הטכניון - מכון טכנולוגי לישראל

TECHNION - ISRAEL INSTITUTE OF TECHNOLOGY

הפקולטה להנדסה כימית
ע"ש וולפסון
The Wolfson Department of Chemical Engineering

Wolfson Department of Chemical Engineering Seminar

Wednesday, April 21st, 2021 at 13:30

Online seminar via Zoom
https://technion.zoom.us/j/97591164072

Spatially Controlled Inorganic Growth within Polymeric Templates

Rotem Azoulay

Mid-PhD Seminar

Advisor: Dr. Tamar Segal-Peretz
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Nanofabrication techniques commonly rely on transforming polymeric patterns into inorganic patterns. Direct conversion of the polymer can enable higher tunability as well as simpler fabrication processes and lower costs, compared to currently available processes. Sequential infiltration synthesis (SIS) uses gaseous precursors and atomic layer deposition (ALD) chemistry to grow inorganic materials within polymers. When SIS is applied on block copolymers (BCP), which can self-assemble into a variety of well-ordered structures in the sub 50 nm scale, the growth can be tuned to be selective to the polar BCP domains. Following SIS, the polymer template is removed, resulting in inorganic nanostructures. Until now, SIS processes were limited to one organometallic precursor in each process. Using several precursors while controlling the spatial location of each precursor, can open a path for fabricating multi-materials structures.

In this research, I present a new technique for spatially controlled SIS. The growth location of each precursor within the polymer template is controlled by the precursors' diffusion time. We demonstrate this technique using a model system of cylinder forming BCP which templates AlO_x-ZnO heterostructure nanorod array. We probed the heterostructure array using scanning and transmission electron microscopy (SEM and TEM, respectively), including three-dimensional characterization with scanning TEM (STEM) tomography and energy-dispersive X-ray spectroscopy (EDS) STEM tomography. We further broadened this technique to electrospun polymer fibers to produce core-shell AlO_x-ZnO ceramic fibers. We demonstrate that by tuning the SIS process parameters we can control the size, morphology, and surface roughness of the fibers. Expanding SIS methodology into new 3D morphologies can enable its incorporation in a large variety of applications.

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Predictive Tools for the Design of Encapsulated Assemblies: Validated Process Simulation and Failure Criteria

Mor Politi

Mid-PhD Seminar

Advisors: Prof. Yachin Cohen
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Reliable numerical predictive tools are instrumental in the high-end and robust design of encapsulated electronic assemblies. The use of epoxy-based compounds as encapsulants presents some challenges in establishing such tools. Process optimization and residual stress calculations require a rigorous cure simulation, which considers the transient chemical, thermal and mechanical constitutive behavior of the curing resin. Failure prediction and design margin estimation require extensive failure criteria calibration, as the latter is highly dependent on temperature, strain rate and stress state. The prediction of failure becomes even more difficult when considering a highly divergent stress field and model singularities. This research aims to establish computational tools and experimental methodologies for the reliable prediction of the residual stresses and failure of a thermoset encapsulant, and their incorporation in process design.

To this end, we study the development of residual stresses and strains in an epoxy based encapsulant using a finite element cure process analysis. The analysis is validated using a specially designed test specimen, employing various strain sensing techniques. For in-bulk residual strain measurement we use fiber optic strain sensors, for which a data reduction scheme for matrix-fiber strain transfer calculation is developed. For the prediction of failure under highly divergent stress states, we suggest and experimentally calibrate a scale-sensitivity based failure criterion.

The results show good compatibility between experimental and numerical prediction of the thermal behavior and cure induced residual stresses. The limitations of neglecting the viscoelastic behavior of the resin are numerically and experimentally demonstrated. Lastly, we present a method for calibrating a probabilistic volume-sensitive failure criterion for epoxy resins under non-uniform stress states.