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Micro-encapsulation of Fe-Si ultra-high temperature phase change material (PCM)

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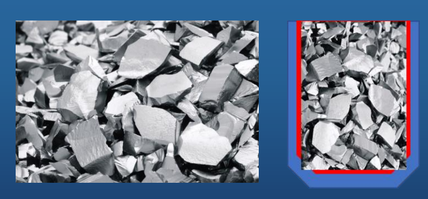
ABSTRACT

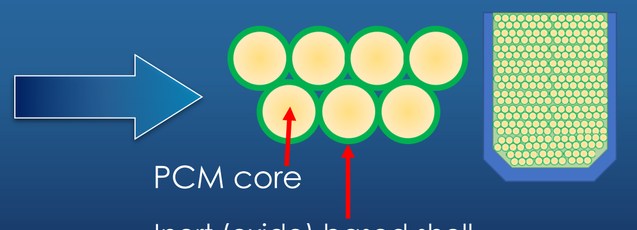
In this work, a micro-encapsulation approach was introduced for the first time to a binary Fe-Si phase change material (PCM). The alloy composition was developed through a thermodynamic modelling. After that, a multistep processing was designed and applied to fabricate spherical microcapsules having a structure of SiO_2 shell and the Fe-Si alloy core. Finally, basic thermophysical properties of encapsulated Fe-Si powders were experimentally validated in DSC studies.

CONCEPT & RESEARCH OBJECTIVE

Development of a new PCM/container design based on a SELF-ENCAPSULATED MICROCAPSULES having **PCM core and ceramic shell**

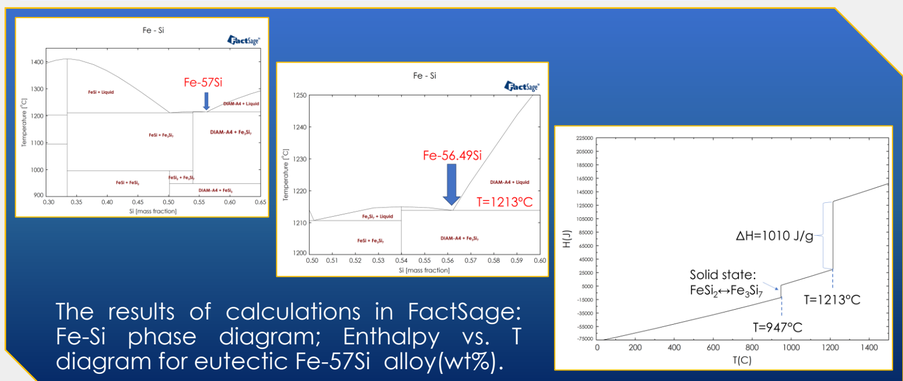


Conventional PCM/container design



Each (micro)particle is like an individual PCM/container system!

1 Thermodynamic modelling and selection of Fe-Si PCMs



The results of calculations in FactSage: Fe-Si phase diagram; Enthalpy vs. T diagram for eutectic Fe-57Si alloy(wt%).

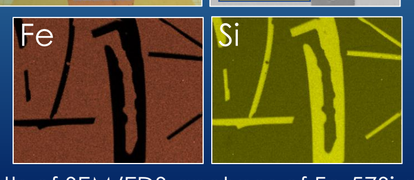
2a Fabrication of Fe-57Si alloy ingot

Initial materials

A mixture of Fe-75Si ferrosilicon (ELKEM, Norway) and pure Fe

Induction melting and casting

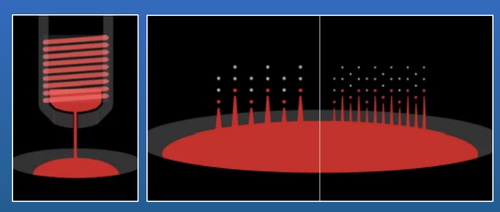
Fe-57Si alloy ingot



The results of SEM/EDS analyses of Fe-57Si alloy

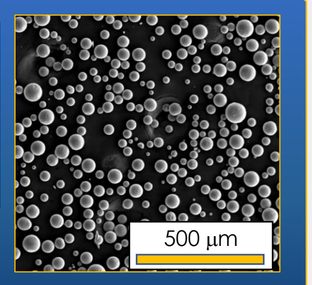
2b Fabrication of Fe-57Si spherical powders from the ingot

