LocalEnergy
Local Resources for Multifunctional Tetrahedrite-based Energy-Harvesting Applications
http://localenergy.lneg.pt/

SYNTHESIS AND CHARACTERIZATION OF $Cu_{12-x-y}Zn_xFe_ySb_4S_{13-z}$ TETRAHEDRITES

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Background

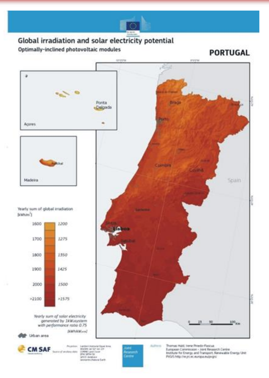
LocalEnergy project focuses on the valorization of endogenous resources (solar and mineral) through the development of energy-harvesting applications based on the tetrahedrite mineral, which offers a high exploitation potential. Naturally occurring tetrahedrite series consists of earth-abundant and relatively non-toxic elements and can be generically expressed as $Cu_6[Cu_4(Fe,Zn)_2]Sb_4S_{13}$. Besides that, tetrahedrites show p-type semiconductor material behavior with high Seebeck coefficient, a complex cubic crystal structure and extremely low thermal conductivities at moderate temperatures, reaching zT~0.7 around 700K after adequate doping. Owing to these properties they are considered as a suitable and promising thermoelectric material.

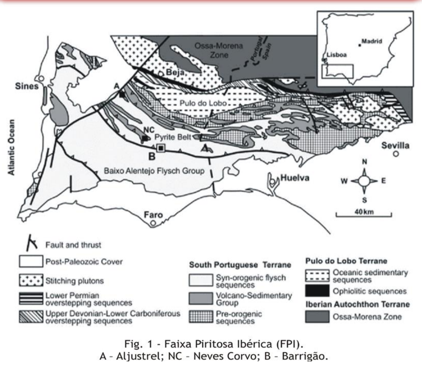
LocalEnergy characteristics

Valorization of two important endogenous resources

Solar energy
Portugal has a high level of solar energy irradiation

Mineral
Tetrahedrite is a local mineral resource, present in the IPB





Develop materials and systems for energy-harvesting applications
- Thermoelectric materials
- New absorbers materials for TFSC

Tetrahedrite-based materials ($Cu_{12-x}M_xSb_4S_{13}$)
- Natural
- Synthetic
- Synthetic

Powder sintering of synthetic tetrahedrites

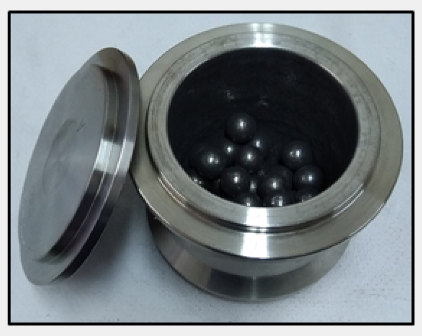
Target composition
$Cu_{12-x-y}Zn_xFe_ySb_4S_{13-z}$
x = 0, 0.5 and 1.0
y = 0, 0.5 and 1.0
z = 0, 0.1 and 0.3

Raw materials

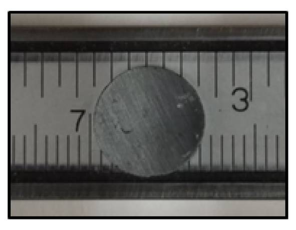
Mixed and sealed inside glove box

Mechanical alloying
380 rpm // 2 h
BPR 20:1
stainless steel jars and balls (15 mm)

