SYNTHESIS OF TIN DISELENIDE ($SnSe_2$) NANOPARTICLES FOR PHOTODETECTOR APPLICATIONS

FINAL REVIEW OF THE MINOR PROJECT

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
Deemed to be **University** *u/s 3 of UGC Act, 1956*

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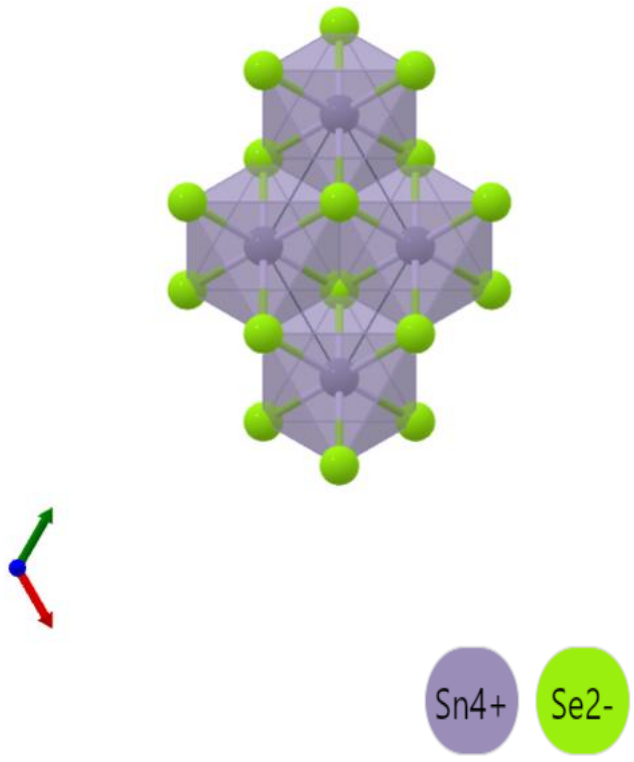
CRYSTAL STRUCTURE



- **Tin diselenide is a Group-IV dichalcogenide**
- **$SnSe_2$ is trigonal omega structured and crystallizes in the trigonal $P\bar{3}m1$ space group.**
- **$SnSe_2$ has hexagonal symmetry with repeating Se–Sn–Se units, and the two interacting layers are interconnected together via van der Waals forces, forming a stable "three-layer" structure These layers are weakly coupled along the c axis by van der Waals forces.**
- **This property enables the formation of 10 polytypes by lattice relaxations for the repetition unit along the stacking axis.**

PROPERTIES

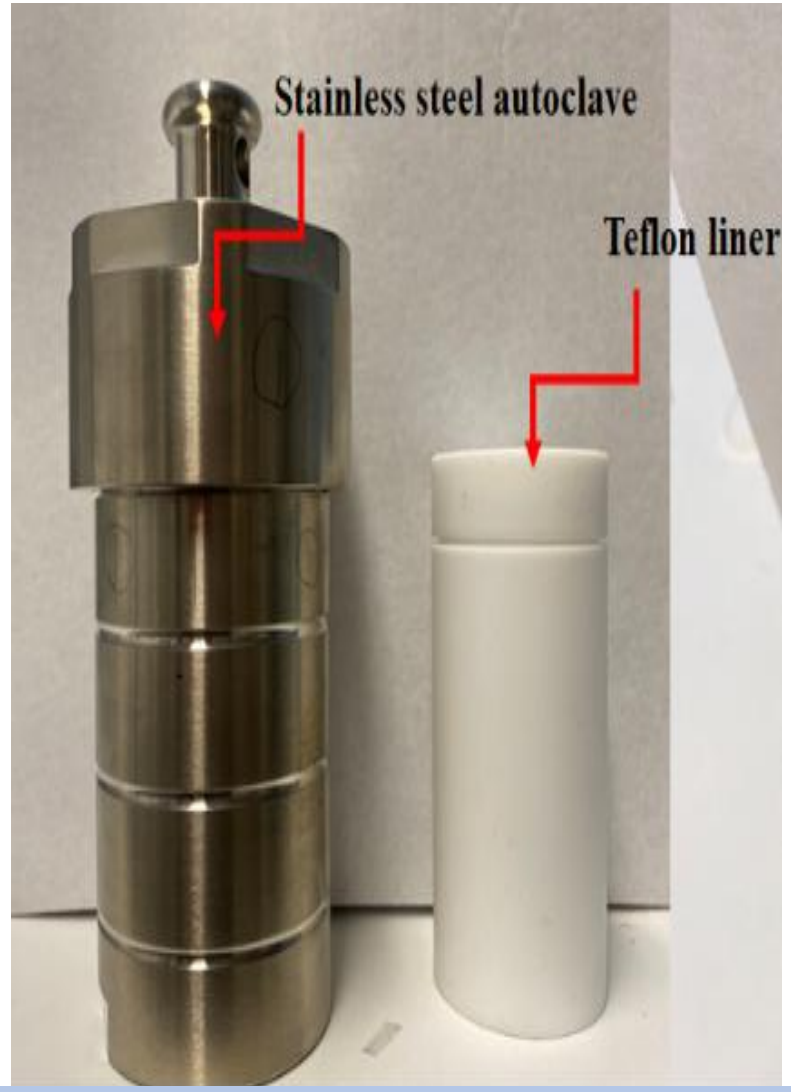
- **$SnSe_2$ crystals have a high carrier mobility of 8.6 $cm^2 V^{-1} s^{-1}$ at room temperature.**
- **$SnSe_2$ is a n-type conductivity material.**
- **$SnSe_2$ is an indirect band gap (1.0 eV) semiconductor with**

➢ **Absorption coefficient of 1.3×10^4 cm^{-1}**

➢ **Carrier mobility of 233 $cm^2 V^{-1} s^{-1}$**

➢ **Carrier concentration varies from 10^{17}–10^{19} cm^{-3}**

EXPERIMENTAL METHOD



Add 1.05 gm of $SnCl_4.5H_2O$ dissolve it in a 30 ml of DI water in a clean 100 ml beaker and make it as two separate solutions A and B.

Add 0.473 gm of Selenium metal powder and dissolve it in a 30 ml of DI water in a clean 100 ml beaker and make it as two separate solutions C and D.

We have taken as 1:2 and 1:3 ratios of $SnCl_4.5H_2O$ and Selenium metal powder.

Place these 4 beakers on the hotplate stirrer & stirring takes place at a 500°C for 15 mins.

EXPERIMENTAL METHOD

For beaker C add 5 ml of $N_2H_4.H_2O$ (Hydrazine hydrate) as a drop wise solution into the Selenium metal powder solution for 15 mins & it turned out into black color solution.

Now, add the black color solution as drop wise into the $SnCl_4.5H_2O$ which is Beaker A.

For Beaker D add 2gm of NaOH as reducing agent to the Selenium metal powder solution for 15 mins.

Then, add 5 ml of $N_2H_4.H_2O$ as a dropwise solution into the Beaker D for 15 mins & it turned into brown color.

Now, beaker D Selenium metal powder solution as drop wise into the beaker B.
Then, transfer these mixtures to a 100ml Teflon lined two different stainless autoclave.

EXPERIMENTAL METHOD

The two sealed autoclave was heated at 180℃ for 24 and 48 hours in a furnace and cooled naturally.

