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Mechanical Engineering Lecture in Micro/Nano Engineering

Microfluidic Bacterial Electrophenotyping for Biotechnology

Cullen R. Buie

Assistant Professor
Harold and Esther E. Edgerton Career Development Professor
Department of Mechanical Engineering
Massachusetts Institute of Technology

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In microbiology the ability to obtain genetic information far outpaces our ability to obtain phenotypic (or physical) information. This is a critical limitation because in many cases it is difficult, if not impossible, to infer the function of genes in an organism from genetic information alone. For the advancement of biotechnology and healthcare it is necessary to assess the links between genotype and phenotype. We have developed microfluidic techniques that exploit electrokinetic phenomena to determine connections between cell electrophenotypes (i.e. electrical properties) and genetics. First, I will present a detailed theoretical model to investigate the effect of appendages such as pili on the dielectric polarization of bacteria. The results demonstrate an interesting interplay between soft layer conductivity and double layer conductivity on polarizability, subtleties often neglected in previous models. Next, we exploit sub-species level differences in cell surface polarizability in novel three dimensional insulator based dielectrophoresis (3DiDEP) systems. Compared to previous embodiments of insulator based dielectrophoresis, 3DiDEP devices have an order of magnitude higher sensitivity. Our recent work has shown that 3DiDEP can be useful to distinguish bacteria with sub-species resolution. We will discuss our 3DiDEP design and describe exciting results on the characterization of both pathogenic and electrochemically active bacteria. Lastly we have developed a rapid microfluidic assay to quantitatively measure electric field conditions required for electroporation. Electroporation is widely used to deliver foreign DNA into host microbes for applications in synthetic biology and genetic engineering. However, electroporation has been successful on a relatively small number of microbes due in part to challenges in determining appropriate electroporation conditions (field strength, pulse width, etc.). Our rapid microfluidic electroporation assay can evaluate a range of electroporation conditions in a fraction of a second, a process that previously took hours. Results of this work will broaden the scope of bacteria available for applications in genetic engineering and synthetic biology.

Refreshments will be served before the seminar.
Please contact Tony Pulsone at pulsone@mit.edu with any questions.