

Nanogap Sensor for Electric/Electrochemical Detection of Biomolecules and Microbes

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Nanogap device where two electrodes are separated or coupled in nanometer scale is an excellent platform for electric and electrochemical sensing of biomolecules and microbes.

Conductance jump upon their selective immobilization on the device is quite conspicuous to let an unambiguous judgment of the existence of the targets. Detection probability, or the success rate of the detection can be greatly enhanced without a loss of device sensitivity by simply extending the effective gap distance. Although the conductance variation of a single device would not reflect the target concentration, the on device percentage in an integrated nanogap device exhibited a very nice concentration dependence whose dynamic range was tunable.

Great enhancement of the sensitivity can be obtained by adopting the dielectrophoresis. Nanogap electrodes whose surface was intentionally roughened can efficiently trap Au nanoparticles of extremely low concentration. When integrated, it can be used in the quantification of the nanoparticles in a wide dynamic range. Based on this, a new strategy for active detection of target biomolecules can be proposed and tested: Trace amount of infectious disease biomarkers sandwiched between Au and magnetic nanoparticles were successfully detected with high sensitivity and selectivity and the results was compared with those obtained by the conventional passive approach.

When the nanogap was adopted in electrochemical sensing, surprising enhancement of redox signal was observed due to the coupling of the two electrodes. When the electrodes for oxidation and reduction are brought into close proximity, one electrochemically-active molecule or ion can generate a large current shuttling between the two electrodes which can be just intact or functionalized. Adopting this method, with a moderate modification in each specific cases, selective detection of the extremely small amount of toxin, virus, and bacteria was successfully implemented.