# Local probe investigation of glasses

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**Abstract:**

Due to the high homogeneity of glass down to the nanometer, fine aspects of glass chemistry and mechanical behaviour are strongly dependant on mechanisms occurring at this scale. Years of debate on stress-corrosion of glass have especially shown that slow crack propagation could not be fully understood without focused investigations of the vitreous material around the crack tip. This sub-micron area sustains high stresses which are likely to enhance chemical action such as corrosion or dissolution, and diffusion of water and ions.
In spite of great developments in the local measurement of physical properties during the last ten years, reaching useful information at the nanometric scale in disordered material is still a challenging task. Scanning probes technique and especially atomic force microscopy (AFM) are nevertheless promising to tackle the issue. The recent development at the LCVN in Montpellier of AFM in-situ observation of crack propagation in DCDC glass specimens has shed light on the space and time scales of occurrence of these phenomena. Recent observations suggested the presence of a non linear process zone in glass [1,2] still under debate [3]; the sodium diffusion was evidenced at the moving crack tip in a sodalime glass [4] and the presence of a liquid condensate inside the crack cavity was evidenced by phase imaging techniques [5]. In this talk, the technique will be shown to be a most handy tool:

- to study purely mechanical behaviour such as crack propagation velocity, displacement field around the crack tip, roughness of surface crack through accurate topographical 3D data
- to observe crack and stress-induced phenomenon such as water condensation and ion diffusion thanks to surface tip interactions and phase imaging.

Potential use of the techniques for characterisation of local wetting properties of free sample surfaces and fresh crack surfaces will also be discussed. Since AFM is limited to surface measurement and lacks of chemical determination, its coupling with local spectroscopy techniques will also be considered.

[1] F. Célarié et al., Phys. Rev. Lett. 90(7), Art. No. 075504 (2003)
[2] D. Bonamy et al., Phys. Rev. Lett. 97(13), 135504 (2006)
[3] T. Fett et al., Phys. Rev. B 88, 174110 (2008)
[4] F. Célarié et al., J. Non-Crist. Solids 353, 51-68 (2007)
[5] A. Grimaldi et al., Phys. Rev. Lett. 100, 165505 (2008)

## 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.**

The interacting mechanisms of stress corrosion at a crack tip fully understood!

**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.**

Short-term : (2011)
- Understanding the structure of water layers on glass surfaces and its effect on the AFM tip-surface interactions for quantitative measurements.
- Obtaining nanometer resolution in the measurement of the stress and strain fields around crack tips in glass.

Middle-term : (2015)
- Understanding the exact role of water in stress-corrosion.

Long-term : (2025)
- Obtaining nanometer resolution in the measurement of the structural and compositional variation around crack tips in glass.

**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) Development of combined techniques to get locally resolved in situ characterization of the whole structural and compositional variation of disordered structure. (2025)
b) Modeling through simulation the subnanometer features at sufficiently large scales to be related to measurable quantities near the crack tip.