Supplementary Information (SI) for RSC Sustainability.
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# Sustainable air plasma regeneration of screen-printed gold electrodes with enhanced electroactive surface area and biosensing performance

Sina Ardalan*[a], Clara T. H. Tran[b], Stuart T. Fraser[b,c], Marcela M. M. Bilek[b,d], Anna Ignaszak*[a,e]

[a]*Department of Chemistry, University of New Brunswick, Fredericton, Canada*
[b]*School of Biomedical Engineering, J03, The University of Sydney, NSW 2008, Australia*
[c]*Culturon Pty Ltd, Newtown, 2042, NSW, Australia*
[d]*School of Physics, A28, The University of Sydney, NSW 2006, Australia*
[e]*Department of Chemistry, Brock University, St. Catharines, Canada*
† Email: sina.ardalan@unb.ca, aignaszak@brocku.ca

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## List of Abbreviation

| Abbreviation | Full Form |
|---|---|
| AFM | Atomic force microscopy |
| $C_{dl}$ | Double layer capacitance |
| CPE | Constant phase element |
| CV | Cyclic voltammetry |
| ssDNA | Single strand deoxyribonucleic acid |
| EIS | Electrochemical impedance spectroscopy |
| E-Polish | Electropolish |
| MCH | Mercaptohexanol |
| OCP | Open circuit potential |
| POC | Point of care |
| $R_{ct}$ | Charge transfer resistance |
| RF | Radio frequency |
| RSD | Relative standard deviation |
| $R_u$ | Uncompensated resistance |
| SAM | Self assemble monolayer |
| SEM | Scanning electron microscope |
| SPE | Screen printed electrode |
| TBA | Thrombin binding aptamer |
| TBS | Tris buffer saline |
| WCA | Water contact angle |
| XPS | X-ray photoelectron spectroscopy |
| $Z_W$ | Warburg impedance |

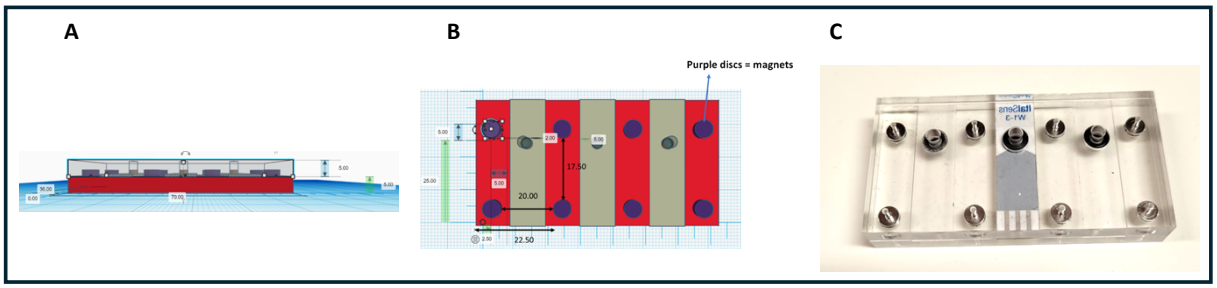


Fig. S1. Schematics and the image of the incubation chamber designed in Autodesk Tinkercad . (A) Front view, (B) Top view, and (C) image of the incubation chamber with a gold SPE sandwiched between the Perspex layers, tightly sealed by neodymium magnets.

