The study of resonant Raman scattering in semiconducting layered GeS

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Semiconducting layered group IV monochalcogenides such as black phosphorous and germanium sulfide with an anisotropic puckered crystalline structure in each layer have recently attracted much attention due to their unique optical and electronic properties and anticipated applications in optoelectronics [1]. Resonant Raman scattering (RRS) is an efficient tool for studding of vibrational properties as well as electron-phonon interactions. Here, we report on investigation of low temperature (T = 7 K), polarization-resolved, resonant Raman scattering experiments on GeS flakes in the range from 90 to 720 cm^{-1}. The RRS measurements are performed in back scattering configuration using a DCM dye laser with a tunable wavelength from 670 to 690 nm (Fig. 1). In order to determine the energy and optical polarization of the neutral exciton (X) complementary photoluminescence (PL) and reflectance (R) experiments are performed. In non-resonant RS spectra four Raman active modes A^2_g, A^3_g, A^4_g and B^2_{1g} are observed, however, when the excitation energy is tuned towards to the energy of the X we can resolve in the Raman spectra 18 peaks, among which 14 have not been reported previously in the back scattering configuration. Intensity of all the new Raman features significantly increases as they are brought into resonance with the neutral exciton. Additionally, they exhibit almost the same polarization dependence as the X. Analysis of the origin and assignment of new phonon modes are based on their energies, polarization-dependent intensities, numerical calculations and comparison with previous experimental and theoretical studies of the Raman scattering in GeS and resonant Raman scattering in other materials. Accordingly, new features in the RRS spectra are attributed to infrared active and second-order phonon modes.

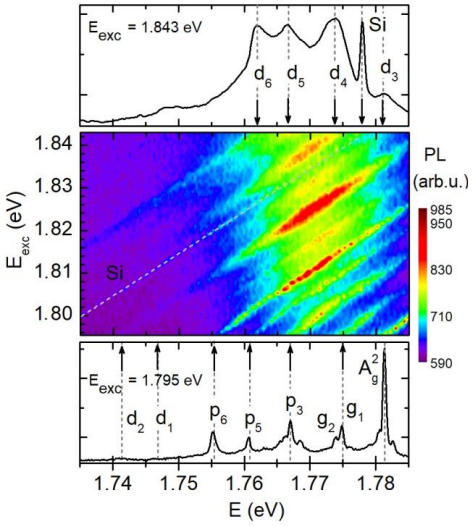

Fig. 1 False-color map of low-temperature PLE/RRS spectra of GeS as a function of the excitation energy E_{exc}.

[1] C.H. Ho et al., *Adv. Optical Mater* **5**, 1600814 (2017).