Non-fluid Latent Thermal Storage Material

Tsuyoshi Morimoto Naoki Furukawa Keiko Kizawa
Atsuko Sano Akira Nagai Hiroshi Yokota

Composite Materials Research Dept.,
Advanced Technology Research & Development Center,
Research & Innovation Promotion Headquarters

1 Abstract

Methods for handling heat vary greatly depending on the environment. For example, heat can be handled as energy or as something to be disposed of. In the former case, there is demand for technologies for utilizing waste heat from the perspective of saving energy. In the latter case, there is demand for technologies for releasing heat and for cooling in order to suppress rises in the temperatures of electronic devices associated with the high-density integration of increasingly smaller semiconductor packages. To address both of these issues, we focused on developing a latent thermal storage material that can retain and absorb heat. The latent thermal storage material we developed is a type of phase change material (PCM). The thermal storage performance of PCMs is most effective at the temperature where the material changes phases from a solid to a liquid. To expand the applicability of PCMs, we have developed a PCM that does not flow even as it changes phases, and have evaluated its effectiveness.

2 Characteristics of the Developed Product

・The material does not flow above the phase change temperatures.
・The material exhibits excellent thermal storage performance, as well as strength and flexibility.
・The form of the material can be fixed after the filling and coating processes.

3 Background of the Development

The latent thermal storage material exhibits thermal storage properties at certain temperatures (the melting point and the boiling point) as it changes phases from a solid to a liquid or from a liquid to a gas. Therefore, the material has limited applications and can only be used inside sealed structures. As a way to suppress phase changes, the microencapsulation of the latent thermal storage component has been investigated.[1] The material comprises a thermal storage component (associated with the solid-to-liquid phase change), such as an n-paraffin, encapsulated in a polymer component, such as melamine or acrylic resin. This polymer shell allows the material to maintain its shape even when it liquefies at temperatures exceeding the phase-change point. However, because the powder-like capsules have a diameter of only several tens to several hundreds of micrometers, the molded material cannot maintain its shape unless it is combined with a binder. In addition, a high level of filling inside the binder is required in order to improve the thermal storage performance, but it is difficult to achieve a mixture that has both sufficient strength and flexibility.

By applying our technologies related to the design of polymer molecules as well as our mixing and dispersing technologies used in composite materials, we have developed a non-fluid latent thermal storage material that has excellent thermal storage performance while also retaining its strength and flexibility.

4 Technical Details

(1) Conceptual diagram of the material

Figure 1 shows a conceptual diagram of the material.

As shown in (a), normal latent thermal storage materials melt and become fluid at temperatures exceeding the phase-change point. To prevent the material from becoming fluid, we developed materials via two different methods as shown in (b) and (c). In (b), we achieved non-fluidity by containing crystal components in a polymer matrix. In (c), the same was achieved by making the crystal structures bond with the side chains of a polymer. Furthermore, by introducing a functional group capable of a crosslinking reaction, the material in (c) can be filled into a complex shape or hardened after coating.

(2) Characteristic of the material: Effective in suppressing rises in temperature

As shown in **Figure 2**, we verified the effectiveness of the developed material in suppressing rises in temperature, by using

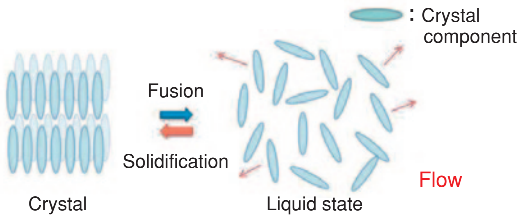
a PV module, on the back sheet of which the thermal storage material was attached. **Figure 2** also gives an overview of the measurement.

Figure 3 shows the measured results for (a) the temperature of the surface of the back sheet and (b) the power generation characteristic associated with changes in temperature after irradiation by a solar simulator. The power generation characteristic is given in terms of maximum power (Pmax).

