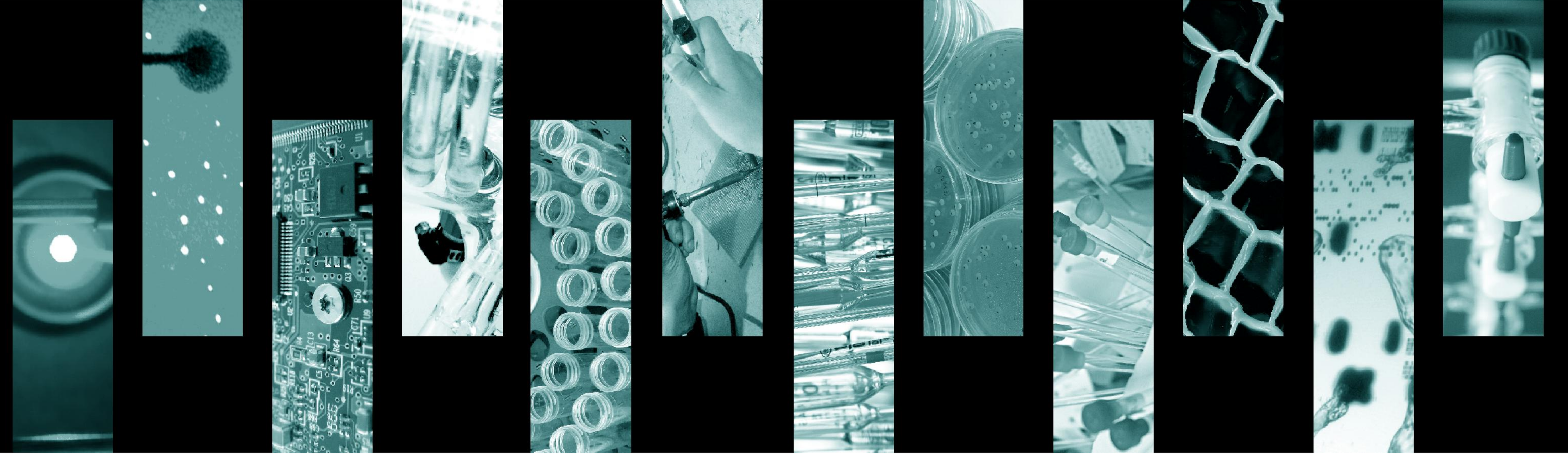

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Growth and Characterization of $SnSe_2$ by selenization of sputtered metallic precursors

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ABSTRACT

In the present work, we present a process to grow tin diselenide thin films by selenization at a maximum temperature of 470 ºC, of tin metallic precursor layers deposited by dc magnetron sputtering.

For this maximum temperature, disk-like grain morphologies were observed. Prominent XRD reflections at 2θ= 30.75º, 40.10º and 47.72º and vibration modes located at 119 cm^{-1} and 185 cm^{-1} were observed.

These results allowed concluding that the dominant phase is $SnSe_2$. The composition analysis, done by energy dispersive spectroscopy (EDS), showed that the films were close to being stoichiometric $SnSe_2$ with a Se to Sn ratio of 1.95.

Photoluminescence characterization was performed and revealed a dominant band at 0.874 eV and two other bands at ~0.74 and 1.08 eV with a lower relative intensities. The observed radiative transitions depend critically on the temperature.