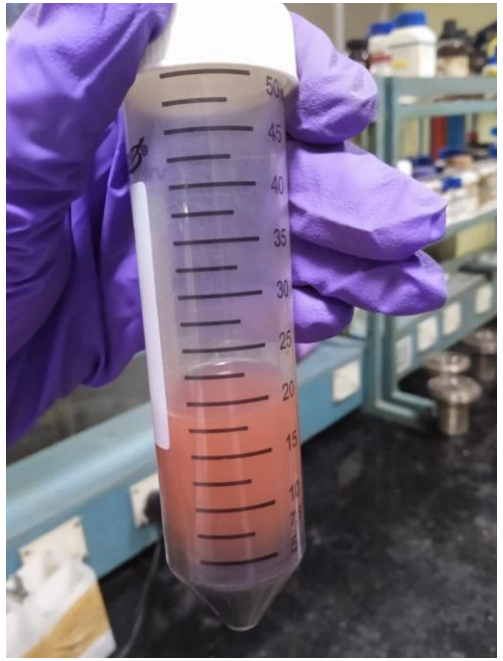
Autoclave with NaOH + $N_2H_4.H_2O$ – it had the reddish color solution with black precipitate

Autoclave with $N_2H_4.H_2O$ – it had the black color solution & precipitate

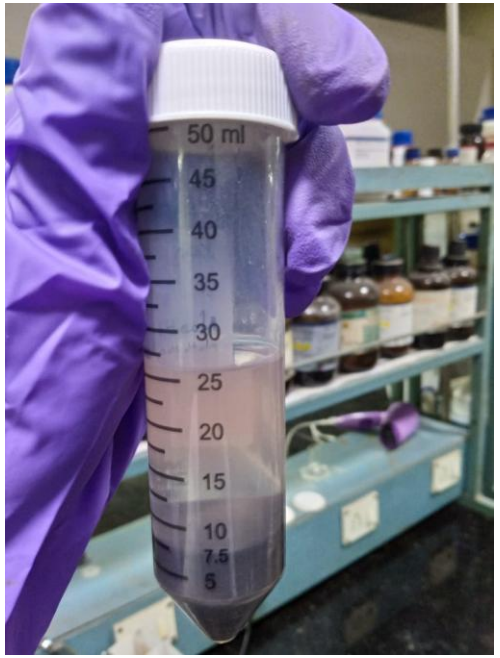
Centrifuge at 3000 rpm for 10 minutes each with 4 times DI water rinse & 1 time ethanol rinse.

Disperse the centrifuge tubes before loading it into the Centrifuge Machine

These products tubes were covered in aluminum foil kept in a beaker & dried at 80 ℃ for 24 hours in hot air oven.



Black ppt with reddish solution



Black ppt with clear solution

BALANCED EQUATION:

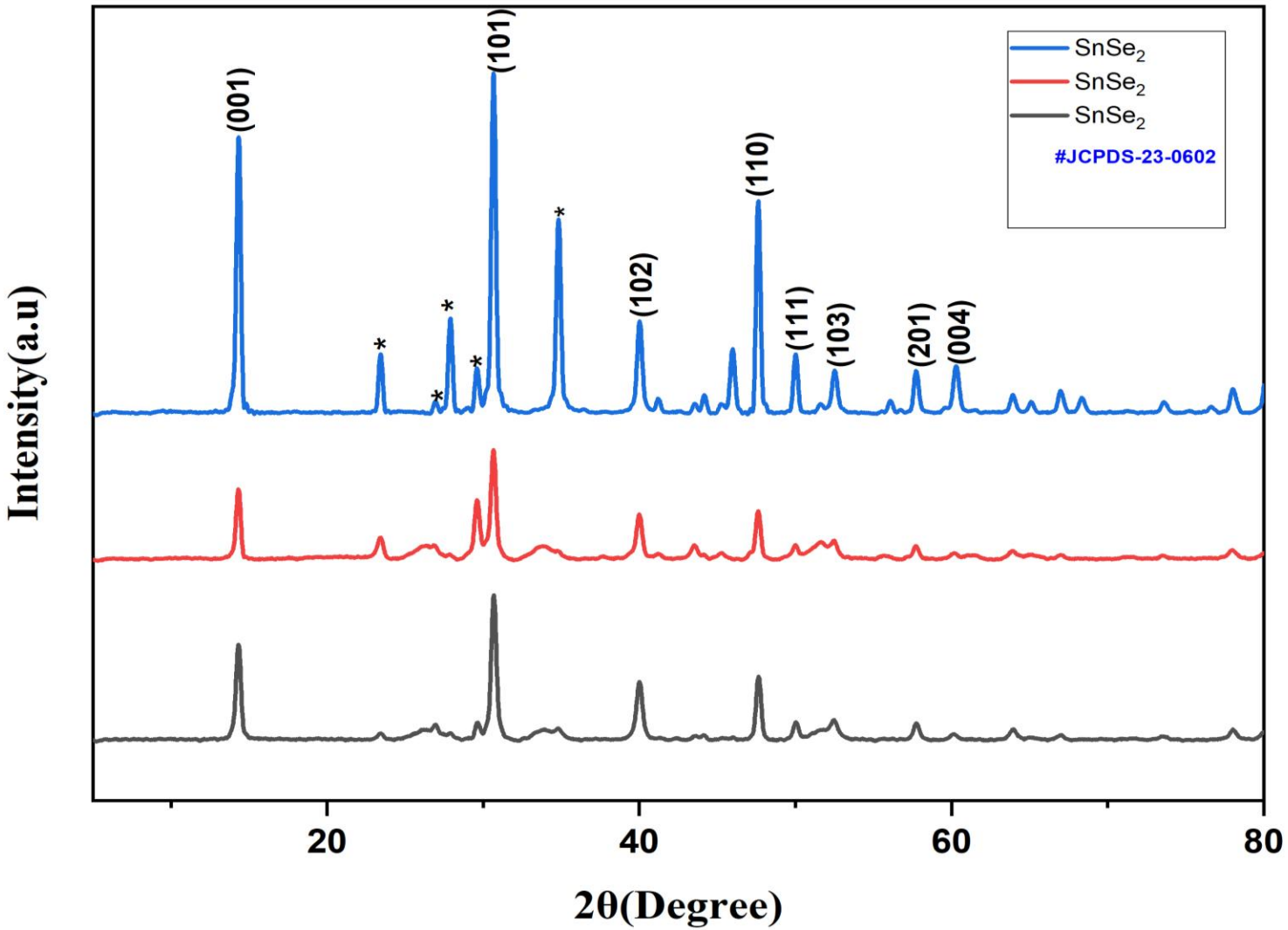
$$SnCl_4.5H_2O + 2Se + 2NaOH + N_2H_4.H_2O \rightarrow SnSe_2 + 4NaCl + 5H_2O + N_2\uparrow$$