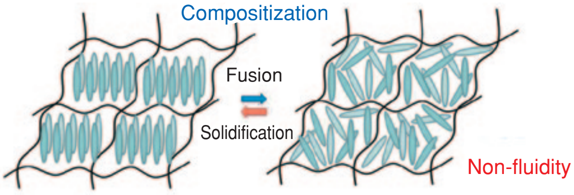
The results indicated that rises in temperature were suppressed near the melting point of the thermal storage material. In addition, although the power generation characteristic tended to decrease as the temperature rose, this decrease was mitigated by reducing the speed at which the temperature rose.

Table 1 Example of feature for non-fluidity thermal storage material and assumption product form

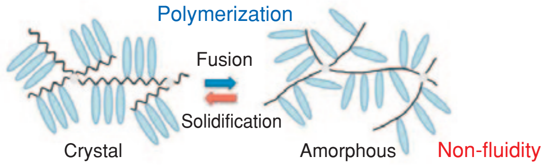
Item	Unit	Thermal storage material being developed		
Sample name	—	A	B	C
Composition	—	Composite		Polymer
Phase-change point (melting point)	℃	18	75	35
Heat of fusion	J/g	137	143	71
Assumed product form	—	Sheet		・Sheet ・Paste (curable)



(a) General latent thermal storage material

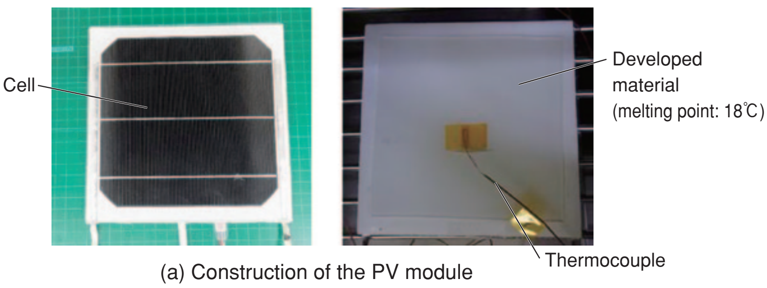


(b) Composite thermal storage material

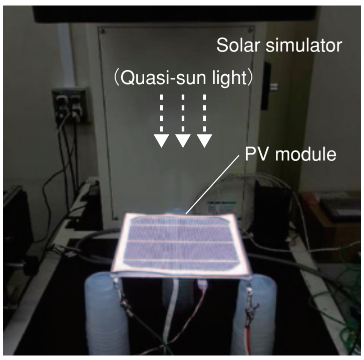


(c) Polymer thermal storage material

Figure 1 Conceptual diagram of phase change of latent thermal storage material

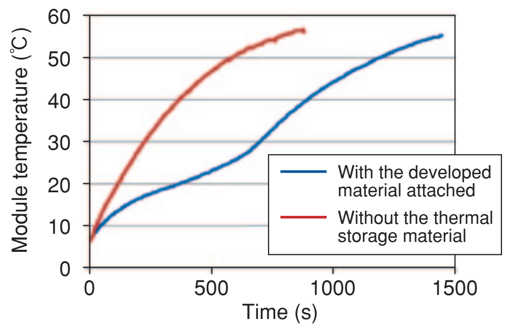


(a) Construction of the PV module
Light-receiving surface (left), back-sheet surface (right)

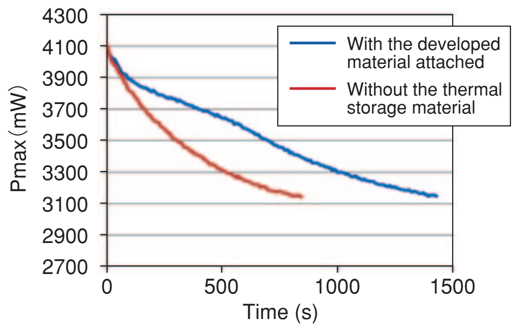


(b) Evaluated appearance

Figure 2 Evaluation overview of PV module



(a) Temperature rise of the PV module



(b) Change in the Pmax of the PV module

Figure 3 Effect of latent thermal storage material

5 Future Business Development

・New applications as a heat absorbing material.

【Relevant patent】

1) Japanese Patent No. 5651272