Three-Dimensional Printing of Continuous Carbon Fiber Reinforced Shape Memory Polymer Composites

Yongsan An[1, a)], and Woong-Ryeol Yu[1, b)]

[1]*Department of Materials Science and Engineering and Research Institute of Advnaced Materials (RIAM), Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Republic of KOREA*

[a)] *drmountain@snu.ac.kr*
[b)] *Corresponding author: woongryu@snu.ac.kr*

Abstract. Shape memory polymer (SMP) is a smart material that is able to recover its permanent shape from temporary one by external stimulus such as heating. Potential applications of SMP to functional products such as self-configurable antennas and folded origami have been proposed, but their processability is not sufficient to fabricate complex structures. A three-dimensional (3D) printing method has been suggested as a manufacturing tool for the complex morphing structures. In addition, shape memory polymer composites have been also studied to overcome the low mechanical properties of polymer. In this research, 3D printing system of continuous carbon fiber reinforced SMP (CCF/SMP) was constructed using a material extrusion type-3D printer. An epoxy type of SMP was used for matrix. Continuous carbon fiber tows were impregnated by pre-cured SMP in the nozzle and were then extruded from the nozzle, being accumulating into specific shape layer by layer. Here, pre-cured SMP had too low viscosity to maintain its shape, so that nanoclay was used to increase the viscosity of pre-cured SMP. Since the nanoclay/SMP nanocomposite matrix shows shear-thinning behavior, the matrix viscosity is lowered enough to be extruded from the nozzle of small diameter. After being extruded from the nozzle, the SMP nanocomposites was then solidified. Then the 3D printed object was cured by heating in a chamber. The CCF/SMP showed great mechanical properties compared to those of conventional 3D printed polymer in the fiber direction. Their shape memory behavior and thermomechanical properties were characterized. Then, a complex 3D shapes composed of basic unit cells was designed considering the fiber orientation. The possibility of developing morphing structures using 3D printing of continuous carbon fiber reinforced SMPC was investigated and will be presented in detail at the conference.

Key words. Shape memory polymer composite, additive manufacturing, continuous fiber reinforced polymer, 4D printing