X-Ray Diffraction $SnSe_2$

(c) Growth hour – 48 hours, Ratio 1:3

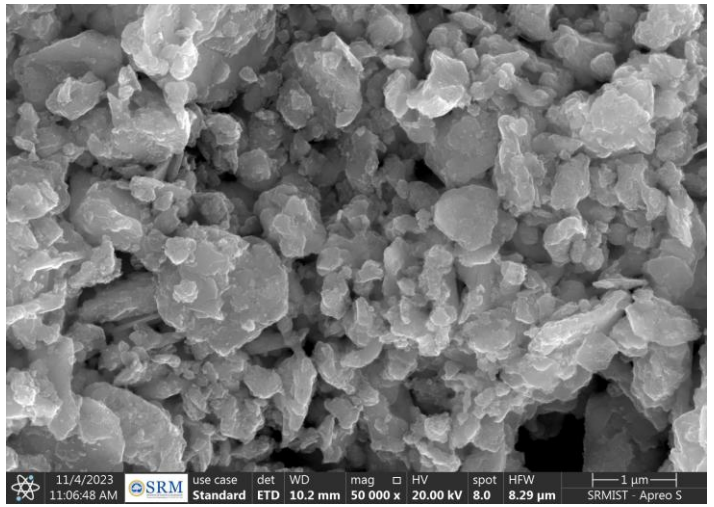
(b) Growth hour – 48 hours, Ratio 1:2

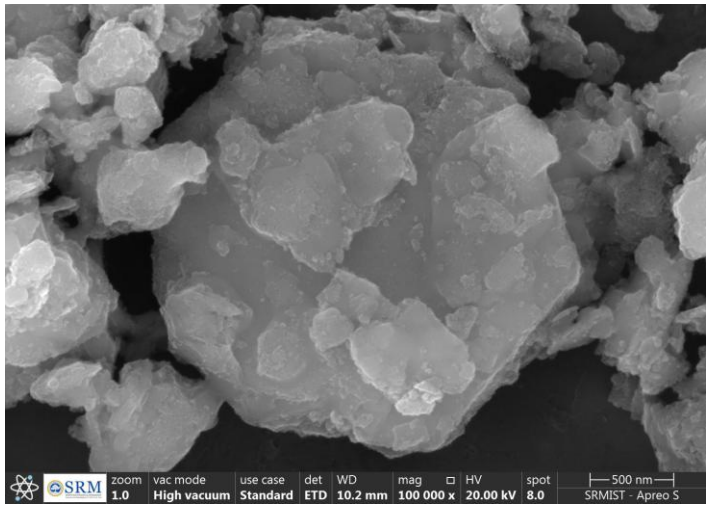
(a) Growth hour – 24 hours, Ratio 1:2

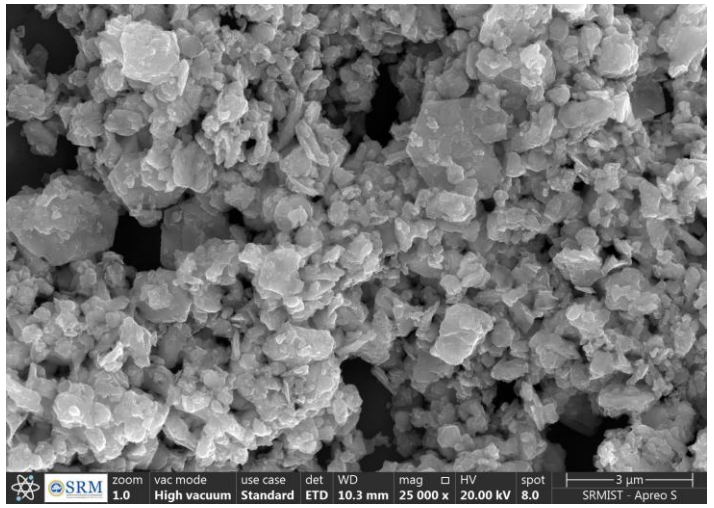


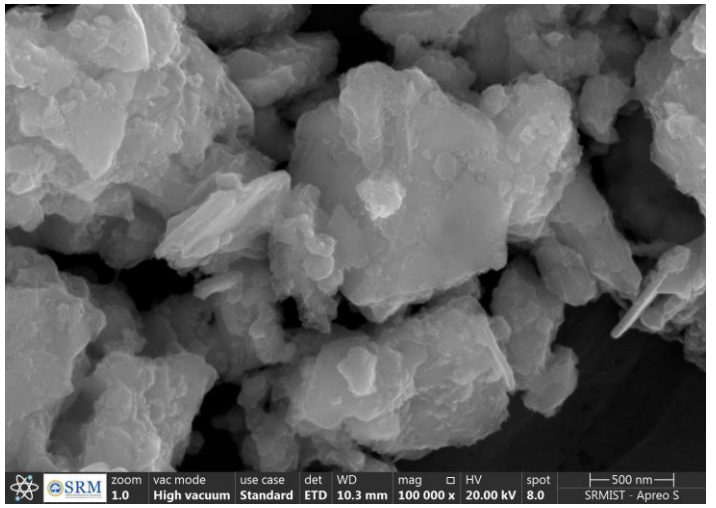
SEM CHARACTERIZATION

$SnSe_2$ with NaOH & Hydrazine hydrate, Growth hour – 24 hours

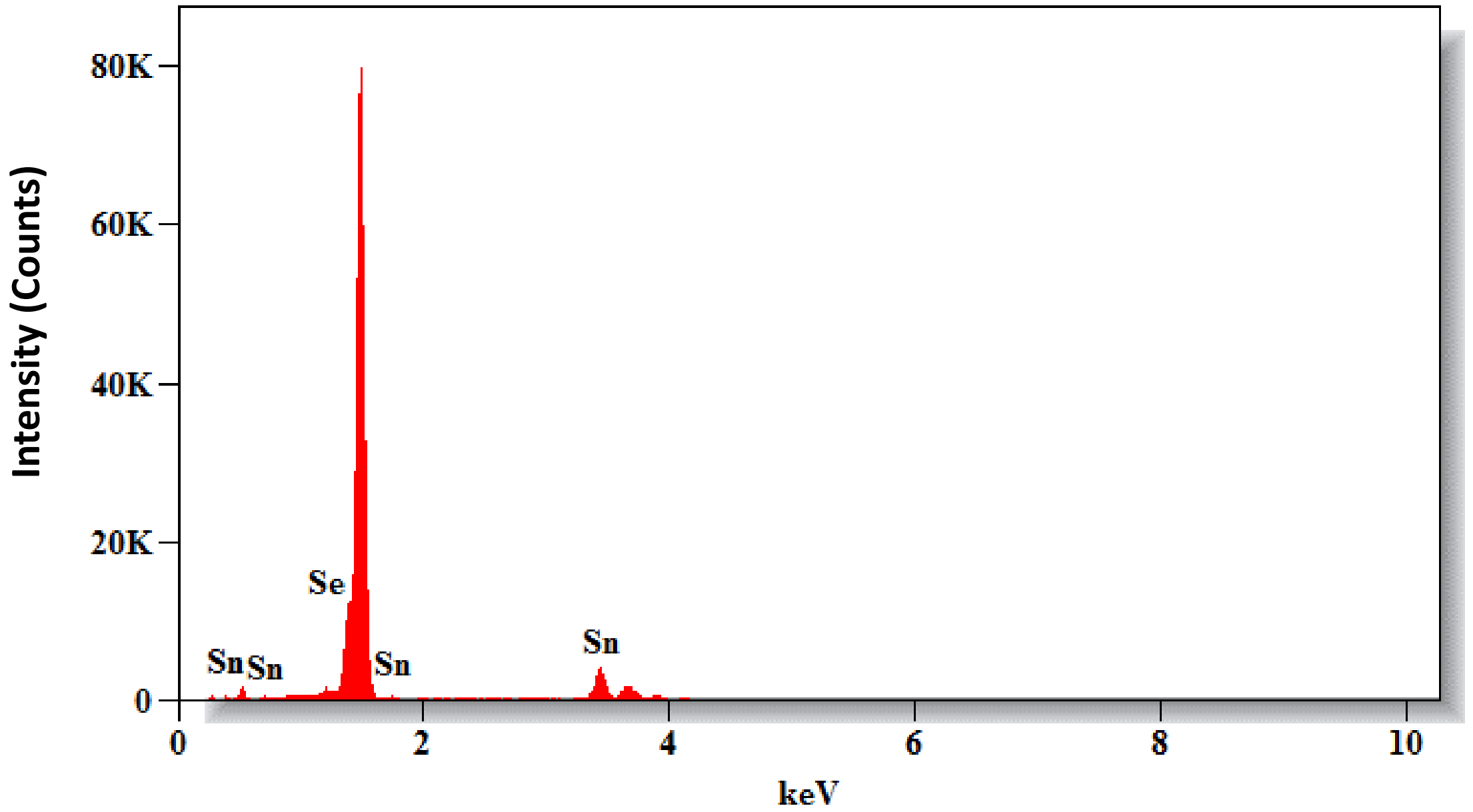




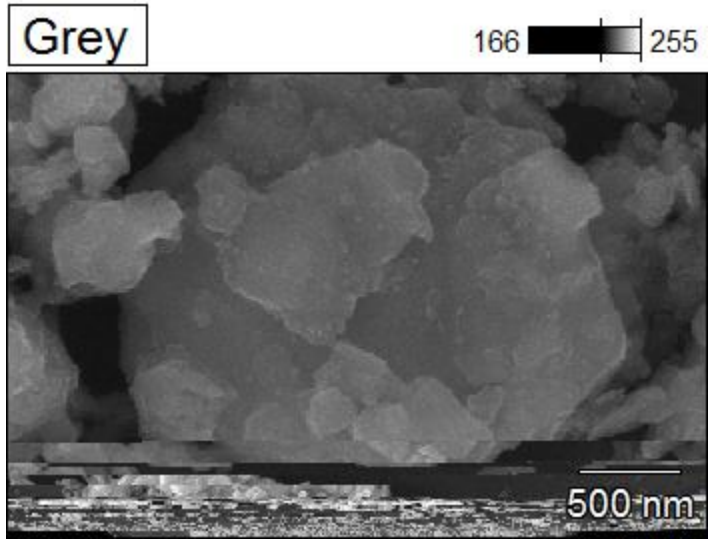