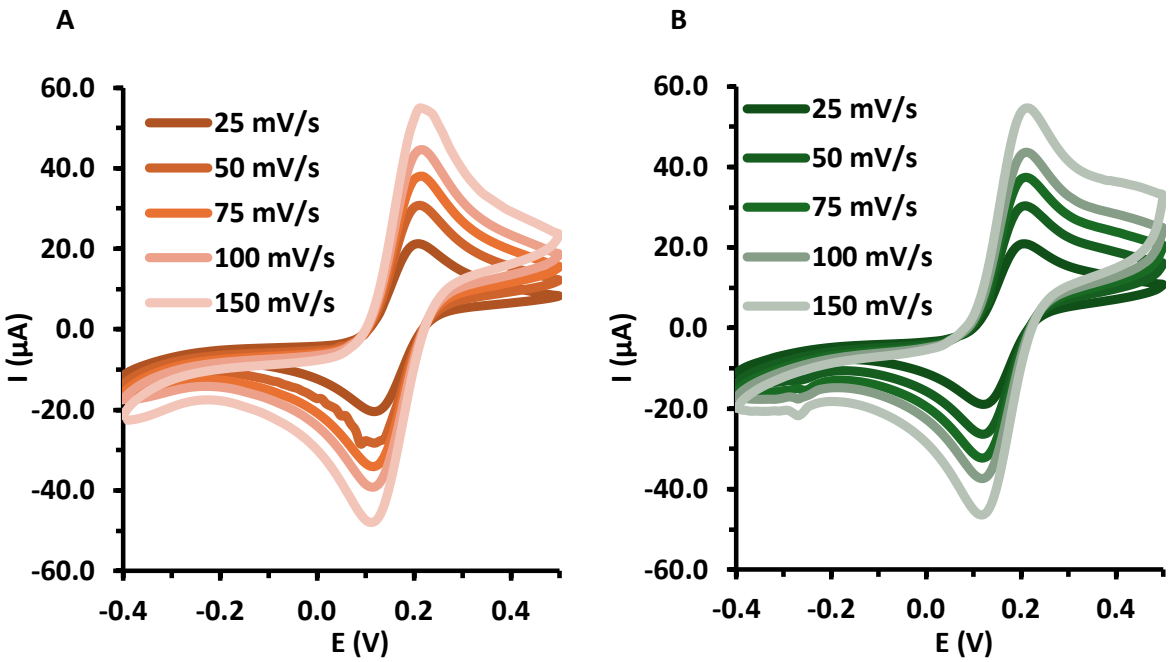


Fig. S2. Cyclic voltammograms of A) E-polished and B) plasma cleaned/E-polished gold SPE in the measurement buffer solution at scan rates 25–150 mV/s vs pseudo-Ag/AgCl paste.

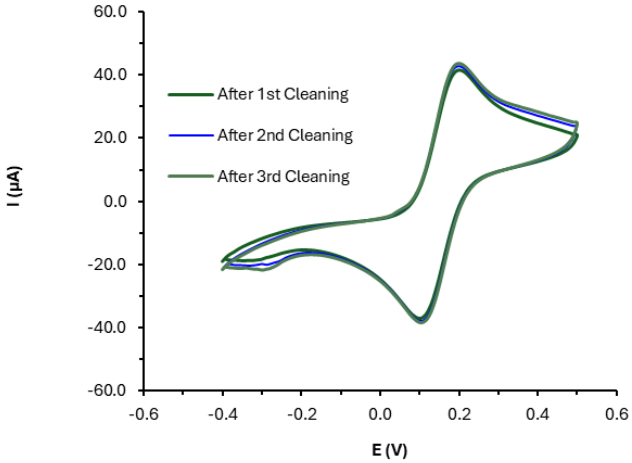


Fig. S3. Cyclic voltammograms of a gold SPE in TBS 1X and ferro/ferricyanide 2 mM after each cycle of plasma cleaning.

