Mechanical & Industrial Engineering
UNIVERSITY OF TORONTO

MIE498H1: Research Thesis 2023-2024

Supervisor	Patrick Lee
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Number of Positions	1
Open to	Mechanical Engineering Students
Term Offered	Full-Year (Y)
Research Area	Materials
Research Topic	Highly Efficient Passive Cooling Structures via Nano-layering

Project Description

In the realm of advanced material manufacturing, Micro-/Nano-layered (MNL) Co-extrusion stands as a remarkable process that unlocks new possibilities. Through a precise sequence of layer multiplying elements, this technique adeptly divides, stacks, and recombines distinct polymeric phases, giving rise to extraordinary multilayered films. These films offer a range of advantages over dispersed blends, boasting reduced percolation thresholds for functional fillers, confined crystallization, and the ability to orient high-aspect ratio fibers. What's more, MNL co-extrusion unveils an intriguing phenomenon—an interphase material forms at the boundaries where two phases meet. The quantity of this interphase, relative to the overall composition, is intricately linked to the miscibility of the phases. This breakthrough manufacturing technique has already been employed in the creation of exceptional optical, mechanical, and gas barrier films. From brightness-enhancement filters for electronic screens to ultra-strong safety and security window films, as well as elastomeric barrier films for cushioning bladders in athletic shoes, the applications are vast, with each film comprising hundreds of layers, each less than 100 nanometers thick. One captivating application we are currently exploring is the integration of a Bragg reflector structure into the MNL design for passive cooling. The Bragg reflector operates through the arrangement of alternating layers, each possessing a unique refractive index. By determining the layer thickness and refractive indices, this reflective structure becomes proficient at bouncing back specific wavelengths of light, including sunlight. As a result, when this Bragg reflector structure is incorporated into the multilayered composite material, it assumes the role of a highly efficient passive cooling mechanism. Passive cooling is a vital technique for managing heat in various applications, and the concept of radiation cooling plays a significant role here. Alongside the reflection of sunlight, the multilayered composite material is engineered to emit infrared radiation, a form of thermal energy, into the sky. Infrared radiation can escape the Earth's atmosphere and dissipate into space, allowing for effective heat transfer and cooling. This process aids in maintaining the material's temperature at lower levels, even under intense sunlight exposure. By harnessing the combined power of the Bragg reflector structure and radiation cooling, the multilayered composite material achieves exceptional passive cooling performance. It not only deflects a substantial portion of the incident sunlight but also efficiently dissipates the accumulated heat through radiative cooling. This innovative approach ensures optimal temperature control, making it particularly advantageous for heat-sensitive applications such as electronic devices and solar panels.

Additional Information	N/A
Application Instructions	Please submit CV, unofficial transcript, to Prof. Patrick Lee (patricklee@mie.utoronto.ca)