PM400 - Retsch



Hot-pressing
515 ºC // 1h30m
~ 60 MPa
0.6 g



Objectives of the presente work

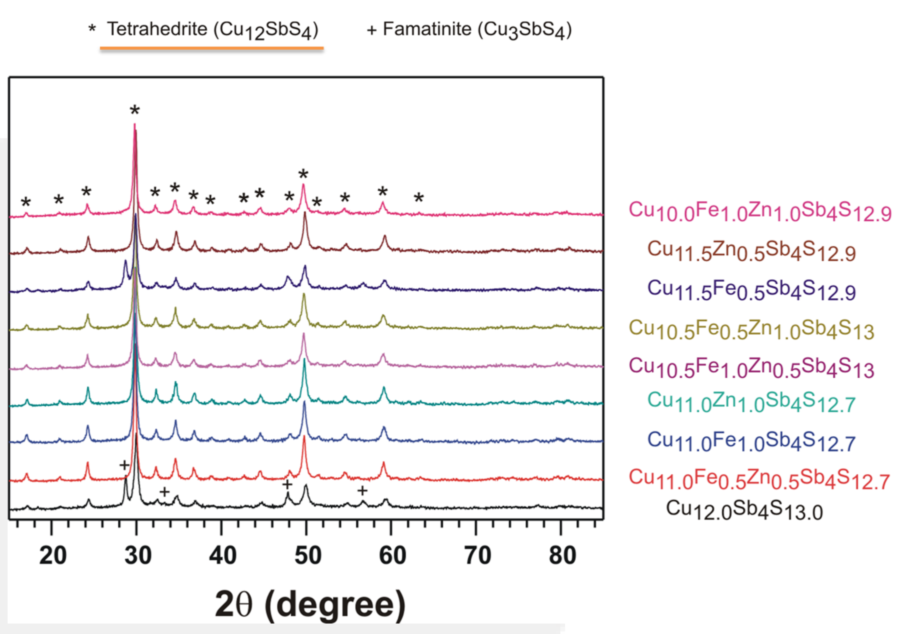
Develop a fast-solid-state synthesis method based on powder sintering for producing synthetic tetrahedrites.

Conclusions

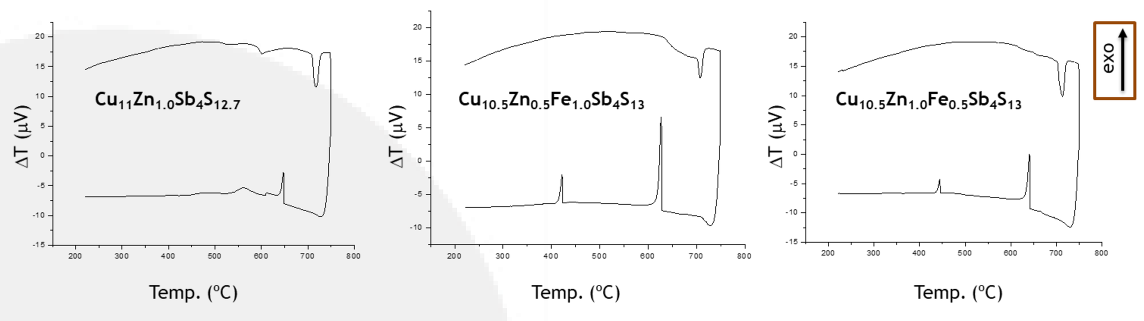
- Direct synthesis of single-phase tetrahedrite materials achieved after a short mechanically alloying step (2 h).
- Fully dense bulk tetrahedrite materials were obtained by hot-pressing.
- Reduction in the overall processing time when compared with that of conventional synthesis methods.

