Micropatterning of Nanoparticles *via* Multi-Phase Direct Ink Writing (MDIW)

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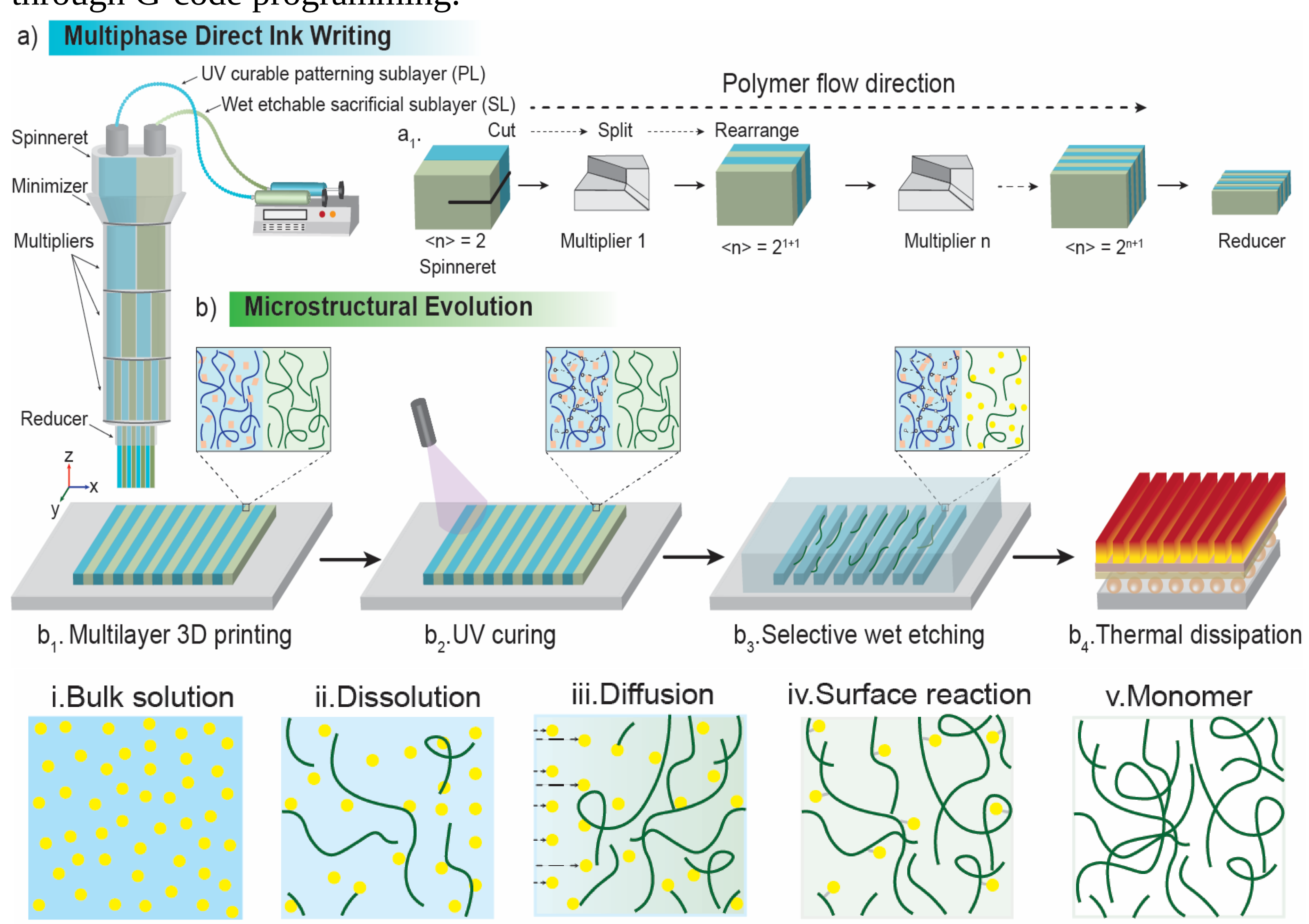
Abstract

