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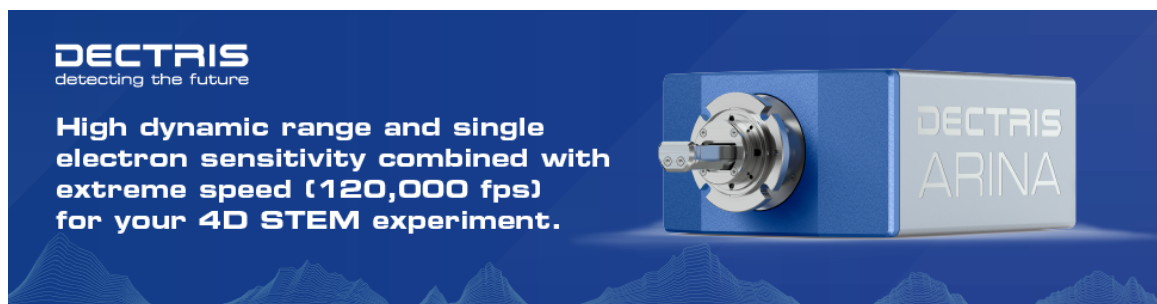
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Staphylococcal Colonization of E-Beam Patterned Surfaces.

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Tissue-contacting implantable biomedical devices provide foreign surfaces to which bacteria can adhere and colonize. Hence, in addition to their primary healing function, such devices increase the probability of infection [1, 2]. Many surfaces have been designed to promote tissue-cell adhesion. Others have been coated with anti-fouling moieties to repel bacteria. Neither can effectively discriminate between tissue cells and bacteria.

Surfaces with adhesiveness laterally modulated over microscopic length scales present an alternate between the extremes of fully adhesive or fully non-adhesive with which to differentially control cell/material and bacteria/material interactions. Here we report on experiments that test how staphylococcal bacteria interact with surfaces that have circular adhesive patches patterned within otherwise non-adhesive surface [3].

Modulated surfaces were fabricated by electron-beam patterning of thin films (~100 nm thick) of poly(ethylene glycol) (PEG) spun cast onto silicon substrates [4, 5]. Exposure to energetic can both crosslink the PEG as well as graft the resulting microgel to the underlying substrate. Unexposed PEG can then be removed by washing in a good solvent for PEG (e.g. THF) leaving behind patterned PEG-microgel thin films. Figure 1 illustrates a typical result with 5 μm diameter patches of exposed substrate in a continuous matrix of PEG thin film. The inset fluorescence image shows that human fibronectin binds only to the exposed patches and not to the PEG.

These surfaces were exposed to inocula of *S. aureus* (NCTC 8325-4; 3×10^8 cfu/ml) and cultured in a medium of flowing Tryptic Soy Broth (TSB) at 37 °C and a shear rate of 0.14/sec in parallel plate flow chamber. Figure 2 presents an SEM image of a dehydrated surface after 24 h of culture. It shows individual bacteria (center patch) or small clusters of 2-4 bacteria confined within the adhesive patches. Time-resolved phase-contrast optical imaging was used to follow the dynamics of bacterial deposition and the subsequent bacterial growth on patterns with various patch diameters (1 μm – 5 μm) and various edge-to-edge patch spacings (0.5 μm – 10 μm). The combination of patch diameter and inter-patch spacings we selected so that the total fraction of adhesive surface was 0.09, 0.20, or 0.35, i.e. the majority of surface was cell-repulsive. We find that the *S. aureus* adhesion to these patterned surfaces is dramatically reduced relative to fully adhesive control surfaces with no PEG microgel patterning. In addition, the development of individual bacteria into multicellular colonies is limited by the restrictions imposed by the non-adhesive PEG microgel thin film surrounding each adhesive patch. In some cases the finite extent of the patches appears to fully arrest biofilm formation. In separate monoculture experiments we show that osteoblasts are able to adhere to, spread on, and proliferate on all of the surfaces except for the most minimally adhesive surfaces have the smallest patch diameters (1 μm).

