Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Selective Nano Manipulation of Fluorescent Polystyrene Nano-Beads and Single Quantum Dots at Gold Nanostructures Based on AC-Dielectrophoretic Force

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DEVICE FABRICATION

A silicon-dioxide (SiO_2) substrate was used, and a photo resistor (PR) was deposited and patterned to form microelectrodes. The lift-off process was performed in acetone for 30 min after the deposition of Ti/Au layers with 5-nm/50-nm thick microelectrode patterns using an e-beam evaporator. The microelectrodes were fabricated with photolithography and the lift-off process before the fabrication of nanostructures to locate the nanostructures accurately in the gap of microelectrodes.

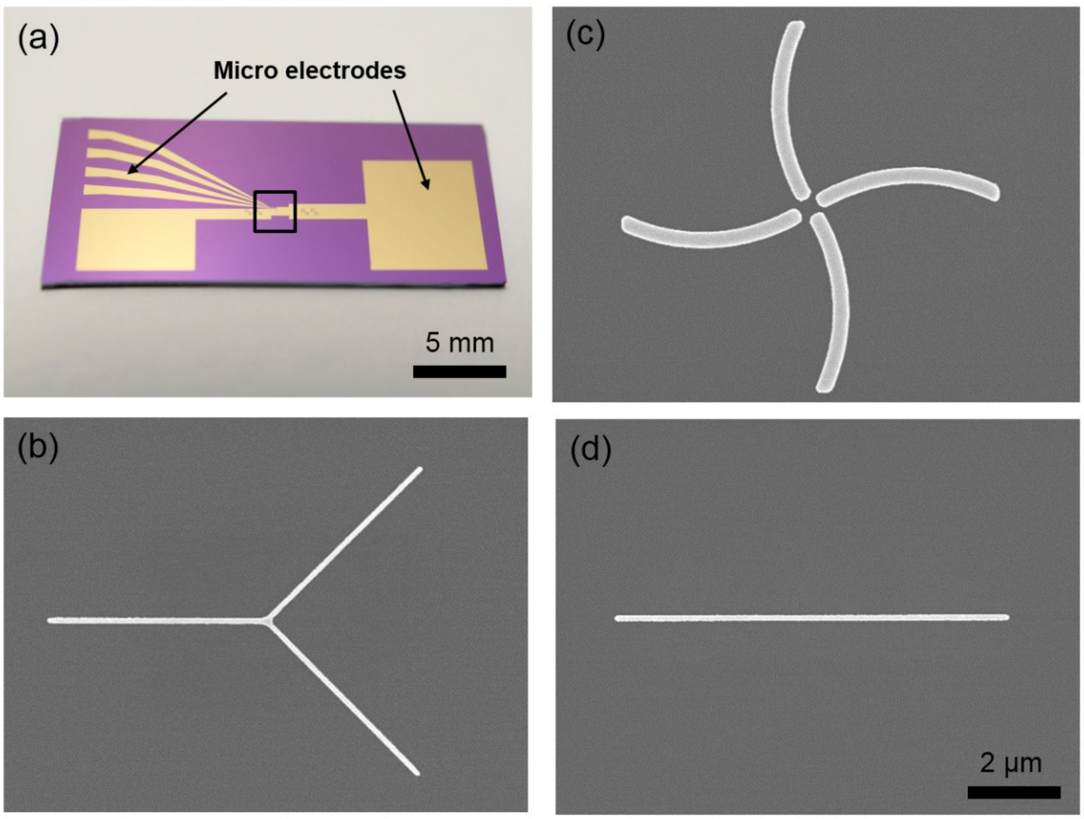

Figure S1. Fabricated device and structures. (a) Image of the entire device (the gap between microelectrodes and nanostructures is located in the white rectangle). SEM image of (b) 100-nm-wide Y-shaped nanostructure, (c) 200-nm-wide quadrupole structure, and (d) 100-nm-wide nanowire.

