Multi-Directional Electrodeposited Gold Nanospikes for Antibacterial Surface Applications

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Supplementary Data

Figure S1. 10 µm × 10 µm AFM image of the unmodified gold surface used as the control for the experiments.

Figure S2. Top-down SEM micrographs of the gold nanospike surfaces as a function of electrodeposition time. The red scale bars represent 500 nm. The concentrations of the precursor materials HAuCl₄ and Pb(CH₂COO)₂ were 6.8 mM and 1 mM, respectively.
Figure S3. Surface Composition Characterisation. Representative EDX, XPS, and XRD spectra of a substratum containing the gold nanospikes following fabrication and washing. Importantly, both Pb\(^{2+}\) and Cl\(^{-}\) precursor ions were not observed in the spectra, hence the surfaces were composed of pure gold, which is an inert material.

Figure S3 annotation: One example of the XRD data obtained is shown in Figure S3, which highlights the preferential growth taking place along the Au(200) plane. Here, energy-dispersive X-ray (EDX) and X-ray photoelectron spectroscopy (XPS) were used to confirm that no Pb\(^{2+}\) or Cl\(^{-}\) ions were present on the electrodeposited surfaces following fabrication (see Figure S3). Had these ions been present, characteristic Pb peaks would have been seen at \(-\text{La} = 10.551 \text{ keV}\) and \(-138.4 \text{ eV}\) and characteristic Cl peaks would have been seen at \(-\text{Kc} = 2.622 \text{ keV}\) and \(-200 \text{ eV}\) in the EDX and XPS spectra, respectively. The absence of such peaks corroborates the recent work on similar systems, which revealed that unwanted precursor ions were not present in the post-fabricated nanospikes.\(^1\)\(^-\)\(^3\) Most importantly, the XRD, XPS, and EDX data revealed that the surface deposited gold was pure, and hence any antibacterial activity taking place upon contact with these surfaces was a result of physical interactions between the bacteria and the surface.
Figure S4. Representative 70 µm × 70 µm CLSM and SEM micrographs of the substrate surfaces. These systems were used as the control for the experiments. The red scale bar in the SEM images represents 1 µm.

Figure S5. Top-down SEM micrographs of the Pb(CH$_3$COO)$_2$ precursor concentration series. The red scale bar represents 1 µm.

Figure S6. Native surface data for the HAuCl$_4$ concentration series. Row 1) 5 µm × 5 µm AFM images of the resultant gold nanospike surfaces. Row 2) Top-down SEM images. Row 3) Cell viability of *P. aeruginosa* (ATCC 9721) cells against the surfaces shown in Row 1 as a function of precursor HAuCl$_4$ concentration. Fluorescent staining of the samples with LIVE/DEAD Backlight highlights the live (green) cells and dead (red) in the CLSM images. The corresponding average non-viable cell count (red cells) is shown as pie charts. The CLSM image size is 70 µm × 70 µm.
Table S1. Surface characteristics of the gold nanospikes as a function of precursor HAuCl₄ concentration. The Pb(CH₂COO)₂ remained constant at 1 mM.

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<tr>
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<th>3.4 mM</th>
<th>6.8 mM</th>
<th>13.6 mM</th>
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<tr>
<td>Spacing (nm)</td>
<td>203 ± 89</td>
<td>211 ± 120</td>
<td>261 ± 182</td>
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<td>Height (nm)</td>
<td>100 ± 52</td>
<td>302 ± 57</td>
<td>178 ± 82</td>
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<td>Cap Radius (nm)</td>
<td>58 ± 20</td>
<td>60 ± 13</td>
<td>72 ± 62</td>
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<td>Density (/µm²)</td>
<td>18.24</td>
<td>16.04</td>
<td>13.80</td>
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<td>Surface Roughness (Ra)(nm)</td>
<td>46.8</td>
<td>93.0</td>
<td>70.6</td>
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References