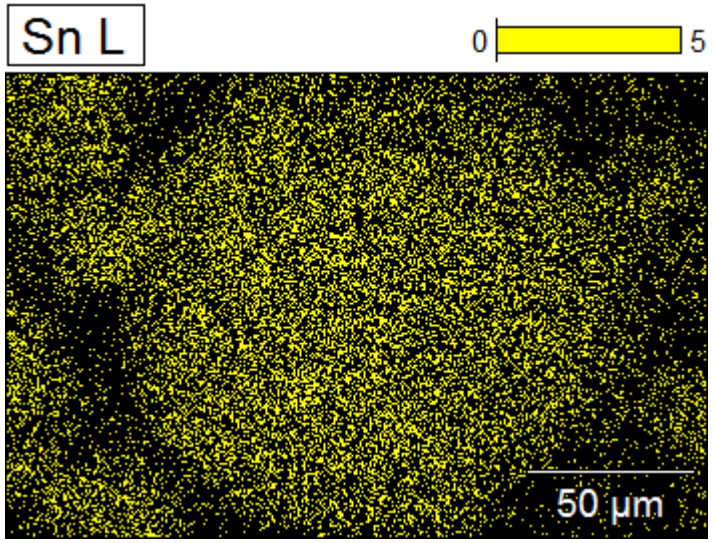


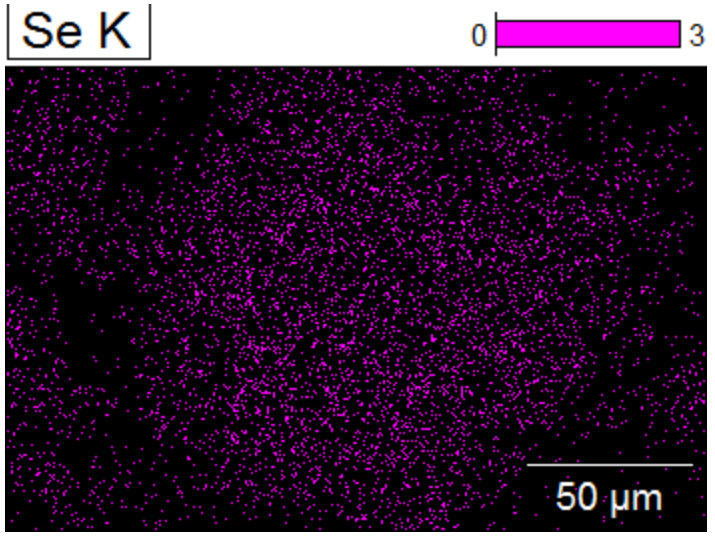
EDS SPECTRUM



EDS MAPPING

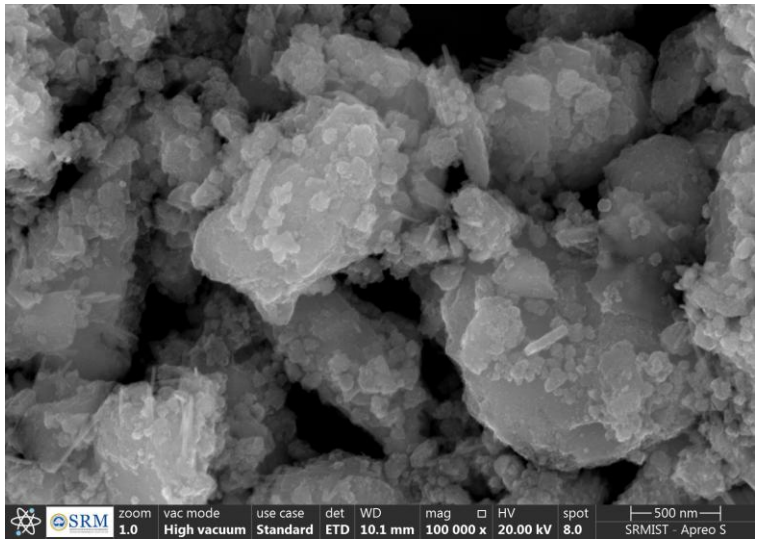


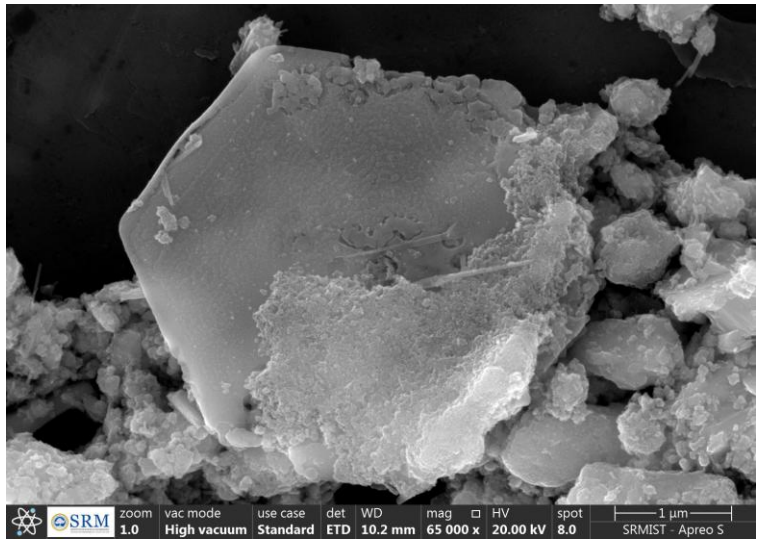


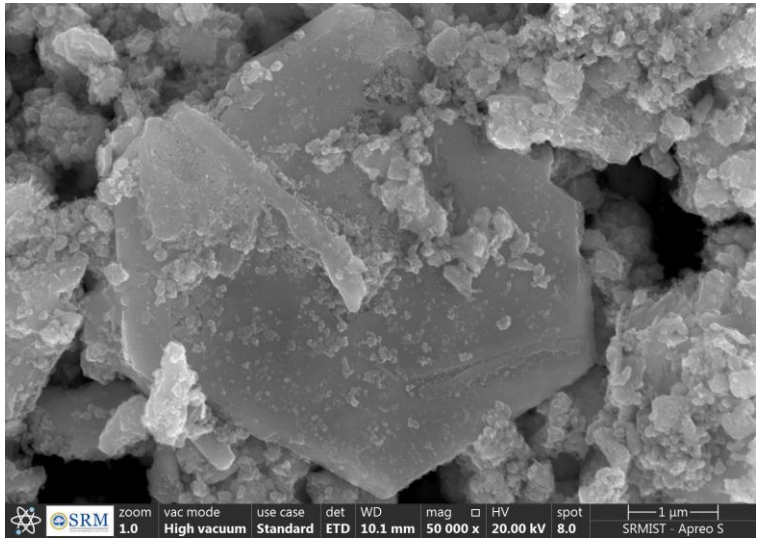


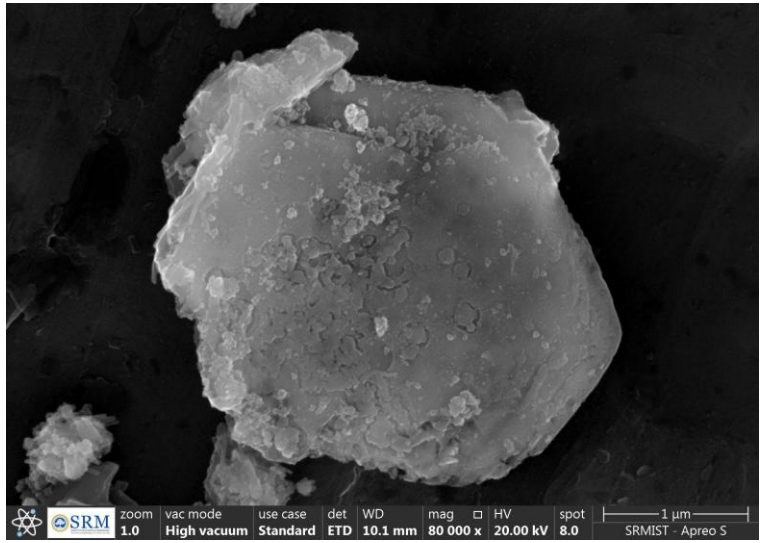
Element	$SnSe_2$	$SnSe_2$	$SnSe_2$	$SnSe_2$	$SnSe_2$
	Net Counts	Weight %	Atom %	Atom % err	Chemical Formula
Se K	13901	53.67	63.52	1.60	Se
Sn L	71942	46.33	36.48	0.22	Sn
		100.00	100.00		

