Porous Silicon Arrays as a Playground for Microbes

Heidi Leonard [1], Christopher Heuer[1], Xin Jiang[1], Talya Borkum[1], Sofia Arshavsky-Graham[1], Sarel Halachmi[2,3], **Ester Segal[1]**

[1]Department of Biotechnology and Food Engineering, Technion - Israel Institute of Technology, Haifa, Israel
[2]Faculty of Medicine, Technion−Israel Institute of Technology, Haifa, Israel
[3]Department of Urology, Bnai Zion Medical Center, Haifa, Israel
esegal@technion.ac.il

The attachment of microorganisms, bacteria and fungi, to abiotic surfaces is of great interest to both the scientific and medical communities and numerous new methods and materials for quantitatively examining bacterial attachment and colony formation on surfaces have recently emerged. Intriguingly, most works have explored micro-/nano-structured substrates as potential antimicrobial surfaces, with an emphasis on antibiofilm properties; whereas, fewer have studied such patterned surfaces as artificial microbial arenas for observing and elucidating the behavior of bacterial communities.
Using engineered porous silicon substrates with carefully designed nano/micro topographies, exhibiting photonic properties, we introduce an optical platform that enables real-time and label-free monitoring of bacterial surface adhesion and colonization. Thus, the porous substrates serve as both a preferable solid-liquid interface for microorganisms networking and a simultaneous transducing element that monitors their response. Such platforms do not require sophisticated microscopy tools or any labels as most of the currently used methods, and it can be conveniently modified with different topographies and surface chemistries, presenting endless study opportunities in a single tool. We demonstrate the application of these platforms to study how different bacterial species, ranging from standard laboratory strains to genetically engineered mutants and clinical isolates, preferentially colonize surfaces with varying topography, wettability and charge and monitor over the formation of a biofilm. Moreover, we employ these manipulated porous surfaces for solving some critical bottlenecks in clinical microbiology [1]. For example, we have developed a chip-based culture-free method for rapid screening of resistant/susceptible bacteria directly from a clinical sample within only 90 minutes, where current clinical state-of-the-art methods require at least 24 hours [2-3].

References

[1] Leonard H., Colodner R., Halachmi S., Segal E., Recent Advances in the Race to Design a Rapid Diagnostic Test for Antimicrobial Resistance, *ACS Sensors*, 3 (2018) 2202-2217.
[2] Leonard H., Halachmi S., Ben-Dov N., Nativ O., Segal E., Antimicrobial Susceptibility of Bacterial Networks on Micropillar Architectures Using Intrinsic Phase-Shift Spectroscopy, *ACS Nano*, 11 (2017) 6167–6177.
[3] Heuer C., Leonard H., Nitzan N., Lavy-Alperovitch A., Massad-Ivanir N., Scheper T., Segal E., Antifungal Susceptibility Testing of Aspergillus Niger on Silicon Microwells by Intensity-Based Reflectometric Interference Spectroscopy, *ACS Infectious Diseases*, 6 (2020) 2560–2566.