HIGH THERMAL CONDUCTIVITY COMPOSITE WITH SHEAR-INDUCED ALLIGNED BORON NITRIDE NANOSHEETS

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1 INTRODUCTION

3D printing has become commonplace for the manufacturing of objects with unusual geometries. It is reported that shear force produced by the fused deposition modelling (FDM) 3D printer could induce the filler to be aligned along the printing direction because of the shear force. [1] It has been used to improve the mechanical properties of the composite, or achieve the shape-morphing structure. [2] Hexagonal boron nitride (hBN) platelets are widely used as the reinforcing fillers for enhancing the thermal conductivity of polymer-based composites. Since hBN platelets have high aspect ratio and show a highly anisotropic thermal property, the thermal conductivity of the hBNs-filled composites should be strongly associated with the platelets' orientation. There are many previous works attempt to make the BN nanosheets (BNNS) orientated, for example applying magnetic field [3], cellulose skeleton [4]. Here we report a novel strategy for the fabrication of oriented BNNS via FDM 3D printing. Highly thermally conductive TPU/BNNS composites can be obtained.

2 RESULTS AND DISCUSSION

2.1 Shear-induced BNNS alignment

The TPU/BNNS nanocomposite were prepared via FDM 3D printing. Fig. 1 shows the cross-sectional SEM images of 15 wt % TPU/BNNS nanocomposite. It is clear that platelets are aligned along the printing direction.

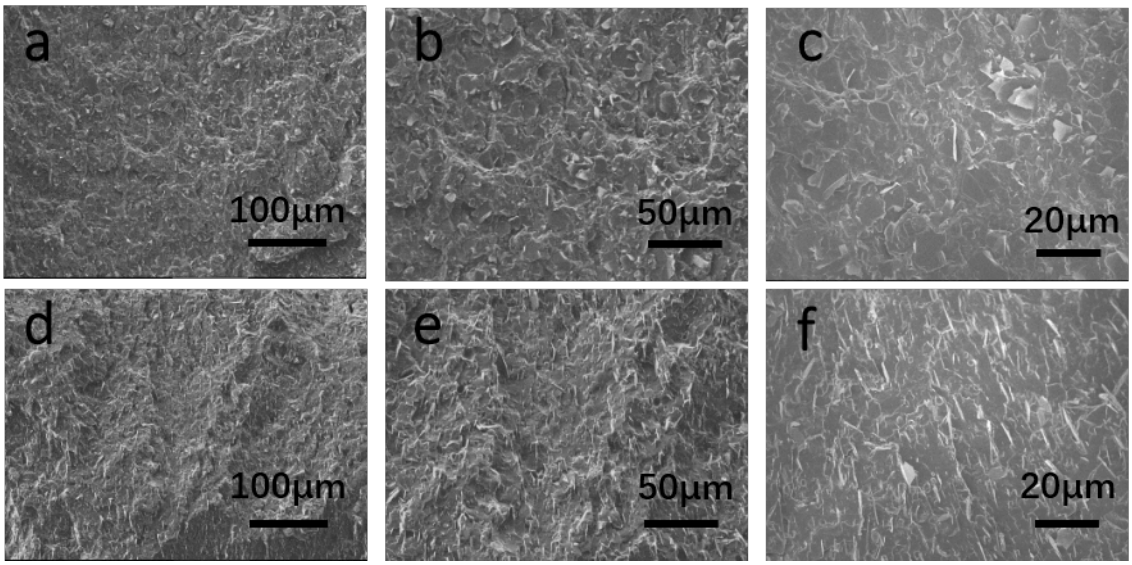

Figure 1: Cross-sectional images of TPU/BNNS composite in different resolution. (a-c) longitudinally printed sample; (d-f) transversely printed sample.

2.2 Thermal conductivity of TPU/BNNS nanocomposites

Via FDM 3D printing, TPU/BNNS nanocomposite exhibits anisotropic thermal conductivity. And thermal conductivity along the printing direction is greatly improved. Figure 2 (a) shows the thermal conductivity curves of TPU/BNNS nanocomposite in different direction. It shows that the thermal conductivity in in-plane direction is much higher, more than 3 times when BNNS loading is 20wt%, than that in out-plane direction. Figure 2 (b-e) are infrared thermal images of TPU/BNNS and TPU samples. One can see that the surface temperature of in-plane directional TPU/BNNS nanocomposite continuously increases with time at a higher rate because of its higher thermal conductivity.

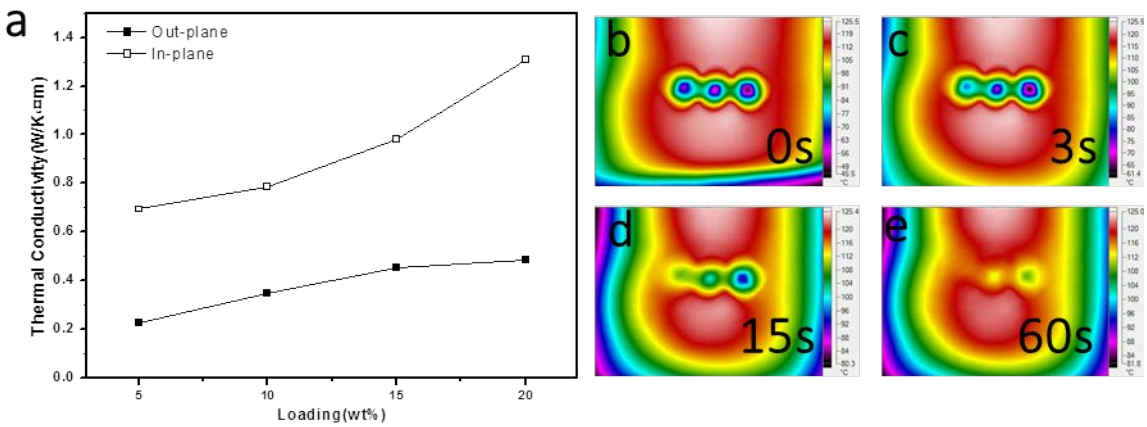

Figure 2: (a) Thermal conductivity curves of the different directional sample. (b-e) infrared thermal images of in-plane directional TPU/BNNS sample (left), out-plane directional TPU/BNNS sample (middle) and TPU sample (right).

3 CONCLUSIONS

In conclusion, via FDM 3D printing we can obtain TPU/BNNS nanocomposite with highly oriented BNNS. The composite exhibits anisotropic properties. And the thermal conductivity of the composite is greatly improved along the printing direction.

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