$SnSe_2$ with Hydrazine hydrate, Growth hour – 48 hours

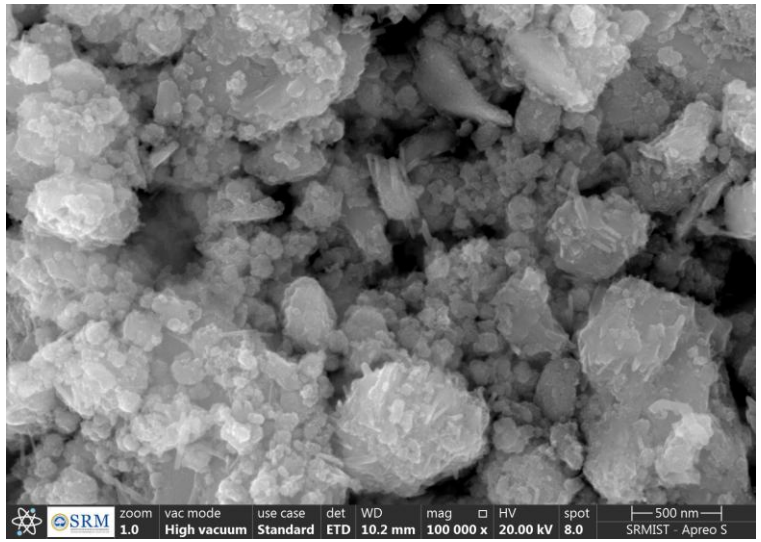


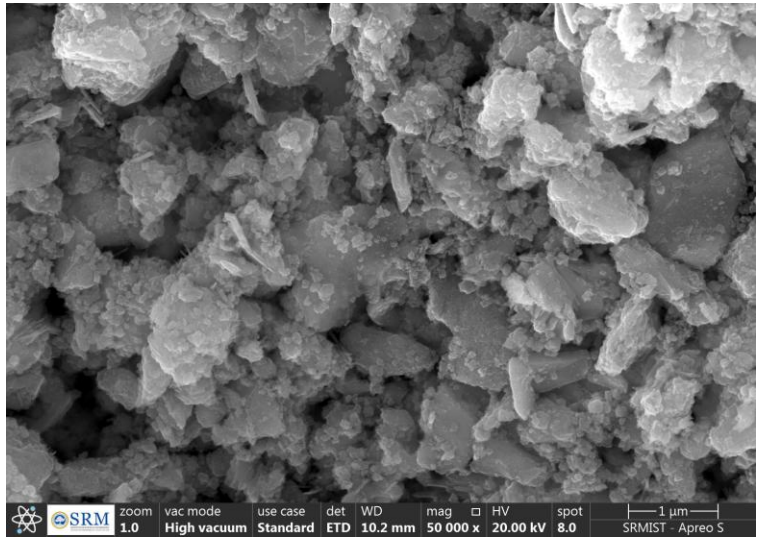


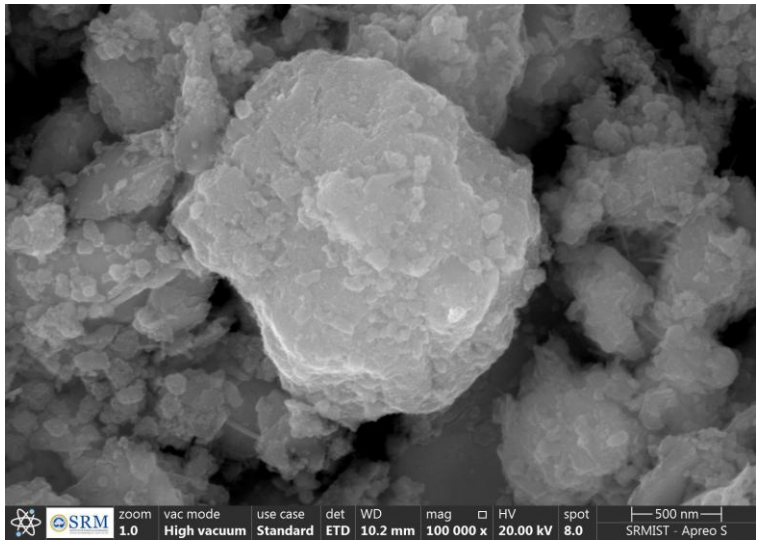


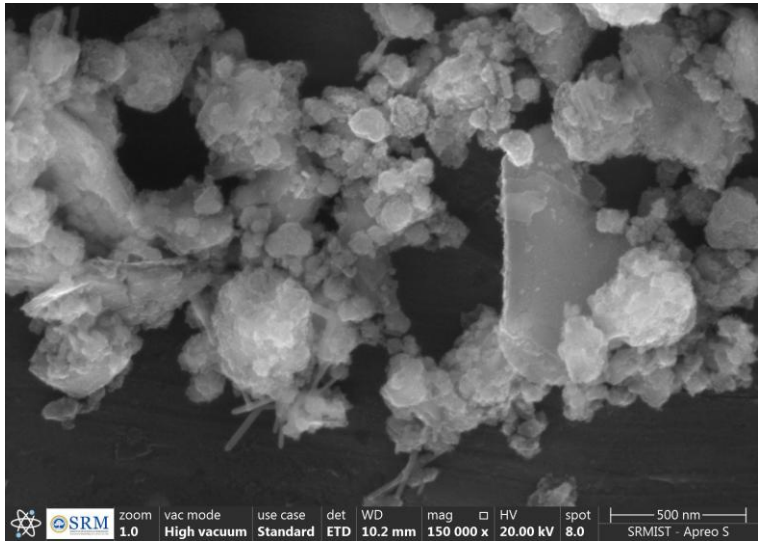


$SnSe_2$ with Hydrazine hydrate, Growth hour – 48 hours

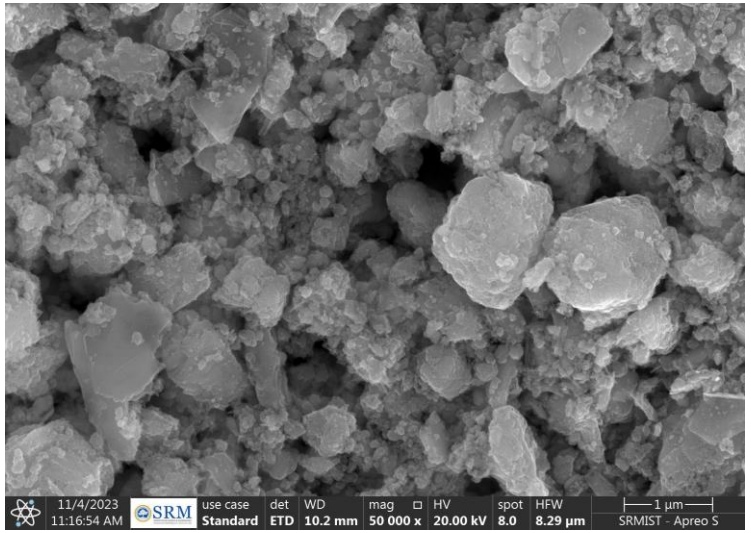