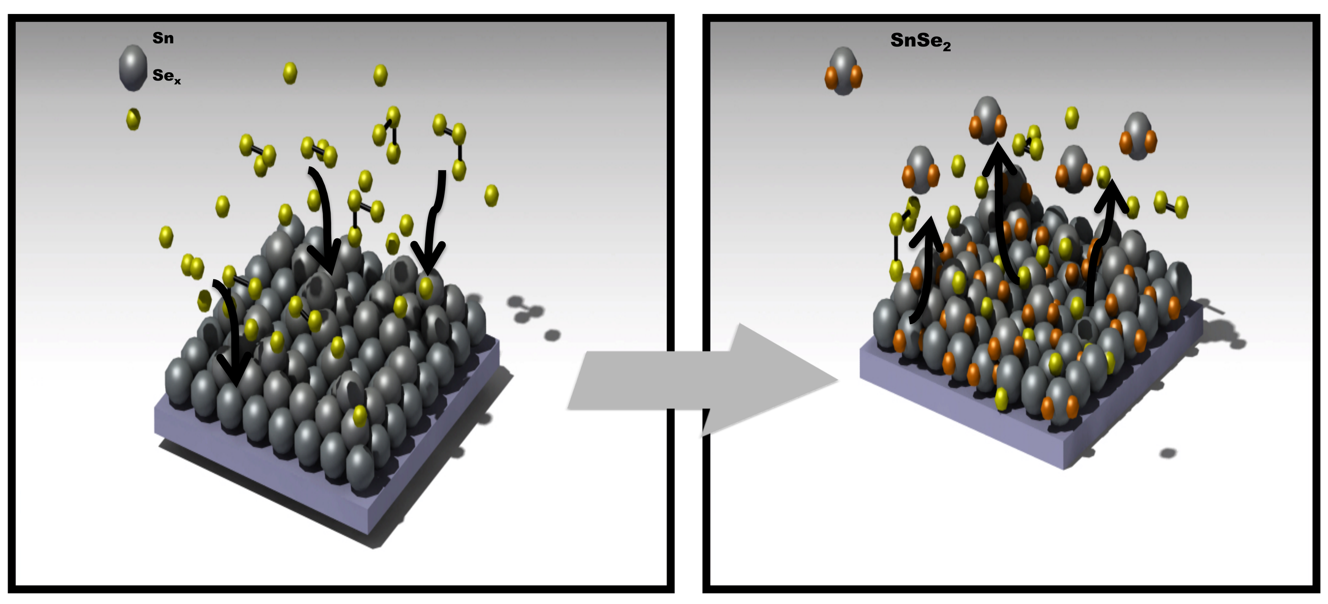
GROWTH METHOD

The growth method used in this work is constituted by two stages:

1) Deposition of the metallic precursor layer, Sn, by DC magnetron sputtering;
2) Chalcogen incorporation, Se, and the annealing process, which allow the crystalline phase formation.

Selenezation system:

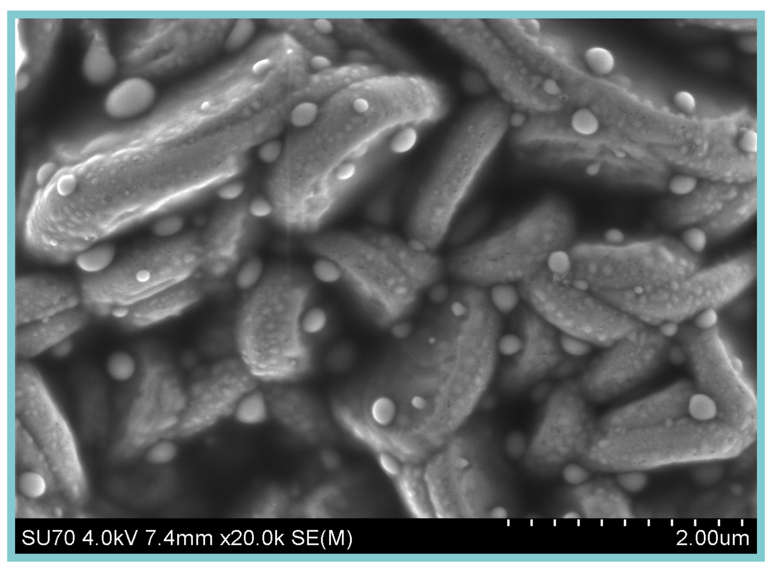
- Tubular furnace;
- Graphite box with 240 mg of high purity Se pellets;
- N_2+ 5% H_2 atmosphere at an operating pressure of 600 mbar;
- Heating rate: 10 $Kmin^{-1}$;
- Maximum selenization temperature: 470 ºC.



GROWTH Reaction schematics of the formation of $SnSe_2$

MORPHOLOGICAL ...

