Raman study of the phonons and phonon-polaritons of the disordered $Zn_{1-x}Mn_xTe$ semiconductor alloy

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Due to their simple structure (two bond species randomly arranged on a cubic lattice), the zincblende $A_{1-x}B_xC$ semiconductor alloys (SCA) set a benchmark to explore how physical properties are impacted by disorder. In particular, the vibrational properties governed by the bond force constant potentially offer a suitable probe at the ultimate atom scale (where the atom substitution occurs).

A longstanding controversy since the emergence of SCA in the 1960s was whether the vibration of a given bond is "blind" to the alloy disorder, *i.e.*, generates a unique mode at any composition (like in the AC and BC compounds), or actually "sees" the alloy disorder, *i.e.*, diversifies into a multi-mode signal (to clarify in terms of number and nature of modes) reflecting inherent fluctuations in the alloy composition at the local scale. Over the past decade and half our group introduced the percolation model (PM)[1] that distinguishes between like bonds depending on whether they vibrate in "homo" or "hetero" environments. The PM has been tested and validated on the phonon and phonon-polaritons of various SCA, hence, solving the controversy in favor of the second scenario, apparently.

In this M2-project we further test the PM on high-quality large-size free-standing $Zn_{1-x}Mn_xTe$ single crystals grown specially for the project over a large x-domain ($x \leq 0.8$) by the Bridgman method,[4] with respect to both phonons and phonon-polaritons in backward and forward Raman scattering, respectively.

The phonons of $Zn_{1-x}Mn_xTe$ are assigned as being of the rare intermediary (hence undetermined) type in the historical classification of the phonon mode behavior of SCA.[2,3,5] This might reflect a lack of understanding, stimulating a careful re-examination of the phonons of $Zn_{1-x}Mn_xTe$ within the PM.

The phonon-polaritons of $Zn_{1-x}Mn_xTe$ remain unexplored. ZnTe-based SCA exhibit a large band gap and hence are transparent to the visible laser excitation. This offers a chance to study their phonon-polaritons by forward Raman scattering (schematically operating in "transmission").

Generally, our ambition is to achieve a coherent fundamental study of the collective dynamic excitations (phonons and phonon-polaritons) of $Zn_{1-x}Mn_xTe$ by Raman scattering at ambient and high-pressure (using a diamond anvil cell).

References: [1]Pagès *et al*. Phys ; Rev. B 77, 125208 (2008); [2]Peterson *et al*., Phys. Rev. B **33**, 1160 (1986); [3]Talwar *et al*., Materials Chemistry and Physics **220**, 460 (2018); [4]Strzałkowski *et al.*, Materials **16**, 3945 (2023); [5]Oles *et al*., J. Phys. C: Solid State Phys. **18**, 6289 (1985);

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