Table. S1. Electrochemical characteristics of a new (untreated), used, and plasma cleaned gold SPE showcasing the improved electrochemical performance and higher surface area via air plasma cleaning.

| Parameters | New | Used | Plasma cleaned |
|---|---|---|---|
| $I_{peak}$ (µA) | 49.5 | 6.8 | 77.4 |
| $\Delta E_{peak}$ (V) | 0.18 | 0.47 | 0.11 |
| $S_{true}$ ($cm^2$) | 0.21 | 0.15 | 0.26 |
| $R_{ct}$ (Ω) | 1.1 | 6.1 | 0.43 |
| $C_{dl}$ (µF) | 1.3 | 0.64 | 3.2 |

Table. S2. Comparison of plasma treatment parameters of this work with previously published studies.

| System | Plasma Power | Sample Size | Pressure | Time | Application | Advantage | Limitation |
|---|---|---|---|---|---|---|---|
| RF discharge air plasma, (this work) | 30 W ~10 mW/cm$^3$ | Substrate 15.2 cm x 16.5 cm | 0.7 Torr | 10 min | Recycling, pre-treatment | Cleans multiple electrodes simultaneously, simple operation, at least 3 recycles | Initial high cost |
| arc-discharge air-plasma generator[9] | 12.9 W | Localized 0.11 cm$^2$ | atmospheric | 15 s per electrode | Pre-treatment | No pump is required, rapid treatment | Require manual assembly |
| Plasma pen[3] | NA | Localized | atmospheric | 2 min | Pre-treatment | No pump is required | Dependence on operator skills |
| radiofrequency argon flow discharge[10] | 50-300 W | Substrate 10 cm diameter | 0.67-6.65Pa | 2-15 min | Pre-treatment | Improved electron transfer kinetics | High power consumption |

Table. S3. Fixed parameter values for the Randel-Sevcik and Warburg impedance equations for diffusion calculations.

| Parameter | Value |
|---|---|
| A ($cm^2$) | 0.21 |
| C ($mol/cm^3$) | $2\times10^{-6}$ |
| n | 1 |
| R (J/mol.K) | 8.314 |
| F C/mol | 96,485 |
| Constant | 0.446 |
| T (K) | 295 |

Table. S4. Warburg Impedance coefficient (σ) derived from faradaic EIS tests for electrodes treated under two conditions.

| **Parameter** | **E-polished** | **Plasma cleaned/E-polished** |
|---|---|---|
| $\sigma$ ($\Omega \cdot s^{-1/2}$) | 1071 | 1461 |

Table. S5. The oxidation peak currents for electrodes treated under two conditions were measured at stepwise increasing scan rates during cyclic voltammetry tests.

| | **E-polished** | **Plasma cleaned/E-polished** |
|---|---|---|
| **$v^{1/2}$ (V/s)** | **ip (μA)** | **ip (μA)** |
| 0.025 | 23.839 | 22.039 |
| 0.050 | 33.619 | 29.553 |
| 0.075 | 41.035 | 37.823 |
| 0.100 | 47.518 | 43.696 |
| 0.150 | 58.814 | 53.784 |

Table. S6. Peak binding energy (BE) comparison form XPS analysis of gold SPE in this work with previously published studies.

| **Element** | **Peak BE (This work)** | **Peak BE (Reference)** |
|---|---|---|
| $Au4f_{7/2}$ | Used: 84.02 eV<br>New: 84.49 eV<br>Plasma cleaned: 84.18 eV<br>Spin-orbit coupling: 3.7 eV | Chromium and gold on glass substrate: 83.95 eV[4]<br>Gold nanoparticles supported on oxides: 84.00 eV[5]<br>Spin-orbit coupling: 3.7 eV[5] |
| C1s | Used: 285.04 eV<br>New: 284.89 eV<br>Plasma cleaned: 285.08 eV | $sp^2$ C═C (284 eV), $sp^3$ C–C (285 eV), and C–OH (286.88 eV)[6] |
| N1s | Used: 400.34 eV<br>New: 400.29 eV<br>Plasma cleaned: 400.08 eV | Common organic nitrogen species: 399- 400.6 eV[8]<br>C-NH2: 400 eV [7, 8] |
| O1s | Used: 532.14 eV<br>New: 532.29 eV<br>Plasma cleaned: 532.58 eV | Common organic oxygen species 532.0 - 533.7 eV[6] |