Electronic Supplementary Information (ESI)

Optimization of gold-palladium core-shell NWs towards H$_2$O$_2$ reduction by adjusting shell thickness

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Figure S1. (a) TEM image of Au$_{75}$Pd$_{25}$ NWs. The top right inset is the corresponding selected area electron diffraction (SAED) pattern and the bottom left inset is the size distribution histogram of nanowires’ width. HRTEM images showing the area of (b) single crystalline, (c) twin boundary and (d) stacking fault in a nanowire.

| Au$_{85}$Pd$_{15}$ NWs | element | the weight ratio (%) | the mol ratio (%) |
|------------------------|---------|----------------------|------------------|
| Pd                     | 9.1     | 15.7                 |
| Au                     | 90.9    | 84.3                 |
| Total                  | 100     | 100                  |

| Au$_{75}$Pd$_{25}$ NWs | element | the weight ratio (%) | the mol ratio (%) |
|------------------------|---------|----------------------|------------------|
| Pd                     | 15.4    | 25.2                 |
| Au                     | 84.6    | 74.8                 |
| Total                  | 100     | 100                  |

| Au$_{55}$Pd$_{45}$ NWs | element | the weight ratio (%) | the mol ratio (%) |
|------------------------|---------|----------------------|------------------|
| Pd                     | 33.8    | 48.8                 |
| Au                     | 66.2    | 51.2                 |
| Total                  | 100     | 100                  |

Figure S2. EDX spectra and their corresponding elements contents of Au-Pd nanowires with different Au/Pd ratios.
Figure S3. (a) Au 4f and (b) Pd 3d XPS spectra of Au-Pd nanowires with different Au/Pd ratios.

Figure S4. SEM images of the as-synthesised products formed by controlling Au/Pd feeding ratio: (a) Au NWs, (b) Au$_{85}$Pd$_{15}$ NWs, (c) Au$_{75}$Pd$_{25}$ NWs, (d) Au$_{50}$Pd$_{50}$ NWs, (e) Pd NPs.

Figure S5. Cross-sectional compositional line profiles of (a) Au$_{85}$Pd$_{15}$ NWs, (b) Au$_{75}$Pd$_{25}$ NWs, (c) Au$_{50}$Pd$_{50}$ NWs.
Figure S6. SEM images of products synthesized at different temperatures: (a) 6 °C, (b) 30 °C, (c) 50 °C.

Figure S7. SEM image of the product synthesized with OTAB.

Figure S8. (a-d) LSV curves of H₂O₂ reduction and (e-f) their corresponding H₂O₂ calibration curves at 0.97 V for Au NWs, Au₈₅Pd₁₅ NWs, Au₇₅Pd₂₅ NWs, Au₅₀Pd₅₀ NWs, respectively.
Figure S9. CV curves of Au polycrystalline electrode (AuPoly), Au-Pd nanowires with different Au/Pd ratios and Pd black in 0.5 M H$_2$SO$_4$ solution.

Table S1 Comparison of the H$_2$O$_2$ sensing performance in this work with that of other Au-Pd nanomaterials.

| Sensing materials          | Sensitivity | Linear range          | Detection limit | Ref.  |
|----------------------------|-------------|-----------------------|-----------------|-------|
| Au NWs assembling spheres  | 6.25        | up to 0.8 mM          | 1.2 μM          | [45]  |
| Pd/PEDOT                   | 215         | 2.5 μM -1.0 mM        | 2.84 μM         | [48]  |
| PdNP/AuNAE                 | 533         | up to 2 mM            | 5 μM            | [16]  |
| AuPd nanocrystals          | 195.3       | up to 3 mm            | 8.4 μM          | [47]  |
| AuPd@GR                    | 186.9       | 5 μM -11.5 mM         | 1 μM            | [49]  |
| Au-Pd/MoS$_2$/GCE          | 184.9       | 0.8 M - 10 mM         | 0.16 μM         | [50]  |
| hAu$_i$Pd$_j$/GCE          | 5095.5      | 0.1-20 μM             | 0.02 μM         | [51]  |
| Au$_{rich}$Pd@AuPd$_{rich}$NWs | 355        | up to 10 mM          | 50μM           | This work |