

## Lifetime statistics and durability under environment

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### **Abstract:**

The common strength related material parameters rupture strength, fracture toughness, or something like a yield limit are much less important for glasses and glass ceramics than for ductile materials. The strength of glassy-like articles is chiefly determined by the density and depth statistics of surface flaws and depend on the surface treatment (polishing, etching..., bulk flaws play no role for high quality glasses and glass ceramics). "Strength" is an instantaneous quantity: It accounts for the momentary stresses on current flaws. "Lifetime and durability", on the other hand, mean the delayed rupture of an article within time. Hence we must consider the stress in the past, the growth of flaws, and the generation of new flaws during the lifecycle of articles. Thus, the "actual strength" (e.g. the rupture stress at late time) can be much lower than the stress an article has already sustained in the past.

Essentially the lifetime and durability of brittle articles are statistical issues, described by statistical distributions with at least the mean lifetime and the scatter of lifetimes as parameters. Such statistical parameters depend on the "load and treatment history" of specimens - in particular at the customer respectively the user! Thus for reliable lifetime statistics we need at least information about:

- The initial strength (flaw statistics of articles at the time of shipment).
- The crack growth mechanisms in various environments.
- Some description about the handling of the articles by customers/users.

This presentation focuses on some methods for obeying such information, namely:

- The statistical assessment of field observations.
- Concepts for accelerated and highly accelerated lifetime testing.
- Mathematical modeling the load and damage accumulation.

### 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.**

- Improvement of the reliability of glass ceramic articles by appropriate surface treatment (e.g. HF-etching).

**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.**

- 2009...2012: Improving methods for the separation of failure causes by statistical analyses of fracture data ("multimodal fracture").
- 2010...2015: Development of models for taking into account the healing of surface defects due to ageing.
- 2015: Understanding the influence of the surface composition and topography on the initiation of surface flaws

**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**

Durability: Improvement and implementation of new techniques for glass surface conditioning. Development of new glasses.