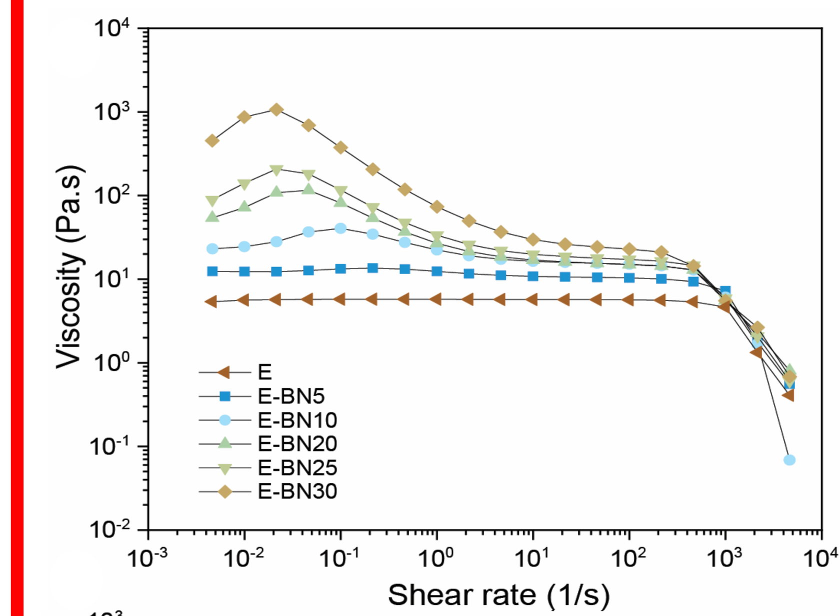
3D printing is an advanced manufacturing strategy for nanocomposite manufacturing due to rapid prototyping, limited material wastage, high processing speed, and customization. This study demonstrated the design and development of a new additive manufacturing mechanism, the Multiphase Direct Ink Writing (MDIW). By matching the viscosity between polymer solutions/nanoparticle suspensions (Boron nitride Epoxy and Polyethyleneimine PEI), an individual line composed of a desirable number of sublayers (i.e., 32, 64, 128) was printed. Preforming Etching rate and removal of the sacrificial polymeric layer (PEI) from the composite film for different layers. SEM will be used to investigate the BN's alignment.

