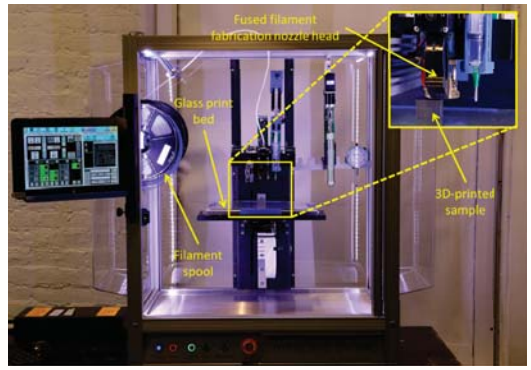
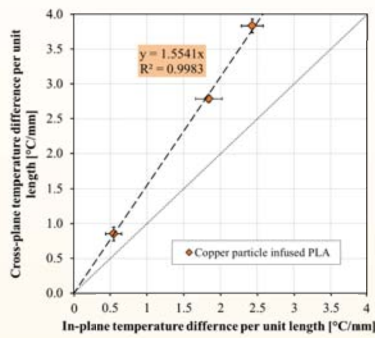
Thermal characterization of 3D-printed components

Solid-state lighting is the preferred choice today for many lighting applications, and the availability of numerous LED products in the marketplace has led to rapid price erosion. The heat sink, which provides necessary thermal management, is one of the more expensive components in an LED lighting system. Because manufacturers are looking to lower the cost of heat sinks, in 2016 the LRC began exploring additive manufacturing, also known as 3D printing, and whether 3D-printed heat sinks could be a solution. In this study, the LRC investigated how print orientation affects the thermal properties of 3D-printed components when using commercially available filaments and 3D printers.



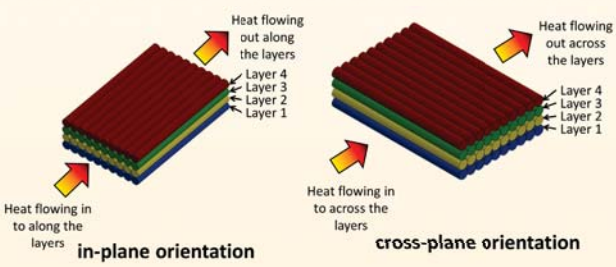
3D printer with multiple tool heads including the fused filament fabrication tool head



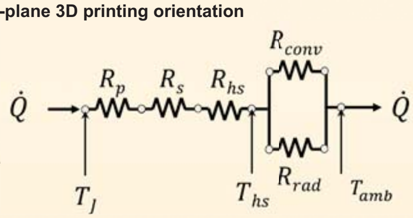
Cross-plane versus in-plane temperature difference per unit length of 3D printed Copper particle infused PLA sample indicating lower temperature difference in the in-plane orientation

Experiment

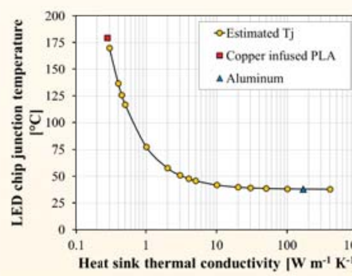
To determine the thermal properties of 3D-printed components, LRC researchers characterized 3D-printed samples fabricated using two commercially available filament materials (with and without metal fillers) in two different print orientations (*in-plane* and *cross-plane*) using a fused filament fabrication method. Next, a simple thermal resistance model was used to estimate the required effective thermal conductivity of 3D-printed components in order for them to be viable alternatives for LED thermal management.



In-plane versus cross-plane 3D printing orientation



1D thermal resistance model



LED chip junction temperature change as a function of heat sink thermal conductivity

Results

The samples printed with an in-plane orientation had an effective thermal conductivity >30% over those with the cross-plane orientation. The 1D thermal resistance model illustrated that a 3D-printable material with ~10 W m^{-1} K^{-1} used in a 2 W LED lighting product would maintain a similar LED junction temperature to an aluminum heat sink. A 3D-printable material with an effective thermal conductivity of ~50 W m^{-1} K^{-1} would allow for 3D-printed heat sinks for most indoor fixtures.

References

Perera et al., *Optical Engineering* 57(4), 041411 (2018).
Narendran et al., *Proc. SPIE* 10378, 10378-35 (2017).

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