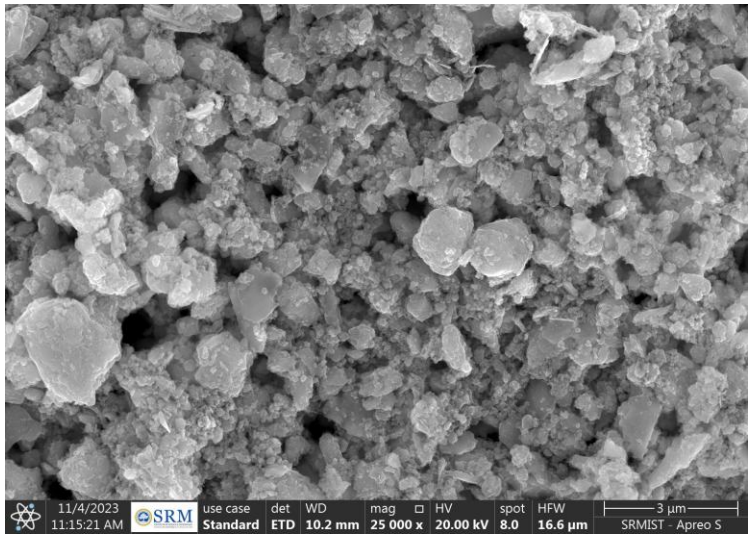


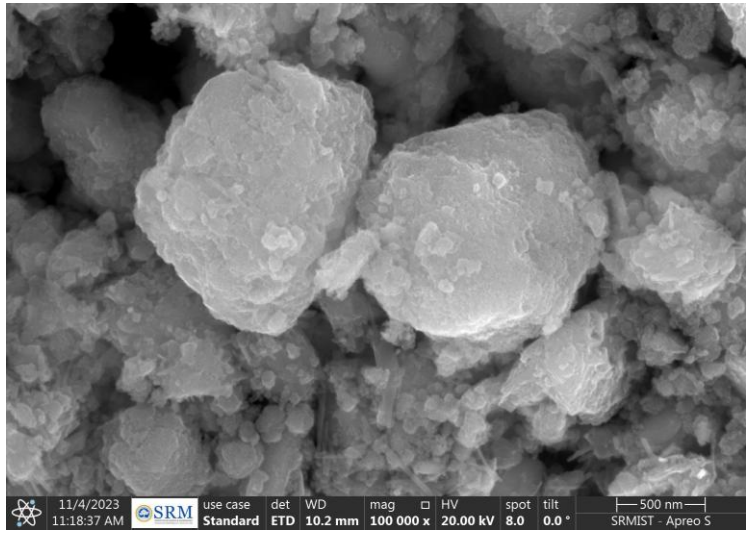




$SnSe_2$ with Hydrazine hydrate, Growth hour – 48 hours







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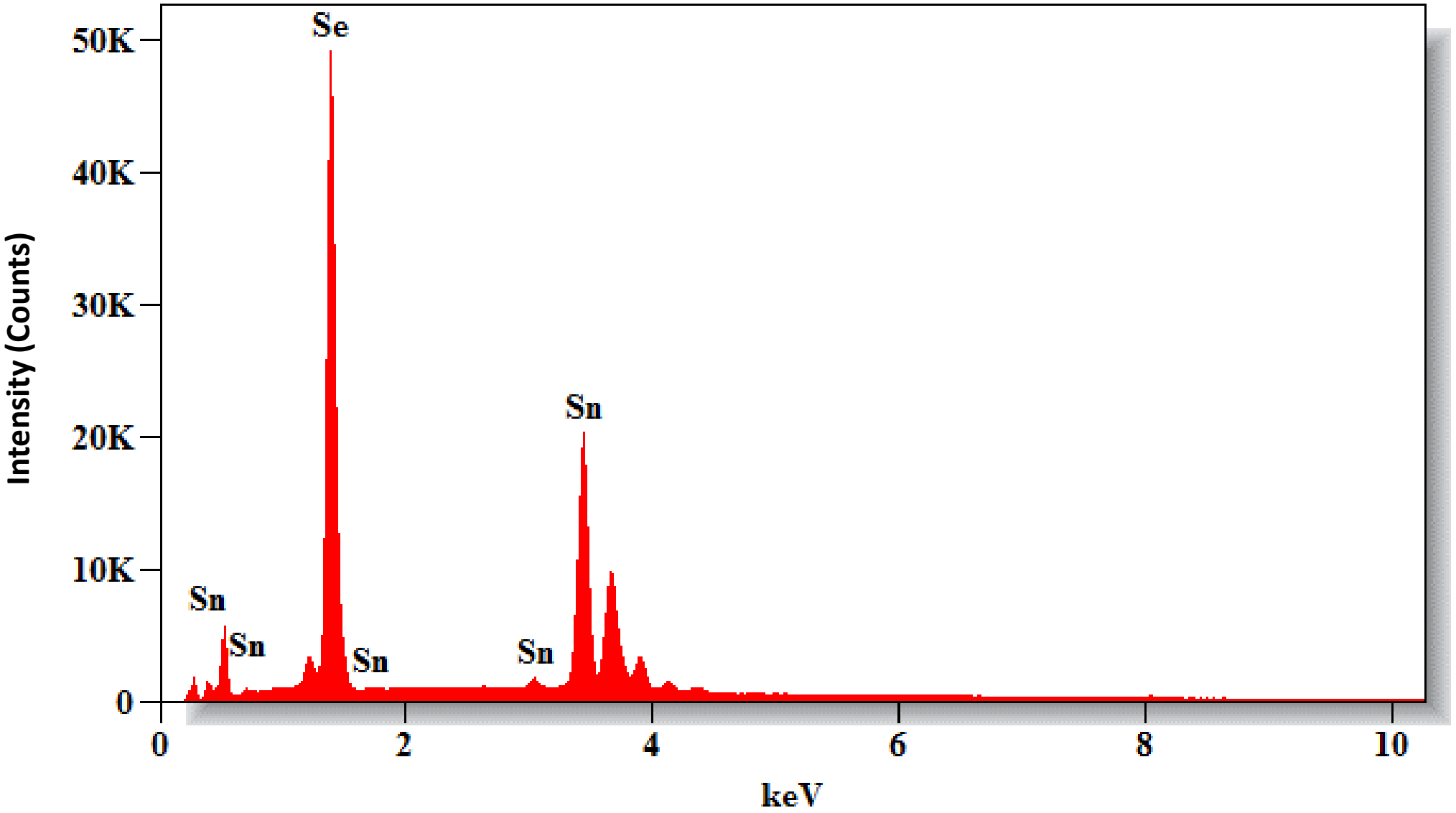
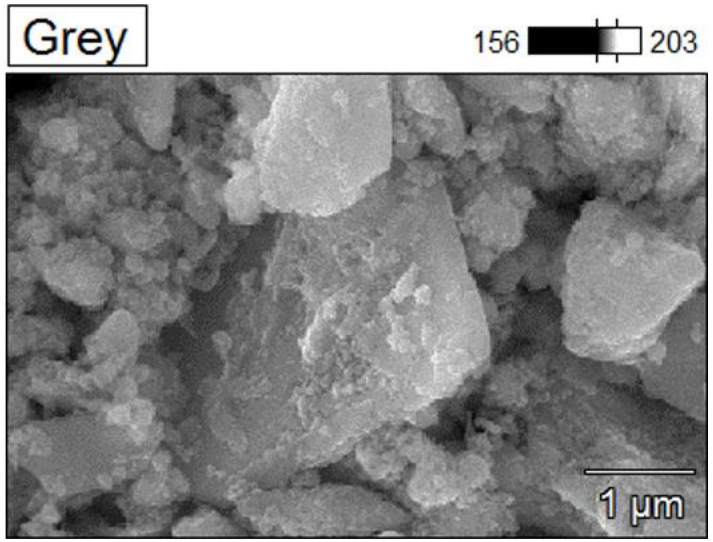
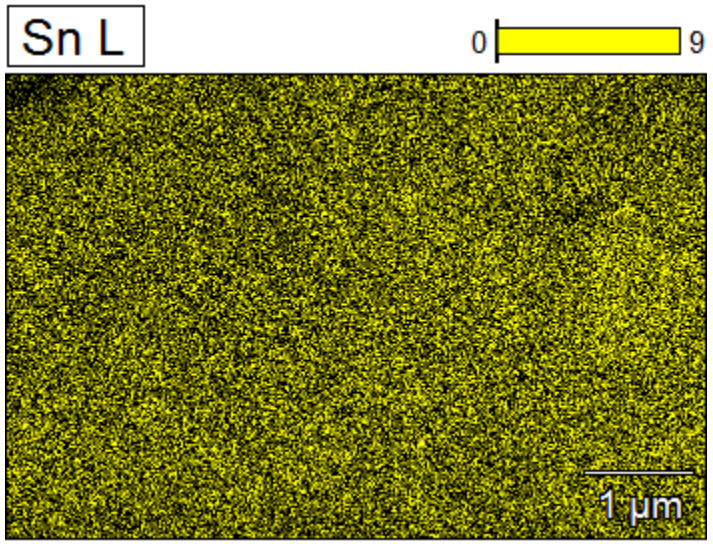
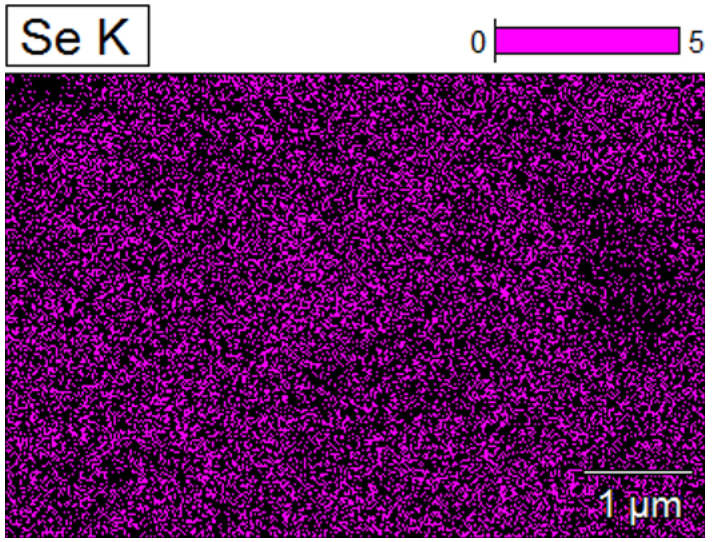


