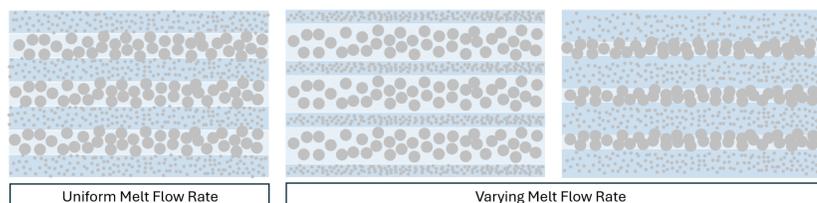


# INTERFACIAL CHARACTERIZATION OF CERAMIC-FILLED EAA IN MULTILAYER CO-EXTRUDED FILMS

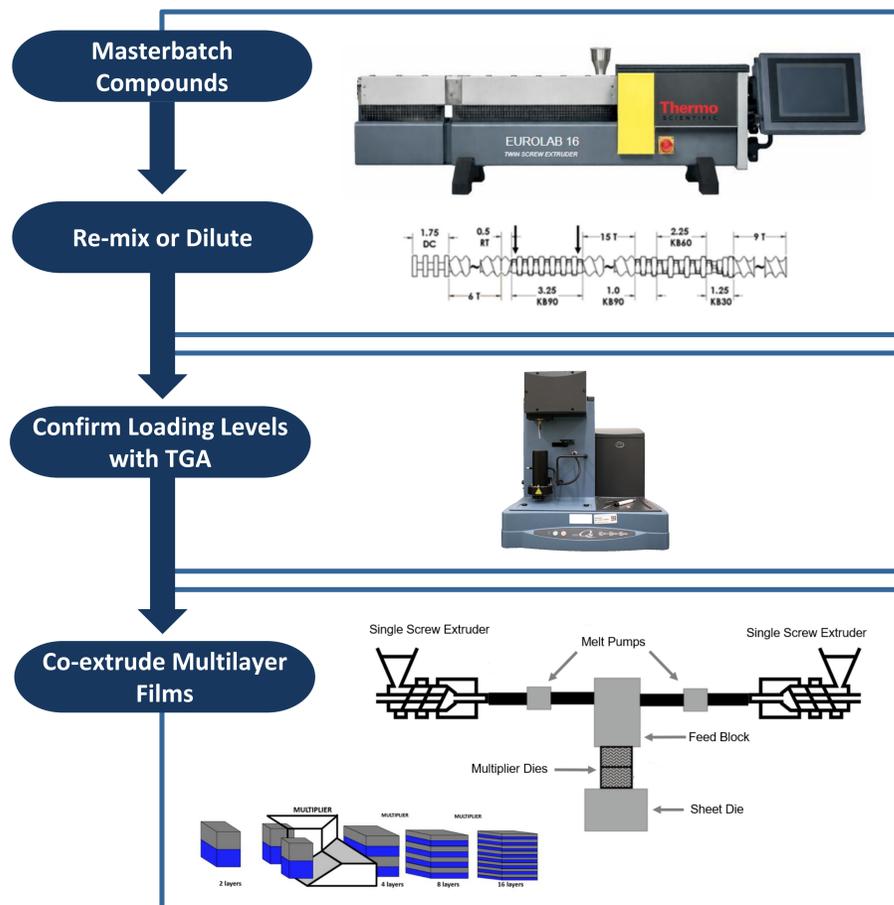
## BACKGROUND

- In multilayer co-extrusion, as individual layer thickness decreases, materials experience geometric confinement, with dimensions approaching filler particle size.
- In filled polymer systems, complex rheological behavior may influence flow stability and interfacial structure under confinement.
- The rheological impact of fillers on the multilayer forced assembly process and the ability to achieve arbitrary layer compositions remains unclear.



## APPLICATION OF EQUIPMENT AND PROCESSING

- Masterbatch compounds are prepared and subsequently re-mixed or diluted using twin-screw extrusion to achieve desired filler concentration.
- Thermogravimetric analysis (TGA) confirms proper concentration from compounding runs prior to multilayer co-extrusion of films.



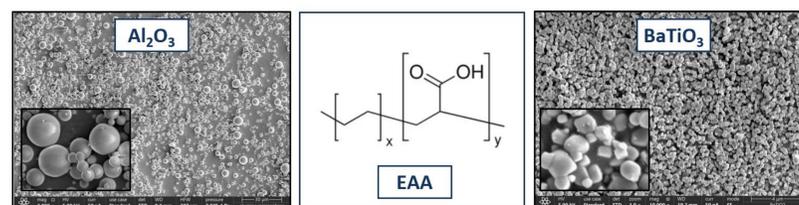
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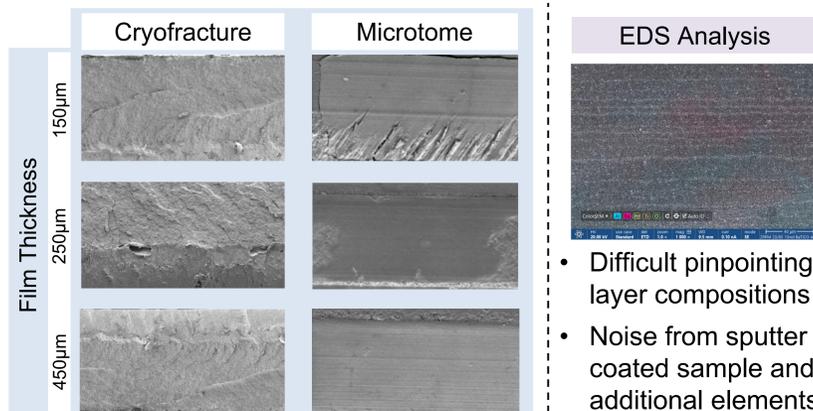
## ABSTRACT

