Optical and Thermal Engineering of Soft Materials: Aerogels and Polymeric Thin Films

Lin Zhao

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Soft materials provide a low-cost versatile platform to achieve remarkably tunable optical and thermal properties. These unique properties enable precise control of heat and light that is crucial for a wide range of applications such as solar energy conversion and climate control. In this talk, I will present my recent work on transparent silica aerogels and birefringent polymeric films that enable novel optical and thermal energy conversion pathways which could help address several energy challenges. In the first part, I will focus on the development of silica aerogels – an open-celled, mesoporous, solid foam with a greater than 90 % porosity – that have the lowest thermal conductivity of all materials. Our work concentrated on achieving highly optically transmitting aerogel monoliths that can operate reliably at temperatures greater than 100°C). I will describe how to tailor the aerogel's microstructure to enable efficient solar-to-thermal energy conversion, which enables applications for power generation, medical sterilization, and other thermal processes. In the second part, I will focus on birefringent polymeric films that utilize stress-induced optical anisotropy stemming from their molecular backbone structure. These microscopically anisotropic films are amenable to large-scale manufacturing, which has intruded novel photonic properties at a low cost. One such application is the design of multilayer polymeric films as efficient infrared reflectors that can reduce the solar heat loads on electric vehicles and buildings. Similar soft material microstructure engineering approaches could help realize novel optical and thermal properties that lead to significant efficiency gains and help pave our way towards a zero-carbon emission future.

Lin Zhao, PhD Mechanical Engineering, Massachusetts Institute of Technology (2019) is a Thin Film Optics Design Engineer at 3M Corporation. He also holds the MS in Nanotechnology, University of Pennsylvania (2014) and BS in Physics and Mathematics, Tsinghua University (2012). Zhao's research broadly addresses energy, water and climate challenges with novel material systems that leverage fundamental principles of heat transfer, material science and optics. His work on specialized aerogel materials and multilayer polymeric films has enabled new pathways for solar energy harvesting, light management, and radiative cooling. His current work at 3M involves the development of novel multilayer birefringent optical films. He is the author of 29 journal publications, and his research has been featured in Nature, The Economist, MIT Technology Review and other major media. Dr. Zhao is the recipient of 3M's Circle of Technical Excellence & Innovation Award (2020), the MIT Outstanding Graduate Research Award (2019), MIT Tata Fellowship (2017), and Chee C. Tung Fellowship (2014).

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