# Visualization of highly graded stress gradients in glassy and crystalline materials and in their heterostructures

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**Abstract:**

In the last ten years, we have explored the feasibility of the piezo-spectroscopic (PS) approach as a means for obtaining a direct experimental access to stress assessments in solids (both in glassy and in crystalline materials). We have extended the analyses of Raman, photoluminescence (PL) and cathodoluminescence (CL) to the quantitative assessment of stress obtaining high-resolution visualization of residual stress fields at the tip of indentation cracks in glasses, ceramics and semiconductor materials. We made efforts in substantiating with theoretical arguments the highly localized nature of laser and electron probes. Furthermore, integration of the experimental technique into multiscale simulation software was adopted for predicting the PS response of materials, and deconvolution procedures, of both laser and electron probes, used to push the spatial resolution toward the nanometer scale.

In this paper, quantitative measurements are presented in silica glass of highly graded stress fields, as they developed: (i) in the *K*-dominated zone ahead of the tip of a median-type indentation micro-crack; and, (ii) at a silicon-silica interface of a metal-oxide semiconductor (MOS) device. The Grabner's formalism was applied to explain wavelength shifts observed in the electro-stimulated spectrum of oxygen point defects in amorphous silica. In order to confirm the stress data collected on the silica side of the MOS device, the theory of phonon deformation potentials in Si single-crystal has been applied for rationalizing the strain/stress tensor components stored on the crystalline-Si side of the device using the shift of the LO Raman transition.

**<u>Questions to be answered:</u>**

**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.**

- Single-nanometer stress-microscopy used for screening advanced devices.
- Magnetic confined nanometer cathodoluminescence probe.
- *In situ* Raman analysis for orthopedic implants.
- Three-dimensional visualization of stress at grain boundaries.

**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.**

- Three-dimensional probe response function deconvolution.
- Unfolding crack-tip stress on the angström scale.
- Spectroscopic assisted finite element stress analysis.

**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**