平成 28 年度　エネルギー･マテリアル融合領域研究センター　若手研究員等研究助成　報告書

研究テーマ名：相変化物質（Phase Change Material: PCM）のマイクロカプセルの開発	研究室名：エネルギーメディア変換材料 氏名：盛 楠

1.研究成果の概要

1.1 Introduction

Thermal energy storage (TES) involves the storage of both sensible and latent heat, which has recently attracted increasing interest related to thermal industrial applications such as solar thermal technologies, aerospace applications, and steel-making industry. Energy storage is essential whenever there is a mismatch between the supply and consumption of energy. One of the solutions proposed is using latent heat of phase change materials (PCMs). PCMs with their high thermal storage density at almost isothermal conditions and their availability at wide range of phase transitions promote an effective mode of storing thermal energy. In last decade, the encapsulation of the PCM has attracted interest as a barrier to leakage of liquid PCM during heat storage. An essential advantage of the encapsulated PCM is prevent the leakage of liquid PCM during heat storage. Meanwhile, the encapsulation could provide more advantages such as a large heat transfer area, barriers against harmful environmental reactions, improves thermal and mechanical stability, and provides structural stability and easy handling. In this research, We investigated the preparation of micro-encapsulated PCMs (MEPCMs) where the PCM consisted of Al-25 wt.% Si microspheres and the capsule of Al_2O_3.

1.2 Experiment

The raw material for the preparation of Al-25 wt.% Si spherical particles (purity 99.0 %) was purchased from Hikari Material Industry Co. Ltd.. The particles were prepared by a spinning disk atomisation method, had an average diameter of 36.3 μm, melting point at 577 ºC and latent heat of 432 $J \cdot g^{-1}$. The MEPCM of Al-25 wt.% Si alloy was prepared by using two steps: First is boehmite treatment in boiling distilled water to form an AlOOH shell on the surface of the alloy. Secondly, a stable Al_2O_3 shell was formed on the Al-25 wt.% Si core by heat-oxidation treatment in an oxygen atmosphere. The experimental procedure is schematically summarized in Fig. 1.

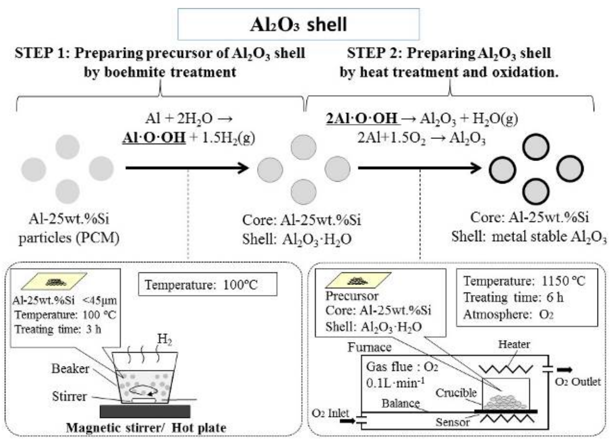

Fig. 1 Experiment procedure to prepare MEPCMs. The MEPCMs were prepared by two steps: (1) precursor of Al_2O_3 shell by boehmite treatment, (2) Al_2O_3 shell preparation by heat-oxidation.

1.3 Results

Fig. 2 shows EDS elemental mapping analysis of raw material (Al-25 wt.% Si). The Al and Si element could be clearly observed on the spherical shape of raw material, and no oxygen could be found on the surface. Fig. 3 shows EDS elemental mapping analysis of the samples after boehmite treatment. The Al and Si element show the similar images, and the oxygen element could be observed on the surface with slight color. This indicated the AlOOH precursor of Al_2O_3 shell was formed during this step. To synthesis compact and stable Al_2O_3 shell, the heat-oxidation step is necessary. Fig. 4 shows EDS elemental mapping analysis of the Al-Si partials subjected to heat-oxidation after boehmite treatment. The spherical Al-Si particles show less Si on the surface, and the oxygen element uniformly covered the whole particle. EDS image of the O element show more dense color than the O element observed in Fig. 3, this indicated more O element could be

