Comparative Study of SnS_xSe_{2-x} alloys by High Pressure Raman Spectroscopy

N. Sorogas*, K. Papagelis, A. N. Anagnostopoulos, and J. Arvanitidis
Physics Department, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece

D. Christofilos
School of Chemical Engineering & Laboratory of Physics, Faculty of Engineering, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece

In this work, the hydrostatic pressure response of the phonon modes of ternary SnS_xSe_{2-x} (x=0.6, 0.8, 1) alloys has been studied by means of Raman spectroscopy. High pressure (up to 8 GPa) was generated using a gas membrane-type diamond anvil cell. Owing to the two-mode behaviour of the E_g and A_{1g} modes in the ternary dichalcogenide alloys investigated [1], four Raman bands are observed at ambient conditions and the frequency evolution of three of them {E_g($SnSe_2$-like), A_{1g}($SnSe_2$-like) and A_{1g}(SnS_2-like)} was followed with pressure. Upon pressure application, all Raman peaks monotonically shift to higher frequencies due to the volume reduction and the bond strengthening (Figure 1).

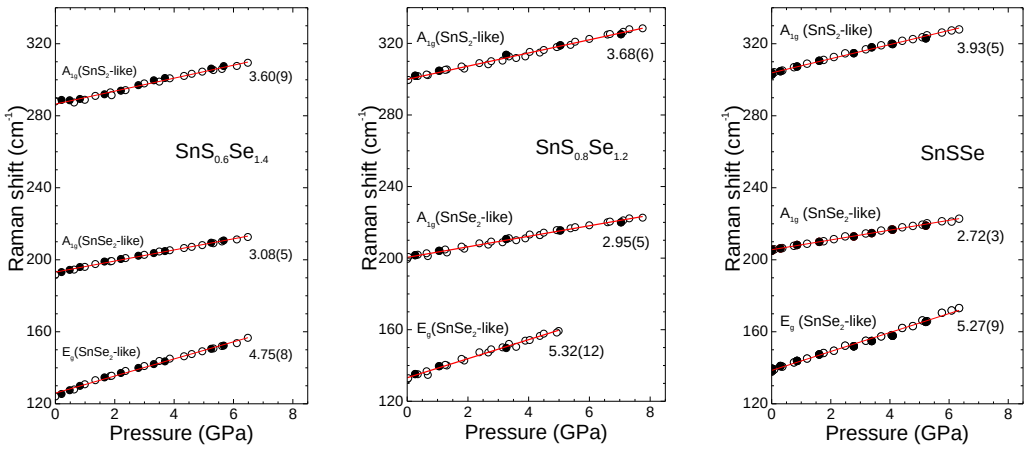

Figure 1: Pressure evolution of the frequencies of the clearly resolved Raman peaks in the SnS_xSe_{2-x} alloys. Open (closed) circles correspond to pressure increase (decrease).

The pressure coefficient of the A_{1g}(SnS_2-like) peak frequency increases gradually from 3.60 to 3.93 $cm^{-1}GPa^{-1}$ with increasing S content, x. These values are compatible with those reported in the literature for the binary SnS_2 [2]. At the same time, the pressure coefficient of the A_{1g}($SnSe_2$-like) peak frequency decreases from 3.08 to 2.72 $cm^{-1}GPa^{-1}$ with x, being always larger than that observed for the binary $SnSe_2$ [2]. Furthermore, contrary to the strong covalent bonding along the a-axis compared to the weak van der Waals interactions along the c-axis, the in-plane E_g($SnSe_2$-like) mode exhibits larger pressure coefficient than those of the A_{1g} modes along the c-axis in all the studied alloys. We also extracted the Grüneisen parameters for the A_{1g}(SnS_2-like): 0.35, 0.34, 0.36 and the A_{1g} ($SnSe_2$-like) mode: 0.44, 0.41, 0.37 for x=0.6, 0.8 and 1, respectively. These values indicate the stronger Sn-S interaction along the c-axis compared to the Sn-Se one in the ternary alloys, in agreement with the existing X-ray diffraction (XRD) data in the literature [3].

References

[1] V. G. Hadjiev, D. De, H. B. Peng et al., Phys. Rev. B **87**, 104302 (2013).
[2] S. V. Bhatt, M. Deshpande, V. Sathe et al., Solid State Commun. **201**, 54 (2015).
[3] J. Yu J, C-Y. Xu, Y. Li et al., Sci. Rep. **5** 17109 (2015).

* nsorogka@physics.auth.gr