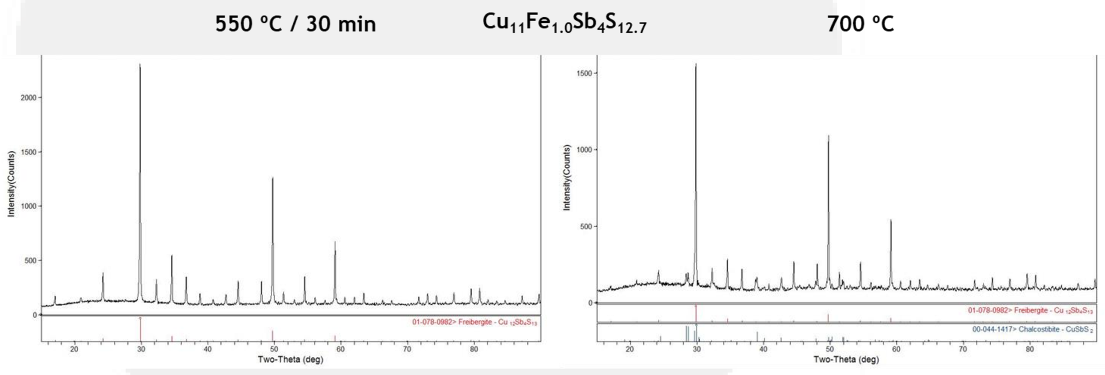
Results

Typical XRD patterns of the milled powders showing the formation of the tetrahedrite phase



