Low Dimensional Nanomaterials and Photonic Devices

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Single crystalline semiconductor nanowires (NWs) have attracted considerable research interests due to their intriguing electrical and optical properties, as well as technical compatibility with the industrial integrated-circuit technologies. Development of simple and robust synthetic methods to control structures of NWs will provide researchers a solid platform for thoroughly understanding physical properties of nanowires, and thus for exploring various state-of-the-art applications of them. Here I will introduce the synthesis of vertically aligned Si NW arrays with controlled structures in terms of diameter, length, position, crystallographic orientation, surface morphology and so on. Moreover, I will introduce applications of Si NWs to advanced devices such as photodetectors, photovoltaics, transistors, and medical devices. In particular, I demonstrate photon-triggered NW transistors, photon-triggered NW logic gates and a single NW photodetection system. NWs are fabricated with long single crystalline silicon (CSi) connected by short porous silicon (PSi) segments. The metal electrodes on both ends of the NW are formed, and a single PSi segment is located at the middle. Exposing the PSi segment to light triggers a large current in the NW with a high on/off ratio of $>8 \times 10^6$. A device with two PSi segments along the NW is triggered using two independent localized pump lasers as optical input signals. We demonstrate photon triggered logic gates; AND, OR and NAND gates. A photon-triggered NW transistor using nanowire with a diameter of 25 nm and a 100 nm-length PSi segment only requires less than 300 pW of laser power. Moreover, taking the advantage of the excellent photosensitivity, we fabricate the single nanowire photodetector with a submicrometre-resolution. Photon-triggered nanowire transistors offer a new venue towards multifunctional devices in a single nanowire, for example programmable logic circuits and sensitive photodetectors.