The Au nanostructures at the 10-μm-wide gap of microelectrodes were patterned with e-beam lithography and a lift-off process. The deposition of an e-beam resistor (ER) layer with high uniformity in the gap was the most important step to achieve accurate nano patterns. The nano patterns of the nanowire and vortex were performed at the ER layer. The nanostructures were patterned to not contact the microelectrodes, and various distances between the microelectrode and the end of the structures were maintained. At the patterns, a 100-nm-thick Au layer was deposited with 0.1-nm/sec deposition rate on a thermally grown SiO_2 substrate to obtain a smooth surface. The lift-off process was also performed for 24 h in acetone to form Au nanostructures.

As shown in Supporting Figure 1 (a), the device for selective manipulation using the floating DEP force was accomplished. The 10-μm-wide gap of microelectrodes was located at the white rectangle marked in Supporting Figure 1 (a). Various shapes of nanostructures, such as Y-shape, quadrupole, and nanowire were formed at the gap. The SEM images of the fabricated nanostructures are shown in Figures S1 (b), (c), and (d), respectively.

BLINGKING MEASUREMENTS

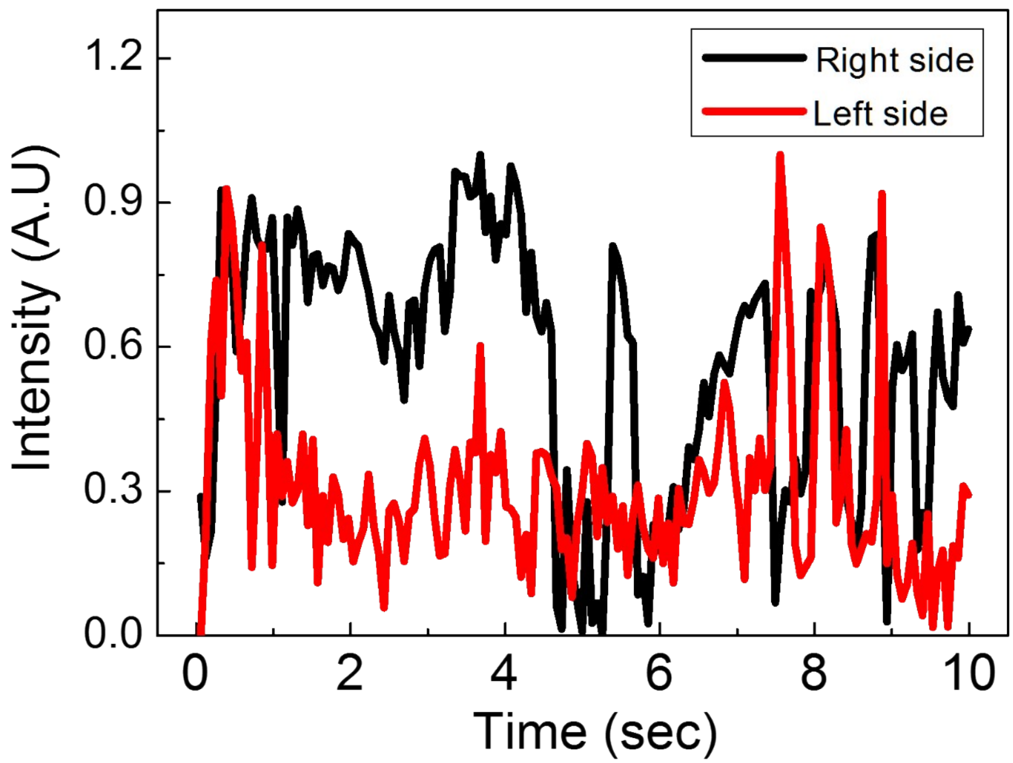

Figure S2. Intensity of QDs attached on both sides of the nanowire.

For the accurate analysis of the attachment of single QDs at a nanowire, the blinking was analyzed in a recorded video (blinking_nanowire_final.avi) by using Image pro premier ver. 9.1 (MediaCybernerics). The intensity of blinking is plotted against time in Figure S2. The signals showed clear blinking at both sides. The QD on the right side turned on for a longer time than the QD on the left side did. The random turning on/off/on/off is natural characteristic of a single QD. The normalized intensities of both sides were approximately the same. Thus, we could verify that the attached QDs at both sides were single.