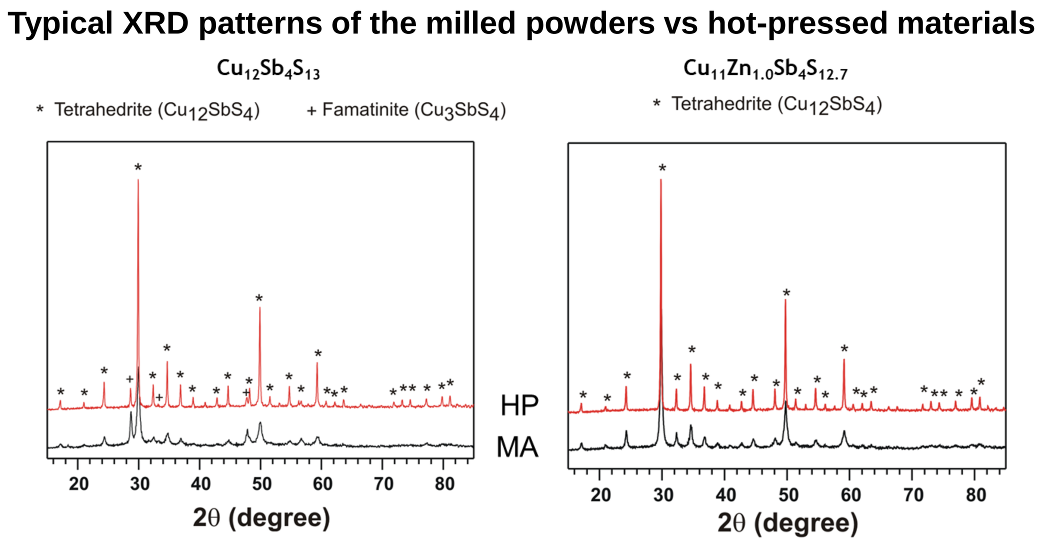
Typical DTA curves milled powders



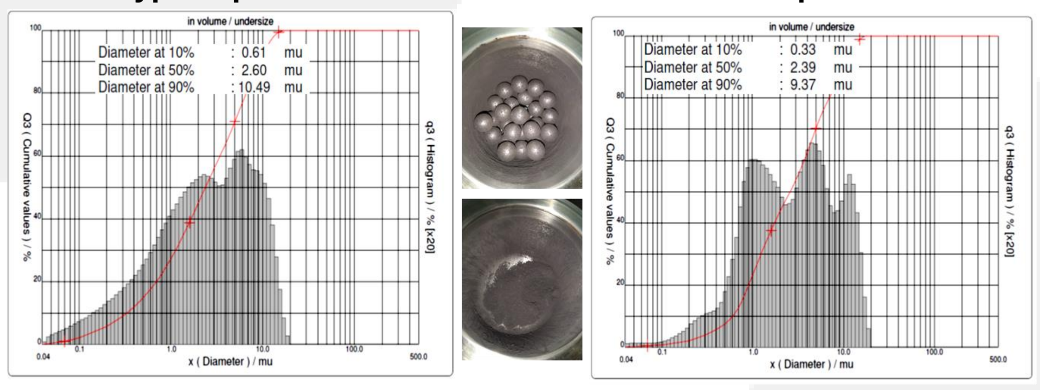


XRD patterns obtained after heating the milled powders at 500 ºC and 700 ºC

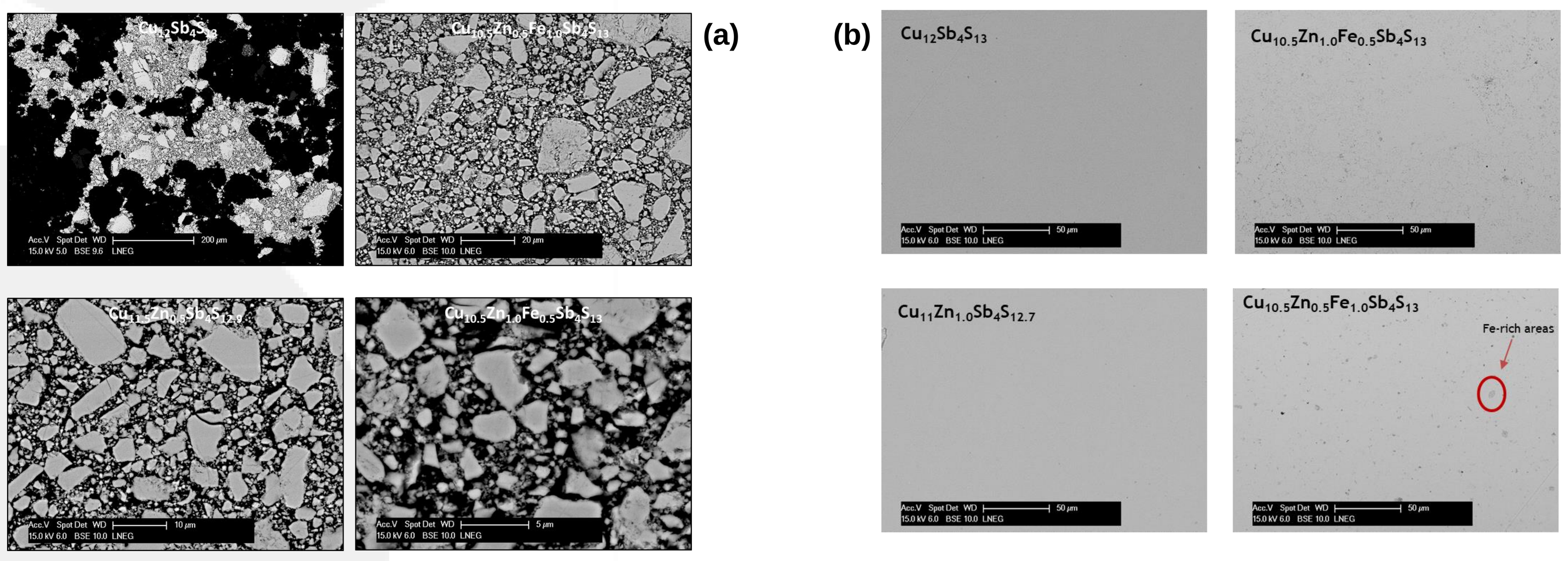
Typical XRD patterns of the milled powders vs hot-pressed materials



Typical particle size distribution of the milled powders



Typical BSE images of the (a) milled powders and (b) hot-pressed materials



Typical density (g/cm³) obtained for the hot-pressed materials

$Cu_{12}Sb_4S_{13}$	4.34
$Cu_{11}Zn_{0.5}Fe_{0.5}Sb_4S_{12.7}$	4.89
$Cu_{11}Fe_{1.0}Sb_4S_{12.7}$	5.01
$Cu_{11}Zn_{1.0}Sb_4S_{12.7}$	4.97
$Cu_{10.5}Zn_{0.5}Fe_{1.0}SbS_{13}$	4.88
$Cu_{10.5}Zn_{1.0}Fe_{0.5}Sb_4S_{13}$	4.91
$Cu_{11.5}Fe_{0.5}Sb_4S_{12.9}$	4.80
$Cu_{11.5}Zn_{0.5}Sb_4S_{12.9}$	4.98
$Cu_{10.0}Zn_{1.0}Fe_{1.0}Sb_4S_{12.9}$	4.26

4.91 - 5.02 (g/cm³)

Acknowledgements

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