SYNTHESIS OF KESTERITE FOR THE PRODUCTION OF PHOTOVOLTAIC CERAMIC

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1. INTRODUCTION

Solar energy is presented as a viable, economic alternative to fossil fuels in the near future. Although nowadays silicon cells dominate the photovoltaic market, new technologies are being developed with promising results. One of these technologies is kesterite, included in thin-film solar cells. Kesterite ($Cu_2ZnSnS(Se)_4$) is a semiconductor material with space group $I\bar{4}$ (Fig. 1a) which is used as an absorbing layer and presents the advantage of containing less toxic elements and being cheaper than other materials currently used, such as chalcopyrite, $Cu(In,Ga)Se_2$ [1].

Generally, glass is used as a substrate in photovoltaic cells, but in this case a ceramic fixing background has been used, since the latter allows it to be included architecturally in buildings, being at the same time both a building material and an electricity generating source [2].

2. EXPERIMENTAL PROCEDURE AND RESULTS

Kesterite (CZTSe) has been synthesised by means of direct deposition of metal salts, a simple and economic method of synthesis which consists of dissolving the metal precursors of Cu, Zn and Sn in ethanol; in this way, we obtain the ink that is deposited using the doctor blade technique on the ceramic substrate covered with molybdenum (lower contact). Thermal treatment is achieved in a reduced atmosphere tunnel kiln and in the presence of the chalcogen (in this case, selenium), to insert it into the structure and form the kesterite crystals. The photovoltaic device is finalised with CdS layers (buffer layer) and i-ZnO/ITO (window layer) (Fig. 1b).

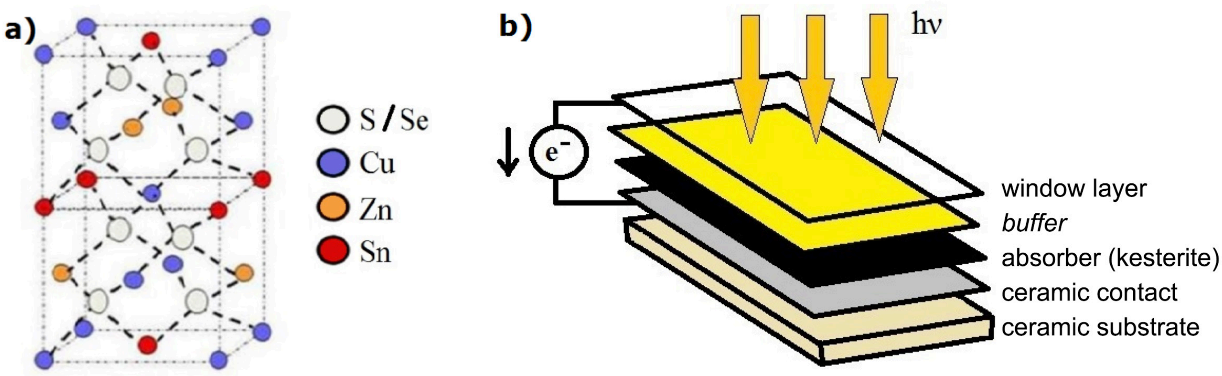

Figure 1: *a) Structure of kesterite, b) Device diagram*

Different synthesis temperatures have been studied during thermal treatment, between 400 and 650ºC. From the characterisation made using X ray diffraction (XRD), Raman spectroscopy and scanning electron microscopy (SEM) of the samples, it has been observed that in all of them, the phase sought, kesterite, appears. Fig. 2a shows the diffractograms, where the (hkl) (101), (112), (204), (312) and (008) planes of the selenium kesterite phase have been indexed. In these, we can see that by increasing the temperature, the crystallinity of this phase increases, although so does the presence of secondary phases, such as $MoSe_2$, formed on the CZTSe-Mo interphase. Raman spectroscopy has been used to confirm the presence of the kesterite phase. The Raman spectra obtained are shown in Fig. 2b. In all the samples, the principal modes of vibration corresponding to the kesterite phase (174, 195 and 233 cm^{-1}) have been observed, confirming the phase observed using XRD.