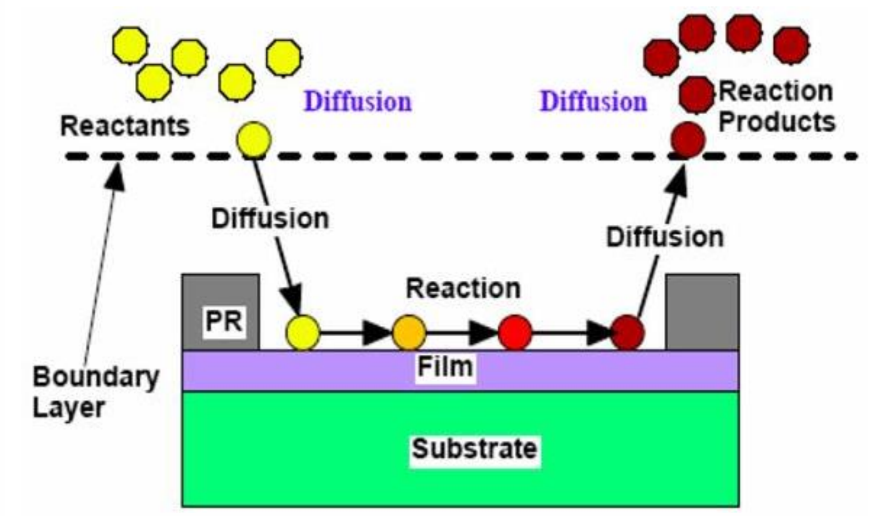
Method

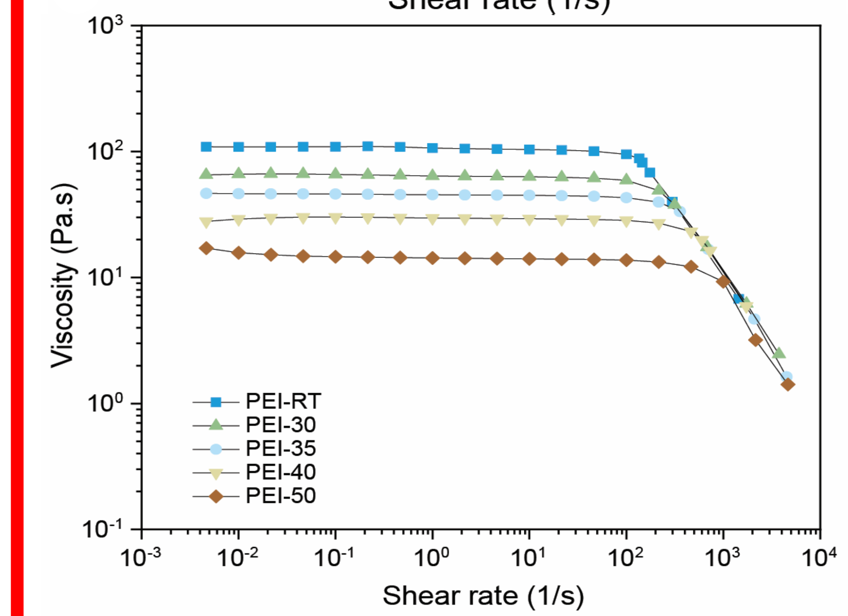
The MDIW process is designed to take in two feedstocks (Epoxy and PEI) as inlets and deposits on a substrate. Both the solutions are pumped using a high-precision automatic pump with controlled flow through the nozzle, each layer having a varied thickness, ranging from 10 to 100 µm. The deposited solutions can be solidified by thermal curing, UV curing, solvent evaporation, etc. The 3D platform translation is controlled through G-code programming.

