Enhancement of NO2 sensing in Sb2Te2Se by vacancies

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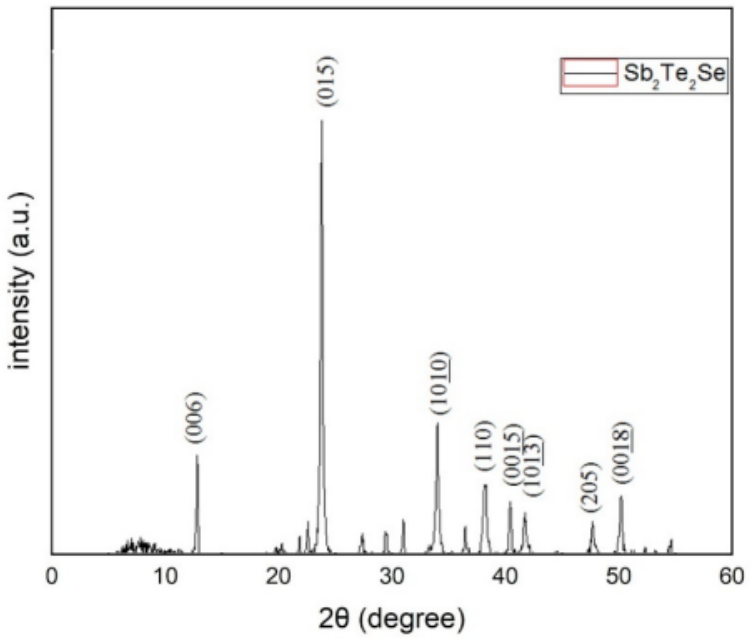
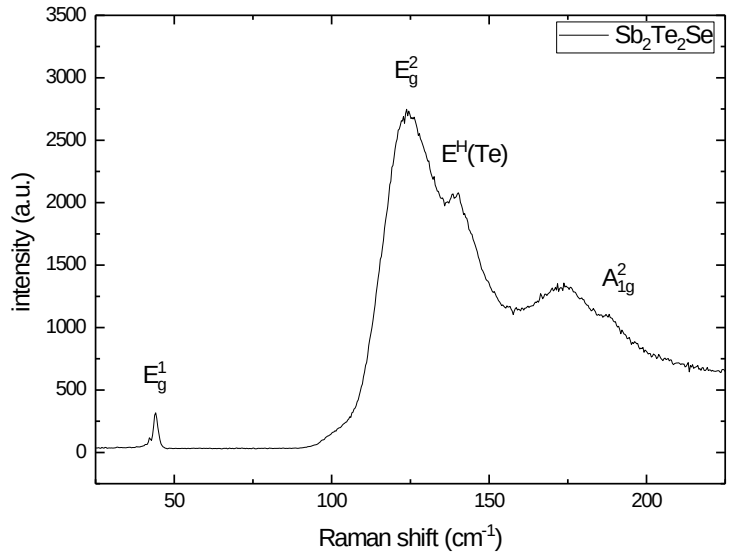
Background

- Since the topological surface states are exposed to the environment, gas sensing applications could benefit from the higher carrier mobility of the topological surface states.
- first principle studies have found NO2 molecules tend to occupy the vacancy sites on the surface of Bi2Te3 and Bi2Se3.[13] This motivates us to study the effects of vacancies in NO2 adsorption on Sb2Te2Se.
- In this work, we study the resistance response of Sb2Te2Se towards NO2 and the effects of vacancies introduced by annealing. We found that the vacancies greatly enhance the response and inferred the significant role the vacancies play in the mechanism of NO2 adsorption in Sb2Te2Se

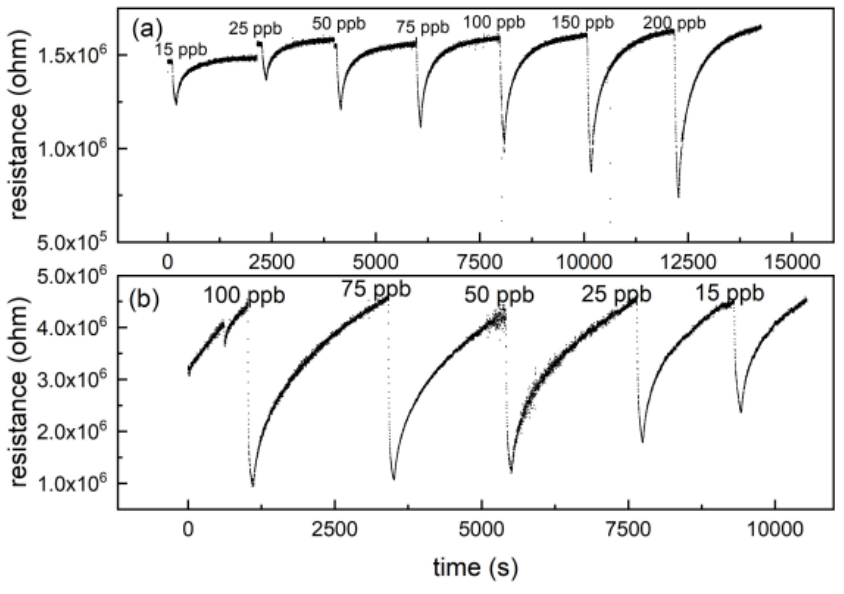
Results and Discussions



XRD spectra of our Sb2Te2Se single crystal. The peaks correspond to rhombohedral structure.