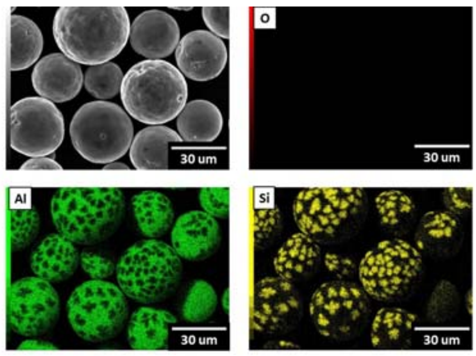

Fig. 2 EDS elemental mapping of the Al-25 wt.% Si raw material.

observed on the particle surfaces after heat-oxidation. The surface morphology of the particles after heat-oxidation was also changed. Some embossment could be observed on the surface. The formation of Al_2O_3 shell could be divided in three stages. In stage 1, from room temperature to about 580 ^{o}C, the dehydration of AlOOH, formed during the boehmite treatment, took place. A fast oxidation of Al occurred in Stage 2, from 580 ^{o}C to 690 ^{o}C, above the Al-Si eutectic melting temperature (577 ^{o}C). The oxygen was supplied to the Al-Si core through shell cracks that formed following the rapid volume expansion of the core. And stage 3, from 690^{o}C to the end of oxidation, corresponded to further oxidation of Al contained in the inner core, and the cracks formed during stage 2 was self-repaired. The embossments observed in Fig. 4 corresponding to the self-repaired parts.

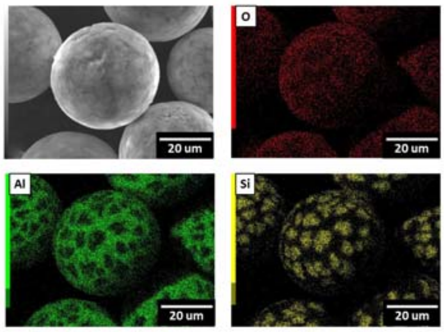

Fig. 3 EDS elemental mapping of the samples after boehmite treatment.

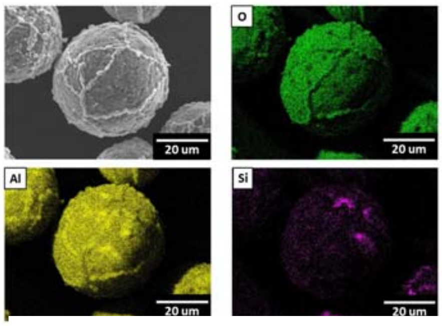

Fig. 4 EDS elemental mapping of the samples after heat-oxidation.

4 Conclusions

An MEPCM consisting of Al-25 wt% Si particles of 36.3 μm average diameter core/ PCM and Al_2O_3 shell was successfully developed. The MEPCM showed characteristics such as high heat storage density, high thermal responsibility, and high endurance for heat storage or transport media, for high temperature applications.

2.研究成果発表リスト (口頭発表・論文等)

①既発表

国内会議：

(1) Nan Sheng, Takahiro Nomura, and Tomohiro Akiyama. Microencapsulated Phase Change Material (PCM) for High-temperature Thermal Energy Utilization. 5th Hokkaido University – Seoul University Joint Symposium, November 25,2016.

学術論文：

(1) Takahiro Nomura and Nan Sheng, et al. Microencapsulated phase change materials with high heat capacity and high cyclic durability for high-temperature thermal energy storage and transportation. Applied Energy, 188 (2017) 9-18.

(2) C. G. Han, C. Zhu, and N. Sheng, et al. Enhanced cycling performance of surface-doped LiMn2O4 modified by a Li_2CuO_2-Li_2NiO_2 solid solution for rechargeable lithium-ion batteries. Electrochimica Acta, 224 (2017) 71-79.

(3) C. G. Han, C. Zhu, and N. Sheng, et al. A facile one-pot synthesis of FeO_x/ carbon/ graphene composites as superior anode materials for lithium-ion batteries. Electrochimica Acta, 235 (2017) 88-97.

②発表予定

Elsevier 投稿予定

3.研究結果のプロジェクト研究等への活用・展開予定

More stable and applicable MEPCMs should be achieved. Some reagent which could promote the growth of the precursor of Al_2O_3 shell will be investigated. Research on the condition of heat-oxidation process is also important.

4.特記事項

注：全体で 2 ページ以内であれば枠の大きさを自由に変更可。