Polarization-resolved Raman spectroscopy on optically anisotropic materials

Susanne Moritz, Lukas Trefflich, Marius Grundmann, and Chris Sturm#

Felix Bloch Institute of Solid State Physics, University Leipzig, Germany

Raman spectroscopy provides a powerful, non-destructive way to probe lattice vibrations, crystal symmetry, and electron–phonon interactions. For years, optically anisotropic materials have been gaining importance in solid-state physics research. Typically, measurements are carried out only in two different configurations in backscattering geometry, namely cross- and parallel polarization of the excitation and scattered light. However, for optically anisotropic samples, these two configurations are not sufficient in order to extract the properties of the Raman tensor, and extensive polarization-resolved Raman measurements are required for a precise characterization, particularly of the Raman tensor [1,2,3]. This is caused by the fact that in optically anisotropic samples, the polarization of arbitrary polarized light beams change during its propagation within the sample. Thus, the polarization of the scattered and incident light depends on the penetration depth where the scattering event takes place. This leads to an effective Raman tensor with complex-valued elements [1,3].

Here, we present a new approach for the determination of the Raman tensor elements, especially for optically anisotropic materials. This is done by determining the change of a linearly polarized incident beam after scattering within the sample. In doing so, the complex phase of the effective Raman tensor elements can be precisely determined, as well as symmetries of the corresponding Raman modes and the orientation of the crystallographic axes. The approach is exemplarily demonstrated on an a-plane sapphire substrate. In the case of the A_{1g} mode, we obtained a ratio of the Raman tensor elements a and b of 1.74, which agrees well with those reported in the literature [4]. For the phase factor between the elements of the effective Raman tensor, we determined a value of 0.51π, in agreement with theoretical expectations [1,3].

[1] C. Kranert et al. (2016) Phys. Rev. Lett. 116, 127401.
[2] C. Kranert et al. (2016) Sci. Rep. 6, 35964.
[3] R. Hildebrandt et al. (2021) Appl. Phys. Lett. 119, 121109.
[4] M.C. Munisso et al., (2009) Phys. Status Solidi B, 246, 1893.

corresponding author: csturm@physik.uni-leipzig.de