EDS MAPPING



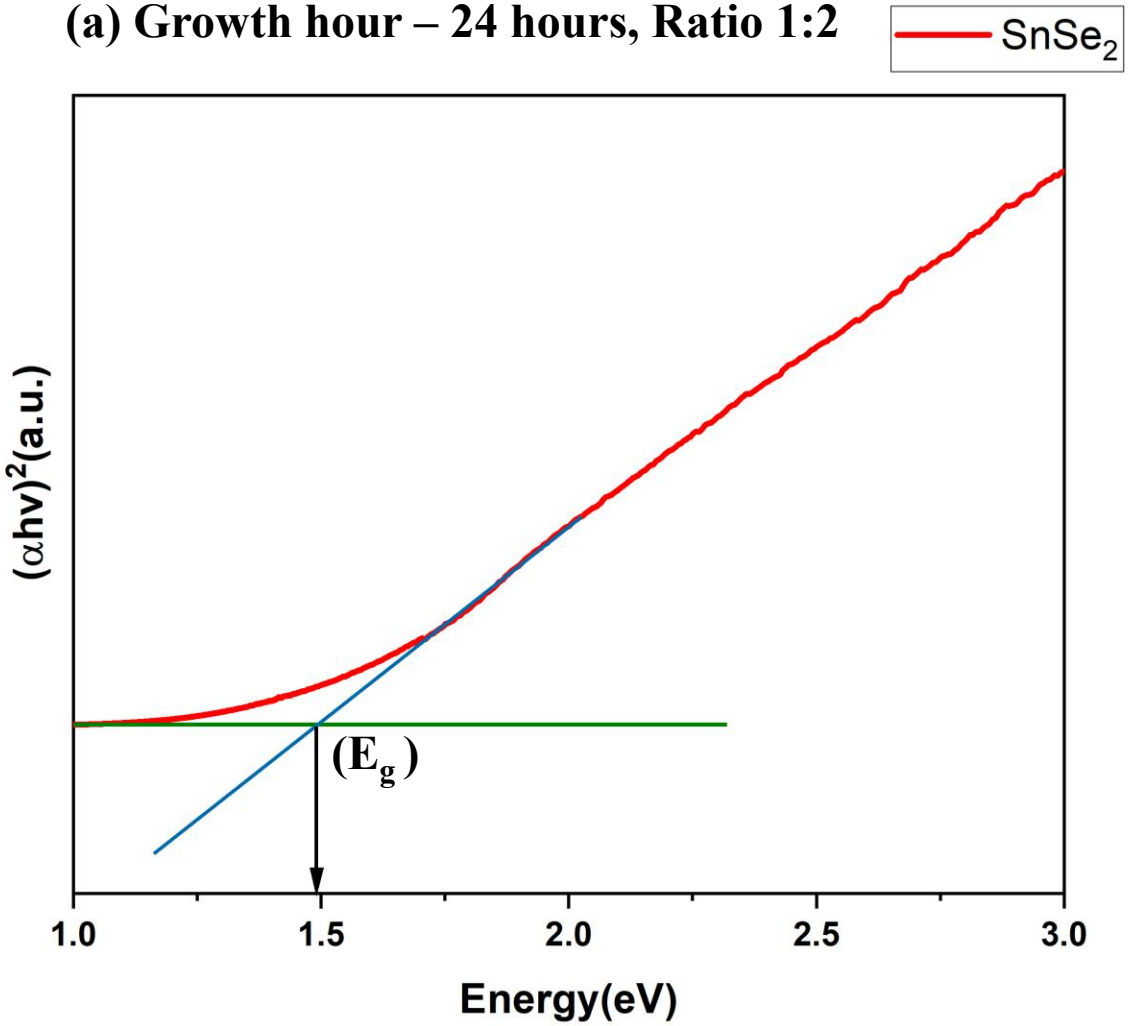




Element	Extracted Spectrum	Extracted Spectrum	Extracted Spectrum	Extracted Spectrum	Extracted Spectrum
	Net Counts	Weight %	Atom %	Atom % err	Chemical Formula
Se K	63650	51.44	61.42	0.71	Se
Sn L	361558	48.56	38.58	0.15	Sn
		100.00	100.00		