AMAZEMET rePOWDER® - Ultrasonic Powder Atomizer



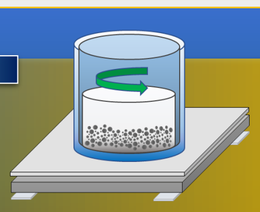
- **rePowder**, unlike gas atomization systems, uses ultrasonic vibration for metal atomization.
- Metal is poured or melted directly on the vibrating part resulting with tiny droplets being ejected from the surface.
- Droplets solidify in surrounding inert gas atomosphere forming powder particles.

See the process here!



Fe-57Si spherical powders

3 Microencapsulation of Fe-57Si spherical powders



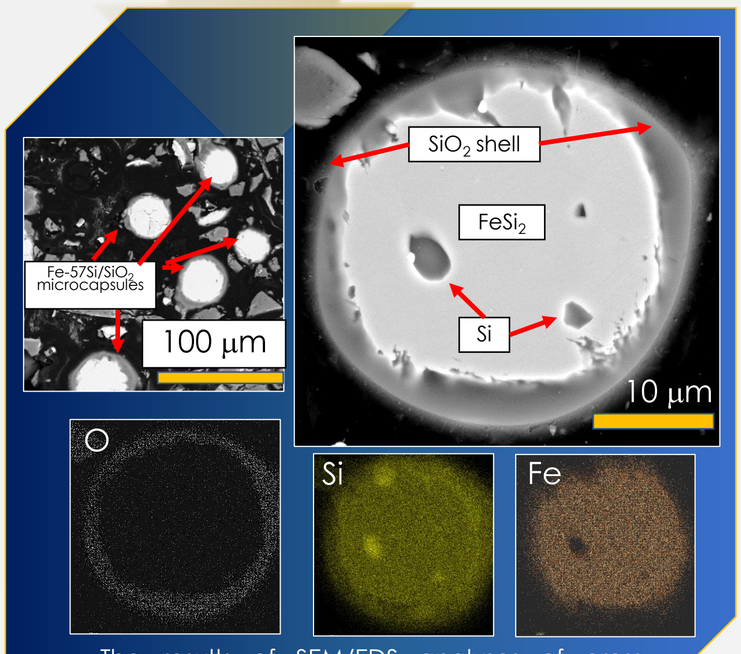
II) Filtering & drying

III) **High temperature oxidation treatment**

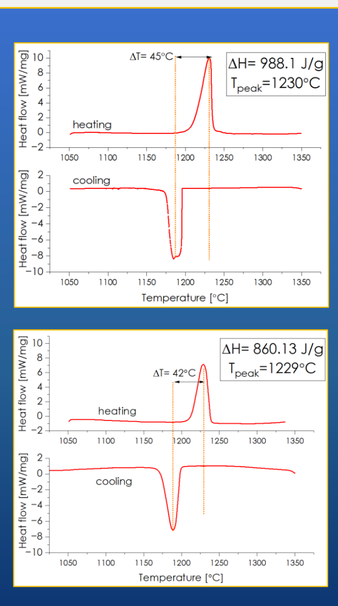
(development of oxide shell)

I) Impregnation of Fe-57Si powders in **nano SiO_2** suspension (surface activation)

4 RESULTS – characterization of microcapsules



The results of SEM/EDS analyses of cross-sectioned encapsulated Fe-57Si powders



DSC curves recorded during heating/cooling of Fe-57Si microcapsules.

5 CONCLUSIONS AND FUTURE WORKS

- The Fe-57Si eutectic alloy shows promising properties as a PCM for LHTES systems operating at T>1200˚C.
- Spherical powders made o the Fe-57Si alloy have been successfuly fabricated by the ultrasonic atomization.
- Proposed two-stage process allows producing Fe-57Si/SiO_2 core/shell MICROCAPSULES.
- Future works on thermocycling properties of the microcapsules are needed.

Acknowledgments

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