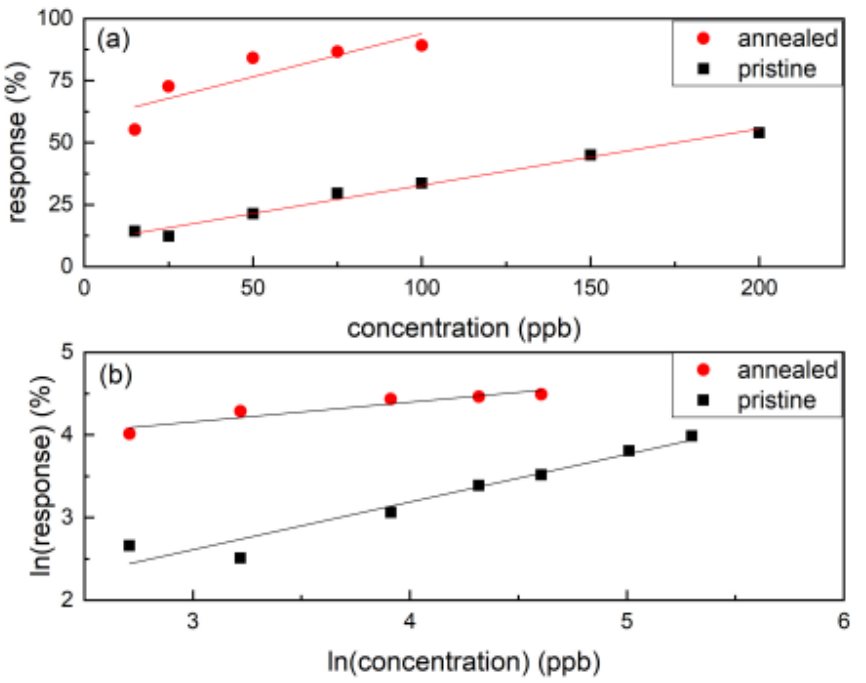


Raman spectra of our Sb2Te2Se single crystal. The peaks correspond to rhombohedral structure.

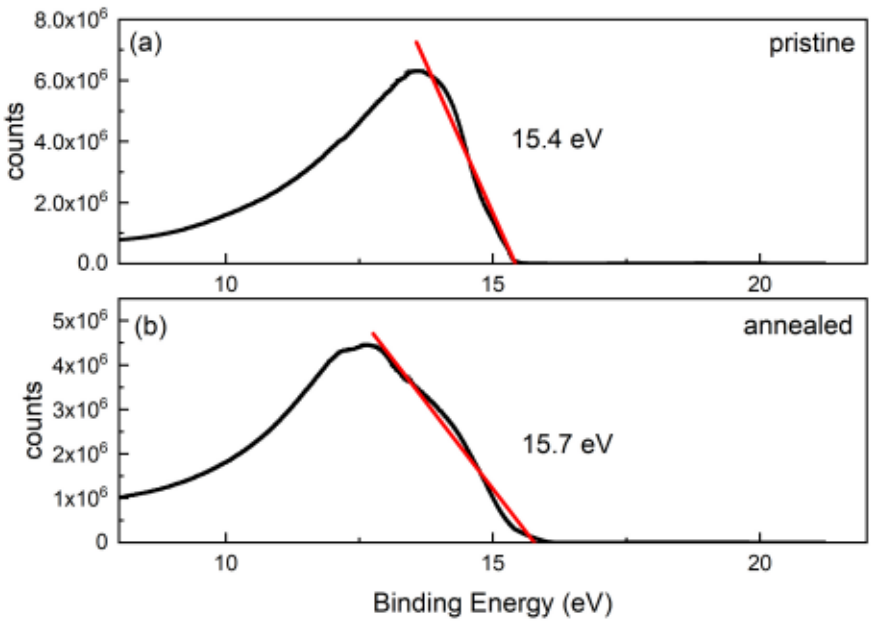


(a) Resistance of the pristine sample to NO2 under different concentrations over time. (b) Resistance of the annealed sample to NO2 under different concentrations over time.

Results and Discussions



(a) The extracted detection responses of the pristine and the annealed sample to NO2 gas. (b) The natural log of response against the natural log of concentration. The sensitivity is obtained as the slope.



(a) UPS spectra of pristine sample shows the valence band sits at a binding energy of 15.4eV and (b) shows the UPS spectra of the annealed sample where the valence band sits at 15.7eV

Conclusions

- In conclusion, we studied the responsibility of Sb2Te2Se as a NO2 gas sensor, whose carrier density was found to be the highest in the A2B3 family in a previous study (A = Bi or Sb, B = Se, Te).
- We found a significant improvement of the responsibility, with the highest 5.9 times to the pristine sample at 25 ppb, after annealing of 175◦ due to the increase in Te or Se vacancies, evidenced by Fermi level shift obtained from UPS spectra.
- This work further verifies the mechanism of NO2 adsorption when vacancies are present and demonstrates that the vacancy dependent behavior applies to the Sb based materials too.