

Hisashi Sugime¹

Takuya Ushiyama², Keita Nishimura², Yutaka Ohno², Suguru Noda³

¹ Waseda Institute for Advanced Study, Waseda University, 1-6-1 Nishi Waseda, Shinjuku-ku, Tokyo, Japan

² Department of Engineering, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Japan

³ Department of Applied Chemistry, Waseda University, 3-4-1 Okubo, Shinjuku-ku, Tokyo, Japan

sugime@aoni.waseda.jp

An interdigitated electrode with dense carbon nanotube forests on conductive supports for electrochemical biosensors

An interdigitated electrode (IDE) has an advantage for high sensitivity due to the amplified current by the redox cycling of analytes. As a material for the electrodes, carbon nanotubes (CNTs) have several advantages such as high electrical conductivity and fast electron transfer kinetics. Direct growth of CNTs on substrates by chemical vapor deposition (CVD) is especially a suitable way to integrate the CNTs into the IDE. We have developed low temperature growth technique (450 °C) of ultra-high mass density CNT forests (1.6 g cm⁻³) on conductive supports.^{1,2} They are attractive for the electrode material in IDE as the CNTs and supports have an ohmic contact which is different from the conventional CNT forests on insulators (e.g. SiO₂ or Al₂O₃).

In this report, we applied the dense CNT forests to the IDE by combining the UV lithography and the CVD process (Fig. 1a and 1b). By optimizing the geometry of the electrodes (width and gap), the performance of the IDE was significantly improved. The cyclic voltammetry (CV) measurements of K₄[Fe(CN)₆] showed that the current of IDE with CNTs (CNTF-IDE) reached to the steady-state current much more rapidly compared to that of conventional gold IDE (Au-IDE) (Fig. 1c and 1d). As a model case of the biomolecules, dopamine (DA) was measured under coexistence of ascorbic acid (100 μM). The selective detection of DA was achieved with the linear range of 100 nM – 100 μM, the sensitivity of 14.3 mA mol⁻¹ L, and the limit of detection (LOD, S/N=3) of 42 nM. In addition, the CNTF-IDE showed superior anti-fouling property with a negligible shift of half-wave potential ($\Delta E_{1/2} < 1.4$ mV) for 30-times repeated CV measurement of DA at high concentration (100 μM).³

References

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[3] Sugime et al., *Analyst* **143**, 3635 (2018).

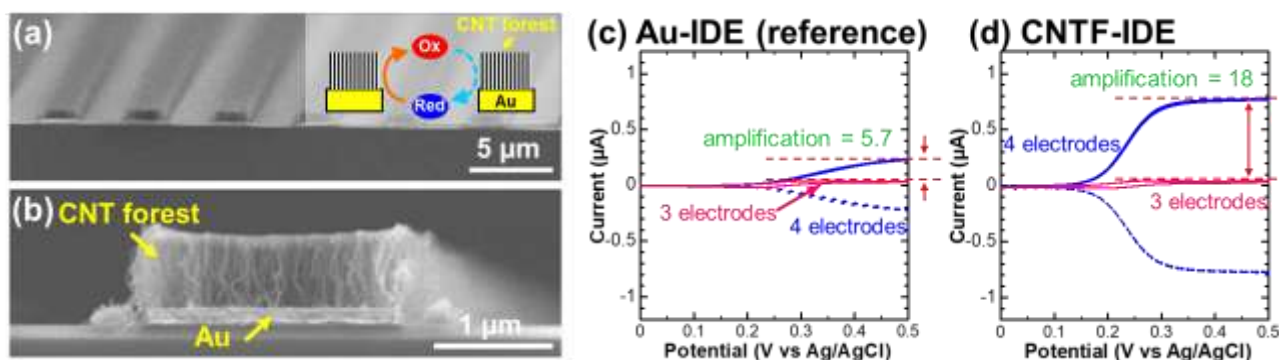


Figure 1: (a, b) Side-view SEM images of the CNT forests on Au electrodes. CV results of (c) Au-IDE (reference) and (d) CNTF-IDE with the K₄[Fe(CN)₆] (100 μM) in KCl (100 mM) at the scan rate of 10 mV s⁻¹.