PURDUE UNIVERSITY®

School of Materials Engineering

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Armstrong Hall of Engineering, Room B071

Chiral and Anisotropic Nanophotonic Materials – Exploiting the Interaction of Biological Matter with Light

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Lisa Poulikakos received her PhD in Mechanical and Process Engineering at ETH Zürich, where she studied with Professor David Norris. Her thesis, titled "Chiral Light–Matter Interactions in the Near and Far Field" introduced an original theoretical and experimental technique to enable the rational design of chiral nanophotonic systems. Since November 2018, she is a postdoctoral scholar in Materials Science and Engineering at Stanford University in the group of Professor Jennifer Dionne. Her postdoctoral research focuses on developing functional nanophotonic surfaces for all-optical, on-chip and label-free cancer tissue diagnostics. She is a recipient of the ETH Medal, awarded to outstanding doctoral theses, the L'Oréal USA For Women in Science Postdoctoral Fellowship and the Swiss National Science Foundation Early Postdoc Mobility Fellowship. Among the leadership positions she has held, she served as Chair of the 2018 Gordon Research Seminar in Plasmonics and Nanophotonics and was the founder and first president of the student-outreach organization "LIMES" at ETH Zürich.

Abstract: From the molecular to the tissue scale, the interplay of order and disorder in biological matter is intimately linked to the onset and progression of leading global health challenges. These encompass neurodegenerative diseases, where the origin has been related to anomalies in the structural handedness – or chirality – of amino acids, and cancer, where staging and treatment can be informed by the presence and arrangement of fibrous tissue in the tumor microenvironment. The clinically-compatible characterization of structural order in biological matter has potential to alleviate existing diagnostic tradeoffs in precision, cost and time, yet the development of appropriate technologies remains prohibitively challenging. Current pathological image analysis routinely relies on qualitative guidelines set as early as the 1920's, while the complex and costly equipment required for modern, quantitative imaging hinders translation to the clinic.

My research leverages nanophotonics – the study and manipulation of light at the nanoscale – to strongly and selectively enhance the quantitative optical detection of structural changes in anisotropic biological matter by developing all-optical, on-chip and label-free technologies with facile clinical implementation. On the molecular scale, I will present an original theoretical and experimental framework to quantify and controllably enhance the chirality of light generated by nanophotonic structures in the near and far field. This work enables rationally designed chiral light–molecule interactions for all-optical, early-onset disease detection. On the tissue scale, I will discuss recent work on dielectric nanophotonic surfaces for rapid, on-chip tissue diagnostics at the point of care. Focusing on the model system of breast cancer, this technique maps the anisotropy and orientation of collagen fibers, a quantitative marker of cancer stage in tissue, onto structural color scattered by the nanophotonic surface. Working at the interface of nanoscale optics and medicine, this research opens possibilities for a rich palette of future trajectories where nanophotonics addresses leading challenges in global health.