Development of SiGeSn IR Detectors

UNIVERSITY OF ARKANSAS
Graduate School & International Education
Materials Science & Engineering

Student: Justin M. Rudie Degree: M.S., Dec. 2021
Major Professor: Dr. Fisher Yu

Nanoscale Materials & Devices | Microelectronic-Photonic Materials & Devices

Background/Relevance

- Current infrared imaging sensors are expensive III-V materials
- Germanium based materials are well suited for IR detection, but material systems are relatively unexplored/characterized
- Characterization of band offsets is necessary for device modeling to advance this material system.

Innovation

- Novel CVD growth techniques to increase Sn in
- Previously unrealized compositions of SiGeSn will be grown and characterized
- Band offsets of SiGeSn/Gesn will be determined

Approach

- CVD growth plans altering pressure, temperature, growth time and other parameters to achieve quality samples
- Confirmation of material content and quality via ellipsometry, PL, TEM imaging, etc.
- XPS of multiple samples to find core level binding energies leading to the determination of the valance band offset (VBO) of the heterojunction.
- Equation to determine VBO:
$$\Delta E_V = (E_a^{(i)} - E_b^{(i)}) + (E_{CL}^b - E_{VBM}^b) - (E_{CL}^a - E_{VBM}^a)$$
- Conduction band offset (CBO)can be determined from band gap data after VBO is known.

Key Results

- Currently finding offsets of Ge/Si and Ge/GaAs to compare with literature to validate method
- Results are in the form: Reference value/My values/Difference

Si2p-Ge 3d	Ge 3d - VBM	Si 2p - VBM	As 3d – Ge 3d	Ge 3d - VBM	As 3d - VBM
70.09/70.06 /0.03	29.69/29.30 /0.39	98.95/98.99 /-0.04	11.78/11.47 /0.31	29.57/28.9/ 0.67	40.79/40.77 /-0.02

- Ge/Si VBO = 0.37 eV compared to 0.83 eV in literature
- Ge/GaAs VBO = -0.4 eV compared to 0.56 eV in literature

Conclusions

- So far method has not been able to recreate know offsets of Ge/Si and Ge/GaAs materials.
- Native oxide present a serious obstacle for finding actual binding energies

Future Work

- Comprehensive sample prep method to ensure oxide free surface without crystal damage
- Proceed with measurements on GeSn/Ge and SiGeSn/GeSn samples.

(MURI) (AFOSR) Grant Number:FA9550-19-1-0341