



## APS March Meeting 2019

### Session A49: Additive Manufacturing of Soft Materials: Novel Characterization and Processing Strategies

#### **A49.00001 : In-situ X-ray and thermal imaging of 3D printed PLA\***

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In-situ WAXS together with FLIR imaging was performed during 3D FDM printing of PLA filaments. The results highlighted the importance of the temperature profiles during printing on the structure/property relationships of the samples. Printing along short axis resulted in increased thermal retention, higher degrees of crystallinity and mechanical strength relative to samples printed along the long axis. Neutron reflectivity used to construct a model of the interdiffusion between filaments as a function of time and temperature. Lattice Boltzmann calculations were used to determine the temperature of the filament as a function of nozzle temperature and extrusion speed. The thermal conduction between filaments in the vertical and horizontal direction was measured at four different nozzle temperatures and the interdiffusion was determined by scanning electron microscopy. The data showed large difference during printing between adjacent filaments. Fusion, was shown to occur when the diffusion length exceeded  $R_g$  of PLA, occurred first in horizontal direction when the nozzle temperature exceeded 215°C and in the vertical direction when it exceeded 245°C.

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#### **Abstract: A49.00005 : In-situ X-ray and thermal characterization of nanocomposites in FDM 3D printing**

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In-situ synchrotron WAXS simultaneously with high resolution infra-red imaging were used to study the correlation between the extrusion parameters, the filaments deposition directionality and the internal structure of the nanocomposite in 3D printing by placing an “open-walled” FDM

printer in the beamline. We used microbeam synchrotron SAXS to study the variance in the crystalline macrostructure formed as function of radial position in the filaments (from core to adjacent interfaces). We used PLA and PP as the polymeric matrix and graphene nano-platelets and hexagonal boron nitride as the fillers due to their excellent mechanical properties and the potential in thermal management applications. We observed the effect of extrusion shear forces on the orientation of the nanoparticles and the influence of the particle/polymer interactions on the polymer crystallization. We show how thermal properties improved by directionality and transcrystallization. We used Raman, electron microscopy and rheological techniques to study the interactions between the polymer matrix and the nanoparticles.

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### **Morphology Controlled Electrospun Fibers as the Catalyst Layer for Polymer Electrolyte Membrane Fuel Cells**

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The efficient operation of Polymer Electrolyte Membrane Fuel Cells (PEMFCs) largely relies on a costly and easily-degradable platinum catalyst layer. Although air spraying techniques has previously served as the main method of catalyst deposition, electrospinning deposition may provide a more promising method by granting users precise control over 3-D structures by manipulating fiber diameter, porosity, and alignment. 12wt% of poly(acrylic acid) (PAA) and Nafion (1:4 weight ratio) solution was used to obtain a semi-viscous base solution for electrospinning. Through Laser Optical Microscopy and Scanning Electron Microscopy, optimal fiber diameter of 1  $\mu\text{m}$  was found when incorporated with Pt/C, allowing uniform catalyst nanoparticles attachment. The fuel cell performance tests indicate that the morphology optimized electrospun electrodes exhibited a 108% increase in max power output over air-sprayed electrodes of comparable loading. This enhancement is attributed to its unique interwoven surface morphology, which increases the specific surface area of electrode and promotes the efficiency of the reactant and proton transport to catalytic sites. Thus, electrospinning can be used as a potential strategy to improve power output of PEMFCs by altering the catalyst electrode morphology.