These findings indicate that differentially interactive surfaces can be designed by laterally modulating surface cell adhesiveness.

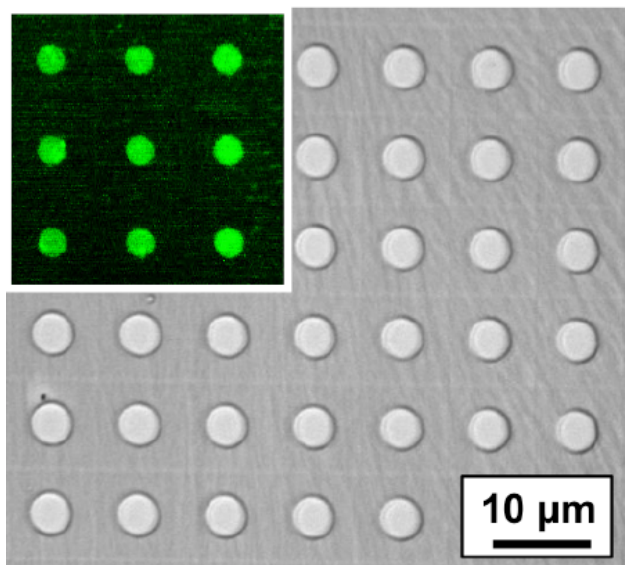


Figure 1. Phase-contrast optical image of a (dry) e-beam patterned film with 5 μm diameter patches of exposed cell-adhesive glass surrounded by continuous thin film of crosslinked PEG hydrogel. The inset shows fibronectin adsorption (green) on the exposed patches and little fibronectin adsorption on the PEG thin-film gel.

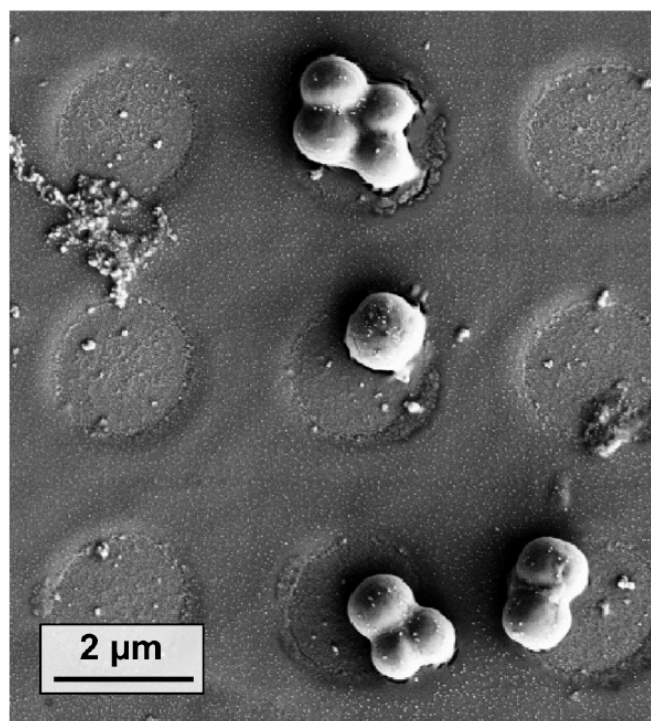


Figure 2. SEM image of a (dry) e-beam patterned microgel thin film with 2 μm diameter patches of cell-adhesive Fn-treated glass surrounded by a continuous PEG microgel thin film after *S. aureus* inoculation and 24 h growth at 37 $^{\circ}\text{C}$ in flowing TSB.

References:

1. Busscher, H.J., et al., *Science Translational Medicine*, 2012. **4**(153): p. 153RV10.
2. Gristina, A.G., *Science*, 1987. **237**(4822): p. 1588-1595.
3. Wang, Y., et al., *Biomaterials*, 2014. **submitted**.
4. Krsko, P., et al., *Langmuir*, 2003. **19**: p. 5618-5625.
5. Wang, Y., et al., *Journal of Polymer Science, Part B: Polymer Physics*, 2013. **51**(21): p. 1543-1554.
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