UV ABSORPTION SPECTRUM

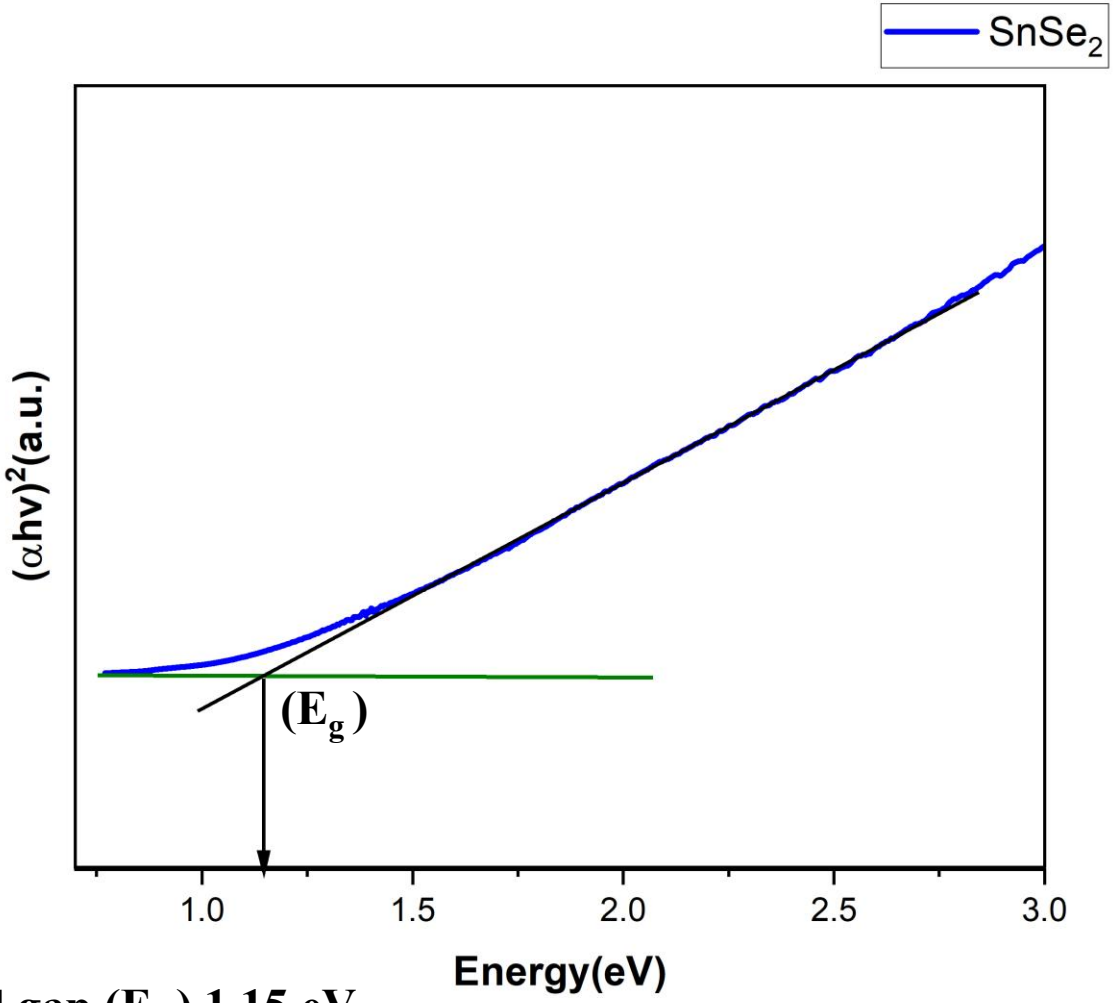
(a) Growth hour – 24 hours, Ratio 1:2



Band gap (E_g)1.50 eV approximately

UV ABSORPTION SPECTRUM

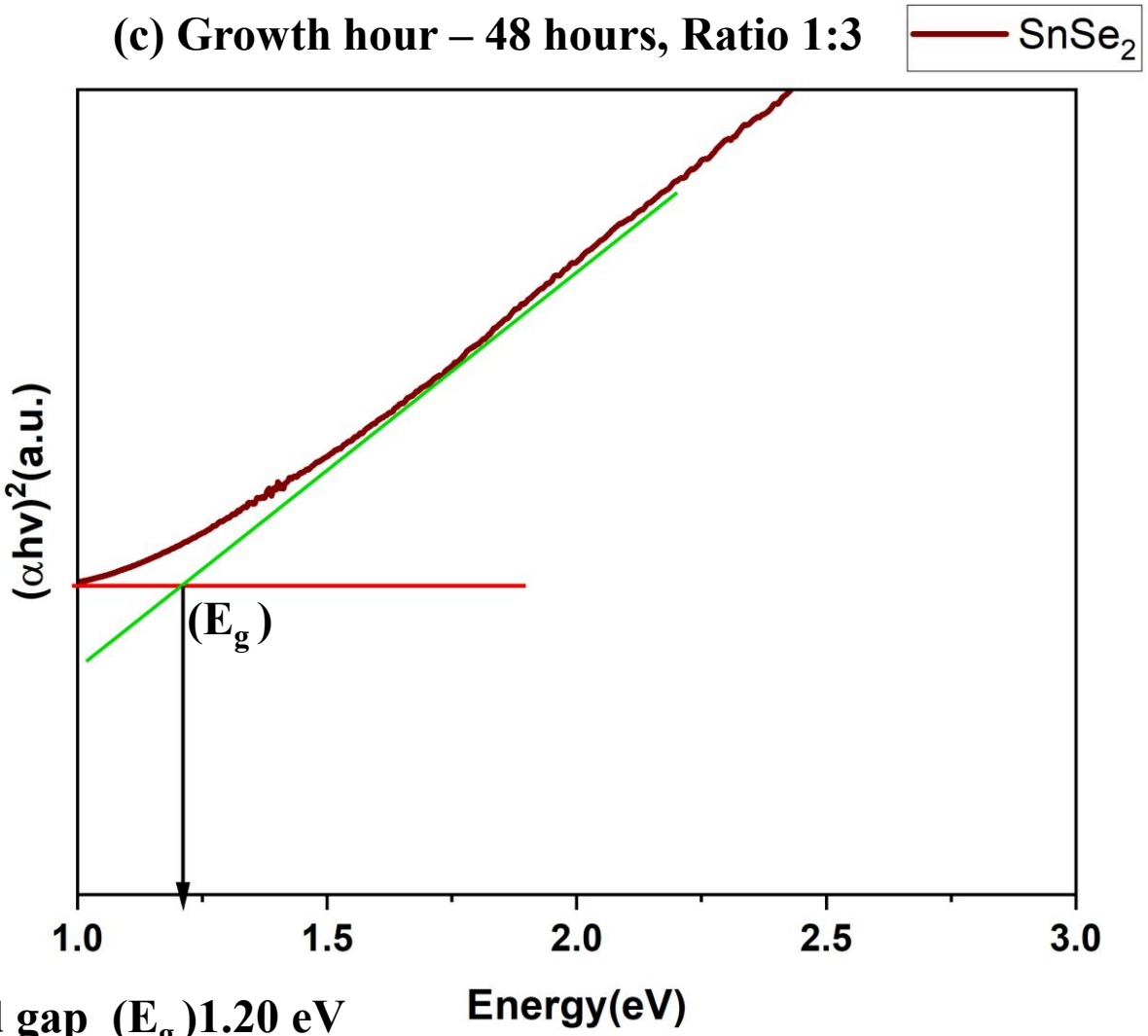
(b) Growth hour – 48 hours, Ratio 1:2



Band gap (E_g) 1.15 eV approximately

UV ABSORPTION SPECTRUM

(c) Growth hour – 48 hours, Ratio 1:3



Band gap (E_g)1.20 eV approximately


Thank
you!