

Sergey Kharintsev

Elina Battalova, Aidar Minibaev, Anastasiya Kazantseva

Kazan Federal University, Kremlevskya str., 16a, Kazan, Russia,

skharint@gmail.com

Electronic Light Scattering in Materials with Broken Spatial Symmetry

Structural defects and spatial disorder in solids inherently disrupt the spatial symmetry of the crystalline lattice and, therefore, alter the local electronic band structure. Inelastic scattering of photons by induced defect states leads to a featureless broadband background in Raman spectra, termed electronic light scattering (ELS) [1-5] – ubiquitous yet historically overlooked phenomenon (Fig. 1). Indirect optical transitions are enabled specifically by structural defects in semiconductors and quantum confinement in metals. ELS is a pre-relaxation physical process distinct from both photoluminescence and vibrational Raman scattering (VRS). The spectral shape and intensity of the ELS signal are governed by the material's energy band structure and exhibit pronounced excitation-wavelength dependence.

The underlying process relies on optically driven momentum transfer from the defect-rich or spatially confined medium to charge carriers. Defect-to-band transitions induce the ELS response that is particularly pronounced at the interface between structurally ordered and disordered domains within a semiconductor. Unlike a single p-n junction, the disorder-order interface generates a unidirectional photocurrent under sub-bandgap excitation, along with non-thermal anti-Stokes photoluminescence and enhanced ELS. In this study, we elucidate the physical mechanisms underlying these confinement-driven optical effects in defect-rich semiconductors and spatially confined metallic systems.

This work is supported by the Russian Scientific Foundation (Grant No. 26-12-00321).

References

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Figures

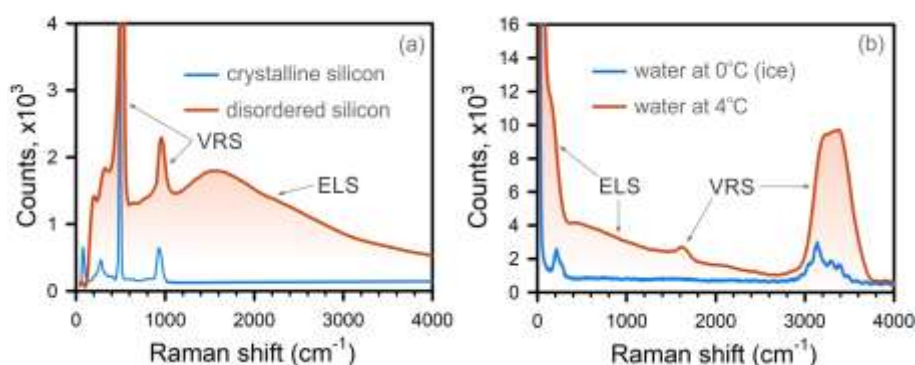


Figure 1: Raman spectra of crystalline and disordered silicon (a), and water at different temperatures of 0°C and 4°C.