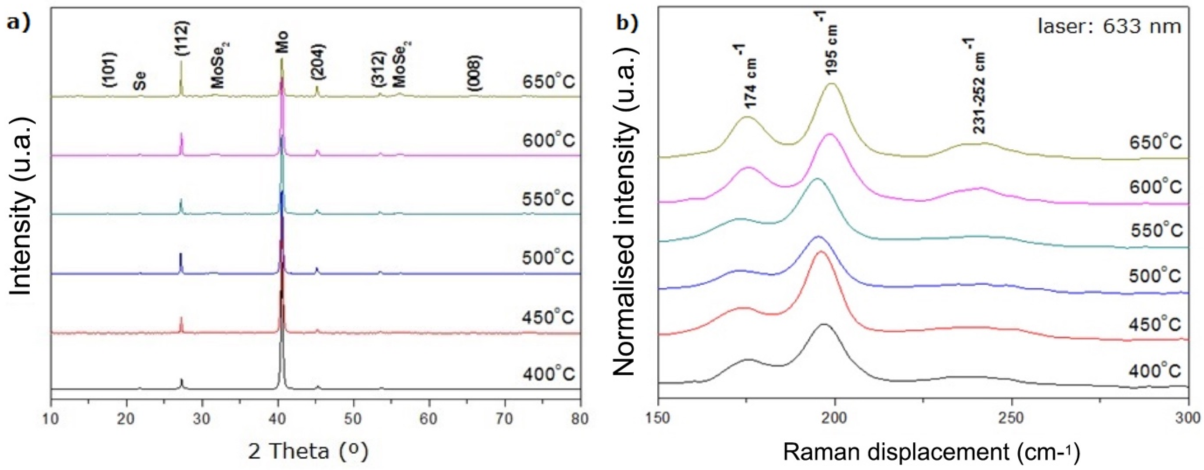

Figure 2: *a) Diffractograms, b) Raman spectra of the samples*

Through a study undertaken with SEM (Fig. 3), it has been noted that all the layers are compact, the surfaces are completely covered with CZTSe crystals and these increase in size with temperature. At temperatures in excess of 550ºC, the crystals present more imperfections and a partial fusion of the crystals begins to appear. For this reason, a temperature of 550ºC has been chosen as the optimum one for synthesis.

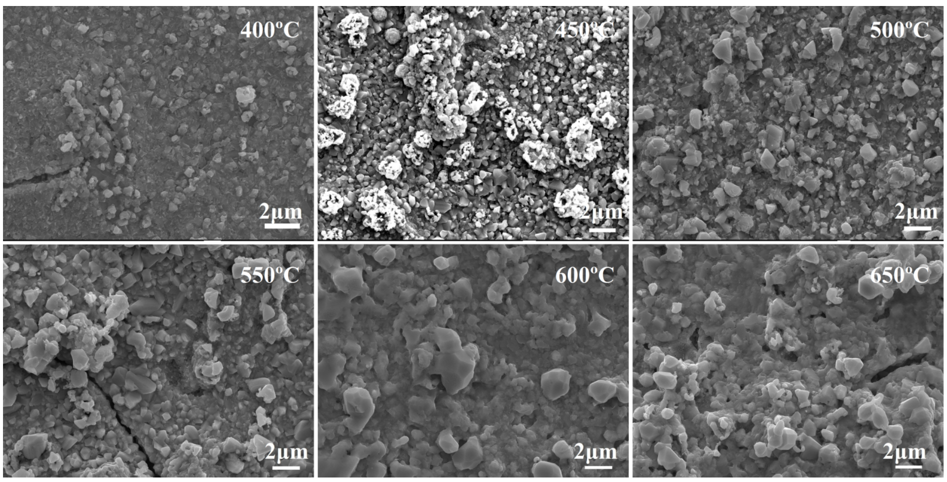

Figure 3: *SEM micrographs of the samples*

3. CONCLUSIONS

The synthesis of kesterite, $Cu_2ZnSnSe_4$, has been achieved by direct deposition of metal salts onto ceramic fixing background.

The phase sought has been formed at all the synthesis temperatures studied, 550ºC being the temperature chosen as optimal.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

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