Design and Evaluation of Operando Magneto-Assisted Direct Writing Processing and Effects of Fiber Alignment in Printed Composite

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Introduction

-This work is focused on development of a an extrusion based printhead customized for these methods to create desired fiber orientation by overcoming shear force and fixating fibers in the desired orientation through curing.
-Develop a printer that executes direct writing and additive manufacturing technology to create customized and complex structures customized to our ink properties
-Designing and evaluation (CAD Design, Zentoolworks, Solidworks) of a printhead that consolidates extrusion,curing, and printing which requires necessary magnetic holders and UV lights
-UV holders to increase effectiveness of alignment overcoming the shear flow
-Rheology of the ink to determine flow parameters: Flow speed/feed rate, extruding pressure, and nozzle size, uv curing time
-Determine flow parameters optimize the parameters of the printhead
-Ink development using the nickel nanowire process and dymax resin

Experimental Method

-Nickel nanowire synthesis by electrodeposition
-Morphology Characterization: SEM of Nickel Nanowire to determine orientation and distribution within the print
-Optical Characterization: UV development and magnet evaluation
-Structural Characterization: Conductivity, DMA,TMA, ARES-G2 testing and rheology. Lambient curing method
-Ink testing with dymax, PEG, and PI vitrimer determine viscosity for strength of the magnet
-running DSC testing UV curing times (10,20,30,40,50 sec)
- Dispense photopolymer with functional nanowires and ink

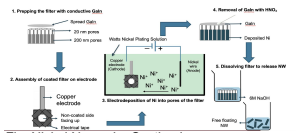
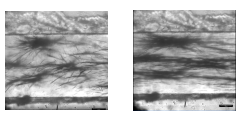


Fig. Nickel Nanowire Synthesis process


Random Orientation

Aligned Orientation

Experimental Method Cont'd

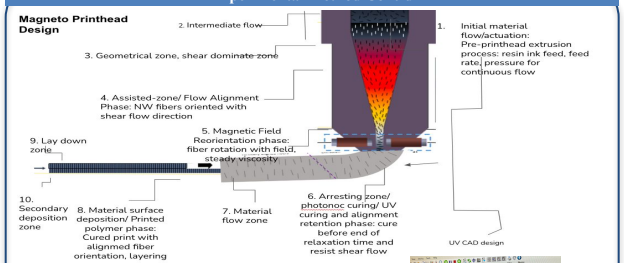


Fig. Magneto printhead design

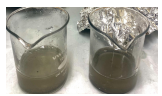


Fig. . Ni NW Dymax ink

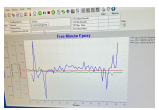


Fig. Lambient UV cure test

Results & Discussion

-Magnetic field and UV testing to determine optimal cure time and viscosity data for the final printhead, contributing to magnetic design and light placement
-SEM image processing and video analysis to establish relaxation time
-Finalized printhead with high-temp resin using Forms 2

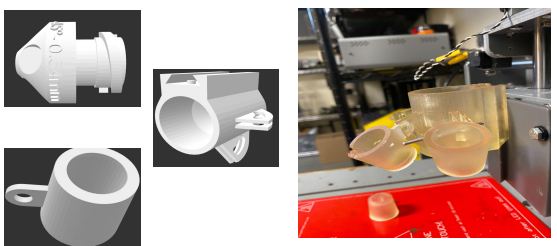
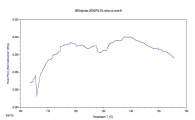
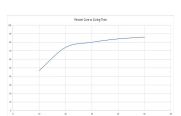
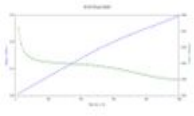


Fig. CAD design and Final printhead vertical ink extrusion

Results & Discussion Cont'd


Pure Dymax no cure DSC:


80%dymax/20%IPA/2 %NiNW Percent cure


55% PEG, IPA and 2% NiNW viscosity

Pure Dymax and 80% dymax/20% IPA/ 2% NiNW ink percent cured data through intervallic time.

$$\%\,Cure = \left(\frac{1-\Delta H_t}{\Delta H}\right) \times 100.$$

Conclusion & Future Work

-The percent cure data will allow us to determine the optimal curing time, thus the flow speed and pressure needed for the direct writing printhead
- The fixation of the Nickel nanowires offers the advantage of enhanced mechanical and electrical strength in customized polymer composites
- Development of new type of design will expand the use of metals in ink testing and 3D printing, through the control of the microstructure fiber orientation of the print
-segue into interlayer bridging

References

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Exploration of Magneto and UV- assisted printhead design for field- controlled orientation of paramagnetic nanorods