Multilayer co-extrusion enables the fabrication of polymer films composed of hundreds or thousands of layers, a process not achievable through conventional extrusion methods. This work investigates the distribution of ceramic nanofillers in co-extruded multilayer films with layers confined to dimensions approaching the filler particle size. The effects of flow and film-thickness variations on process stability and multilayer morphology are examined. To study these effects, 128-layered films of ethylene acrylic acid (EAA) containing barium titanate (BaTiO<sub>3</sub>, approximately 300 nm) and alumina (Al<sub>2</sub>O<sub>3</sub>, approximately 2 μm) are co-extruded at different thicknesses from 150 to 500 μm at varying loading levels and compositions. Scanning electron microscopy and rapid confocal Raman mapping are used to analyze the layer morphology produced under confined flow during co-extrusion. This framework can be used as a guide when designing new multilayered polymer films that require controlled interfaces and tunable functional properties for applications, such as dielectric materials, film packaging, and other engineered multilayer structures.

## MATERIAL SELECTION

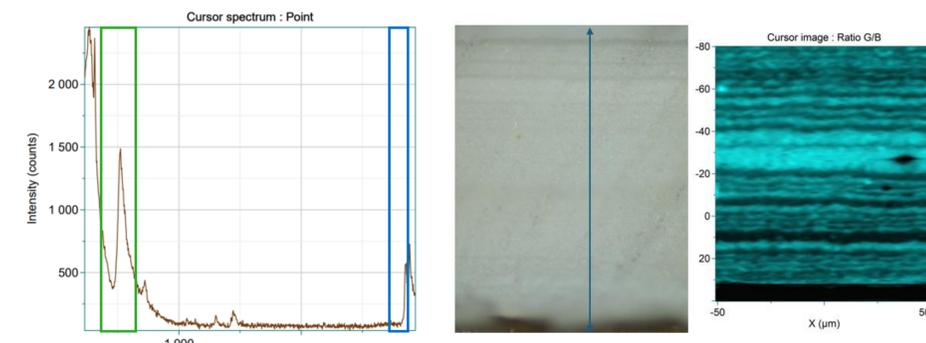


## MATERIAL PREPARATION AND RESULTS



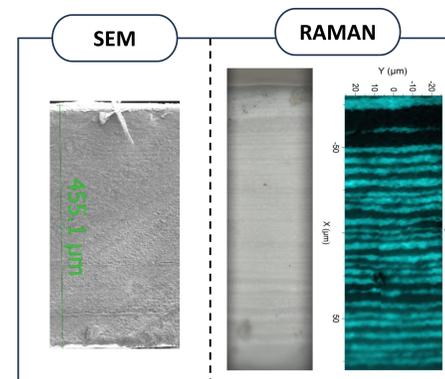
## INTERPRETATION OF RESULTS

Layer A: 40vol% BaTiO<sub>3</sub> in EAA | Layer B: 40vol% Al<sub>2</sub>O<sub>3</sub> in EAA  
50:50 A:B



Map shows ratio of strong BaTiO<sub>3</sub> peak (~520cm<sup>-1</sup>) to PE peak (~2800cm<sup>-1</sup>)

128-layer, ~200μm film, ~1.5μm layers



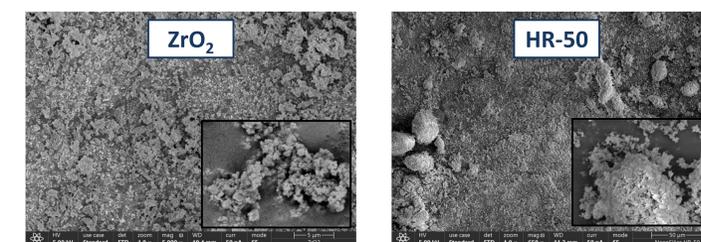
128-layer, ~450μm film, ~3.5μm layers

## Key Takeaways

- Stable layering apparent; however, significant layer thickness variation for thinner films
- Raman can provide map of layers present in film
- Difficult to extract layer thickness systematically using SEM

## FUTURE WORK

- Systems with agglomerated ceramic nanoparticles rather than the current monodisperse fillers will be explored to identify potential changes in multilayer morphology, co-extrusion flow behavior, and rheological response.



## REFERENCES

- (1) Steinmetz, E.; Maia, J. Layer Multiplication Co-Extrusion of Cross-Linked Polymer Microsphere-Filled Systems. *Polymer Engineering and Science* **2023**, 64 (3), 1045–1056. <https://doi.org/10.1002/pen.26595>.
- (2) This work was supported by the Army Research Laboratory via contract #W911NF2020155