SCANNING ELECTRON MICROSCOPY



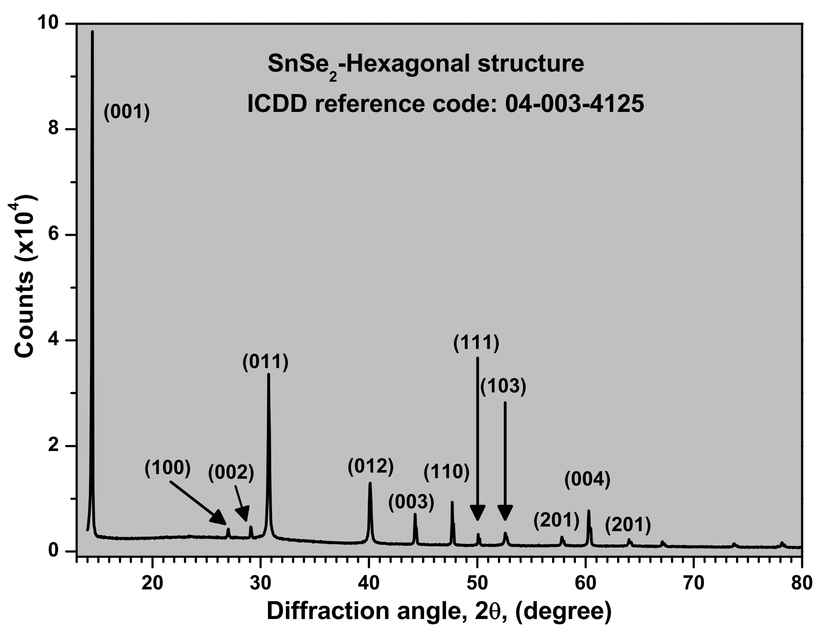
SEM analysis reveals disk-like grains morphologies.

This feature is well explained by the $SnSe_2$ layered structure.

SEM/EDS Hitach SU-70 equipped with a Rontec EDS system operated at an acceleration voltage of 4.0 KV

... STRUCTURAL ....

X-RAY DIFFRACTION



The films are composed of the hexagonal-$SnSe_2$ phase. The peaks are sharp which suggests that the samples have good crystalline quality.

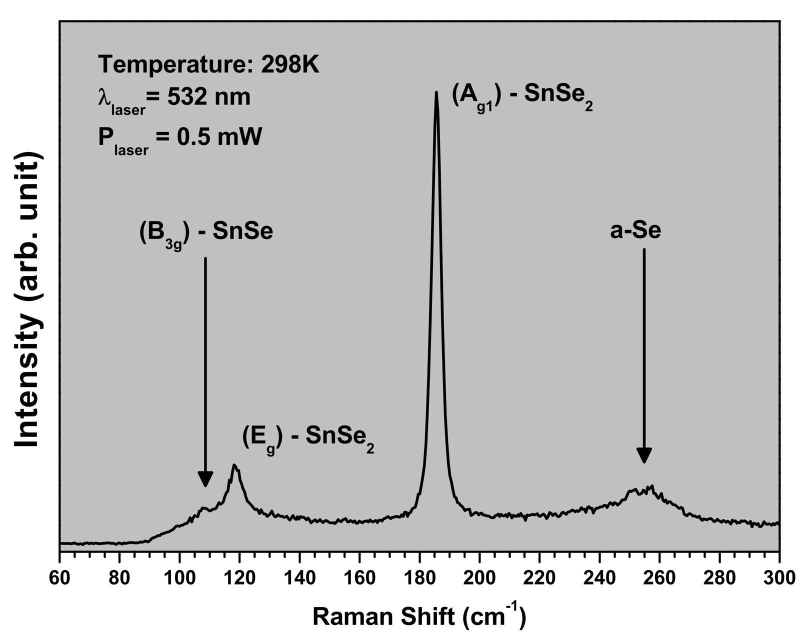
The peak located at a diffraction angle, 2θ=14.44º, corresponds to the (001) plane.

The formation of this phase from metallic Sn precursors and Se vapour may be interpreted as the result of the association reaction defined:

