known high ranking Research Journal in 2025 concerning your presented R&D field of work? Please think in headlines.

“Self-healing sol-gel coatings for glass surfaces”

2.) Please name up to 10 future key challenges (till 2025) regarding your presented field of expertise and indicate please the specific year when you expect the topic to become a real bottleneck for the future developments.

2012 Understanding of surface properties on layer formation

2015 Insights in stress-corrosion on the nano-scale

2018 Control of stress-corrosion kinetics on the nano-scale

2021 Implementation of the controlling parameters of crack propagation in glasses by sol-gel coats

2025 Development of active coats for healing cracks on glass surfaces

3.) Concerning the topics, what would be

a) the key breakthrough and when is it likely to occur

b) what must happen concerning the research field if this topic will never be successful

a) “Active” coating materials with self-healing properties for glass surfaces by sol-gel technology. Localized reactions in the film/glass interface induced by stress corrosion.

b) Improvement of surface quality by “passive” protective coatings