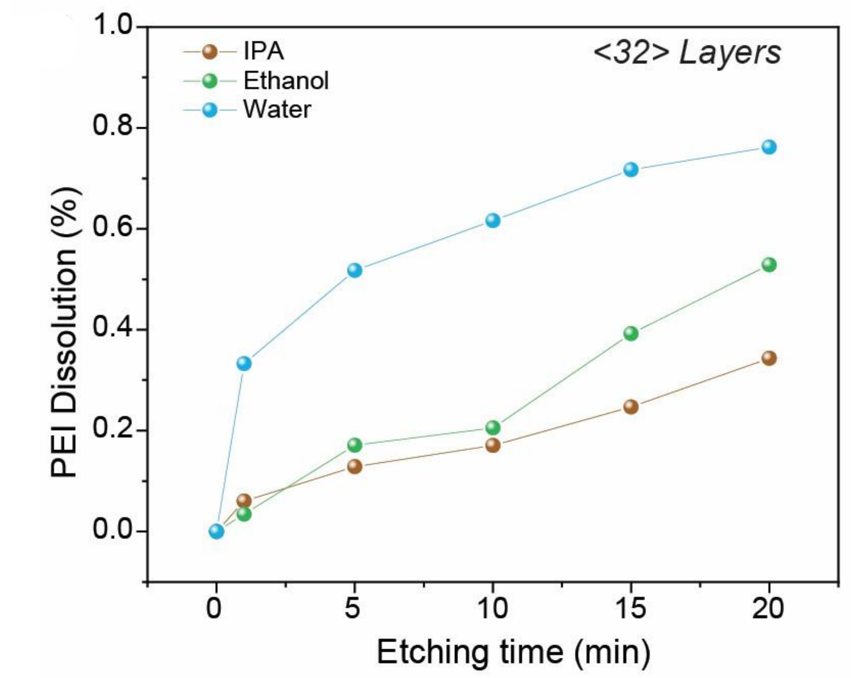


Etching Kinetics





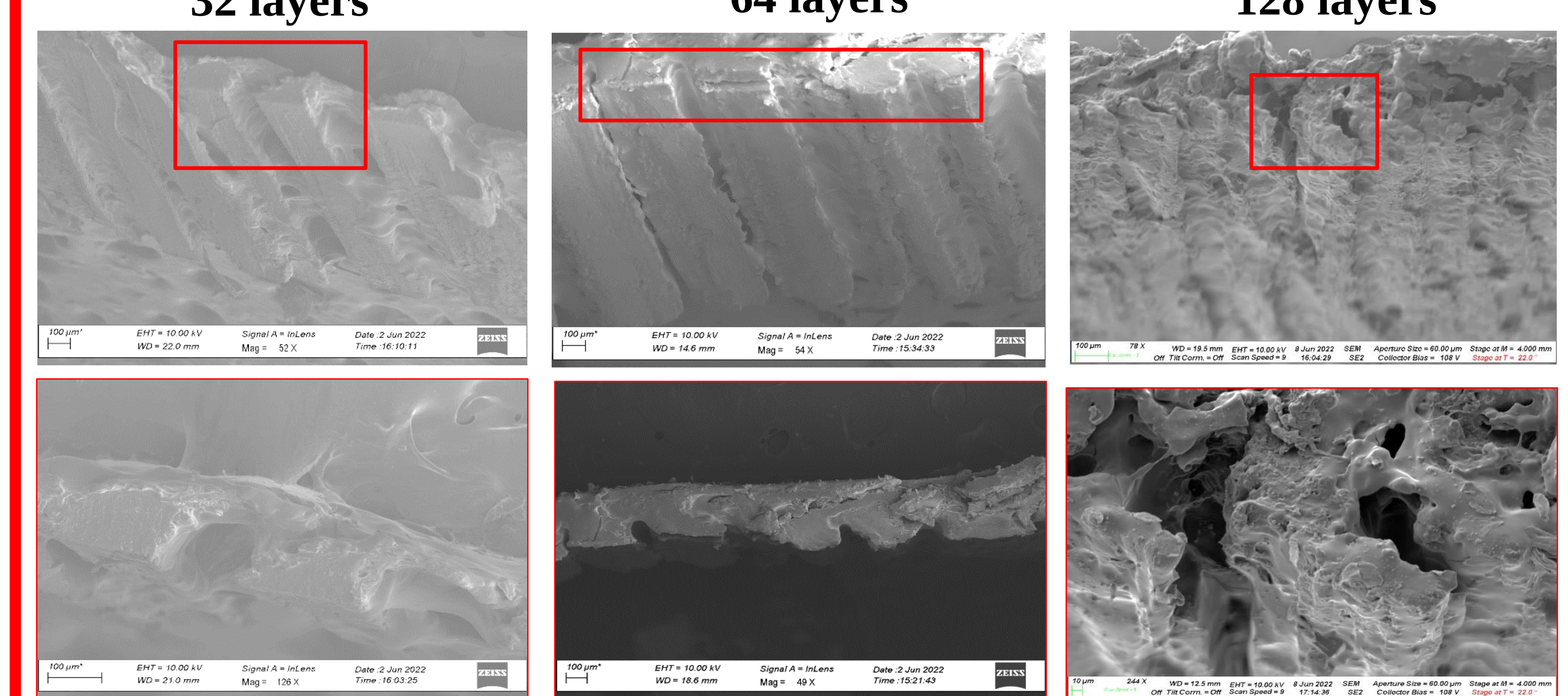




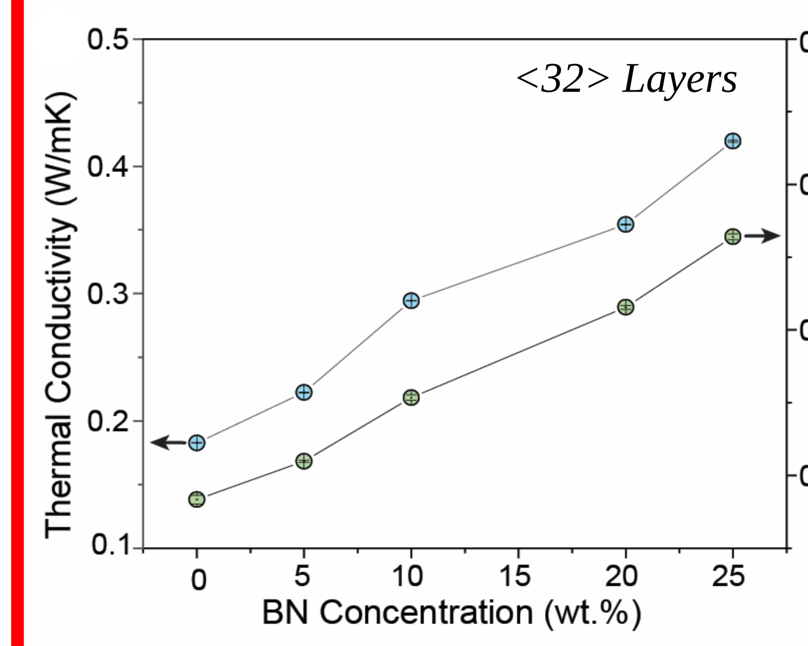
- Viscosity matching is crucial to the 3D printing process, E-BN25 and PEI-50 ink enable the fabrication of multilayer structures.
- The PEI dissolution is increased as a function of time for all etchants, with the water dissolving PEI faster than ethanol and IPA.