$$Sn(s) + 2Se(g) \longrightarrow SnSe_2(s)$$

XRD X´Pert MPD Philips PW 3710 system equipped with a CuK source

RAMAN SPECTROSCOPY

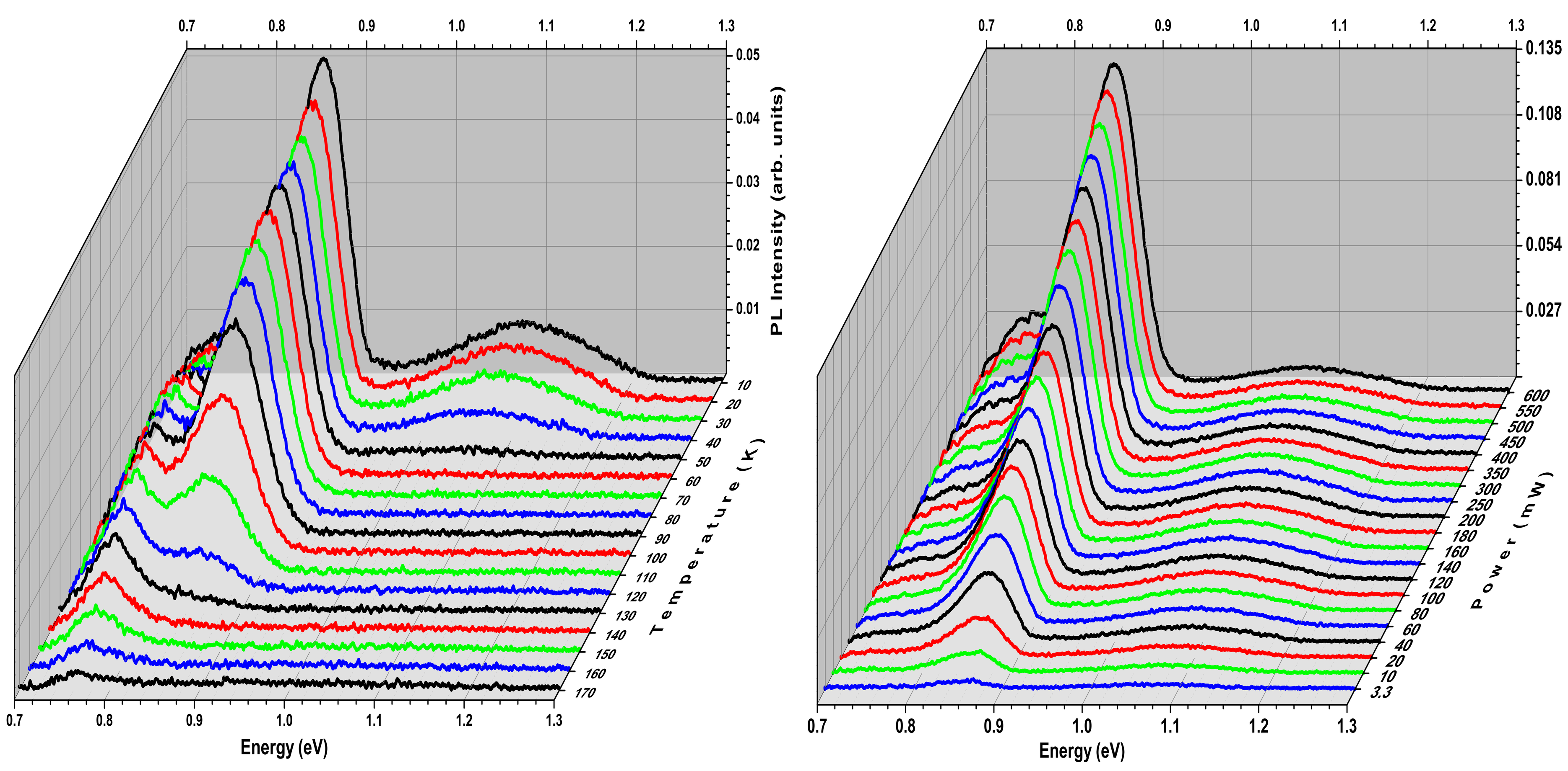


Raman scattering analysis allowed the assignment of peaks at 119 cm^{-1} and 185 cm^{-1} to the hexagonal-$SnSe_2$ phase and at 108 cm^{-1} corresponding to the orthorhombic-SnSe phase.

Traces of condensed amorphous Se with a characteristic Raman peak located at 255 cm^{-1} were observed.

RAMAN LabRam Horiba, HR800 UV spectometer, 532 nm excitation laser

... AND OPTICAL PROPERTIES OF TIN DISELENIDE THIN FILMS



- At 7 K, **three bands** are observed: ~0.74, ~0.874 and ~1.08 eV.
- **As temperature (T) is increased non-radiative de-excitation channels** are thermally activated: the dominant band at 0.874 eV disappears for T~130 K, whereas the intensity of the band at 0.74 eV increases; that band extinguish for T~170 K.
- At **low excitation power** (P) values just the dominant band at 0.874 eV is observed; **as P is increased**, no saturation is present and the other two bands start to be observed

PL Bruker IFS 66v FTIR spectometer, equipped with a Ge diode detector

CONCLUSIONS

Two-step method can be used to grow $SnSe_2$ films. This method is based on the deposition of tin metallic layer and a post annealing process in a selenium atmosphere.

Selenization temperatures at 470 ºC leads to films where $SnSe_2$ is the dominant phase.

Morphological analysis confirms the $SnSe_2$ disk-like grain morphology.

Optical analysis, at 7K, showed three bands located at 0.74, 0.874 and 1.08 eV.

ACKNOWLEDGMENTS

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