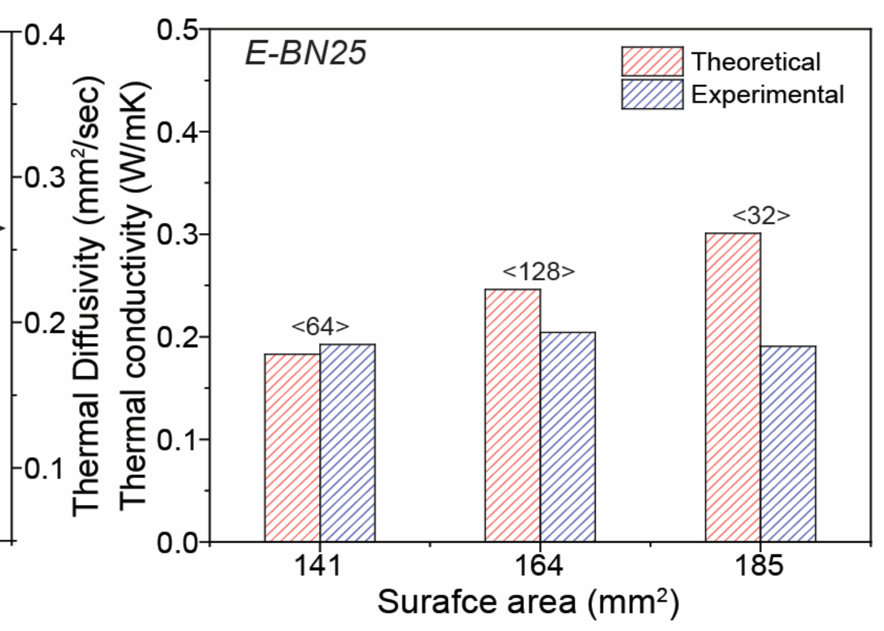
SEM images

32 layers | 64 layers | 128 layers

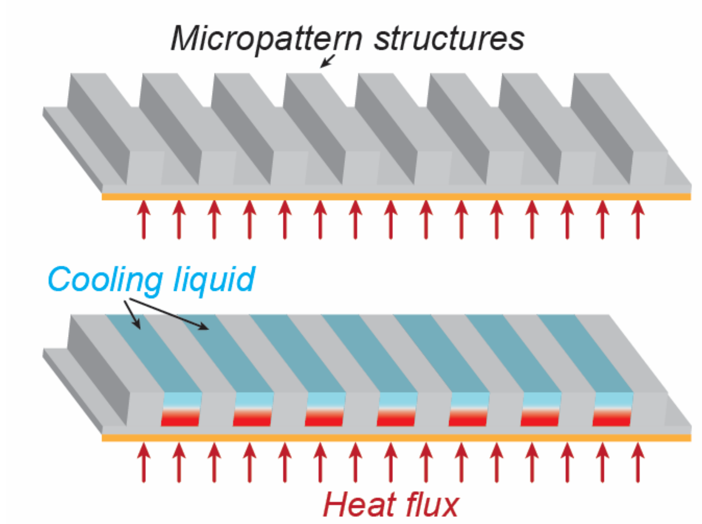


Thermal Properties of the film





- Thermal properties of the E-BN composites shows an increase in the thermal conductivity (K_c) and thermal diffusivity (D_c) with higher BNNPs concentrations.



- Micropatterned structures are beneficial for directed heat transport and constructing thermal dissipation paths, particularly for high computational power electronics.
- ➢ The schematic illustration of microgrooves as channeled microfluidic cooling systems.

Conclusion

- The printed film displayed layers with a multilayered surface morphology and an alternating Epoxy/BN and PEI layer with a 100 microns.
- IPA, ethanol, and water showed good etch-ability for the sacrificial PEI layer without losing the structural integrity of epoxy, leading to the formation of micropattern substrates.
- The higher the layer width/ interaction surface areas improves the PEI dissolution rate depending on the solvent type and etching time.
- Thermal conductivity increases with an increase in Boron Nitride content

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