Silicon Nanowires for Photodetector Arrays

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There is a growing interest in the use of semiconductor nanocrystals and nanowires (NWs) for photodetectors and solar cells due to their tuneable feature size and large surface area [1-3]. McDonald et al. [2] have shown that nanocrystal-based photodetectors can be tuned for enhanced infrared response by controlling the feature size of the crystals, which is attractive for potential biomolecular studies [4]. In addition, Law et al. [1] have shown the use of aligned NWs in dye-synthesized solar cells to enhance extraction of photo-generated carriers, leading to higher external quantum efficiencies of ~50% [1]. While the surface and feature size of NWs can provide the benefits of nanocrystals, they can lead to better extraction of photo-generated carriers along the high mobility NW core. However, carrier extraction in dye-synthesized solar cells [1,3] is hampered by electrode separation of more than 20 μm in view of the limited lifetime of the generated carriers.

This paper presents photodetectors (see Fig. 1(a)) having vertically stacked electrodes with sub-micron (~ 200-400 nm) separation based on silicon nanowire (SiNW) nanocomposites. The thin-film-like photodetector devices are made using standard photolithography instead of electron beam lithography and thus are amenable to scalable array fabrication. Fig. 1(b) depicts a microscope picture of a row of the photodetectors fabricated on a strip of grown SiNWs. The SiNWs are grown using PECVD [5] on photolithography located catalyst areas (see Fig. 2(a) and (b)). The fabrication method of SiNW/oxide nanocomposites, shown in Fig. 2(c) and (d), is not limited to SiNWs and can be extended to different NWs (e.g., ZnO and CdSe) and substrates. As seen in Fig. 1(c), the current-voltage characteristics show Schottky behaviour and are dependent on the properties of the contact metal (ITO, Al, Au) and that of the pristine SiNWs. This makes these devices also suitable for examination of electronic transport in SiNWs. Preliminary results for light sensitivity show promising quantum efficiency that is a function of effective NW density and diameter.

References

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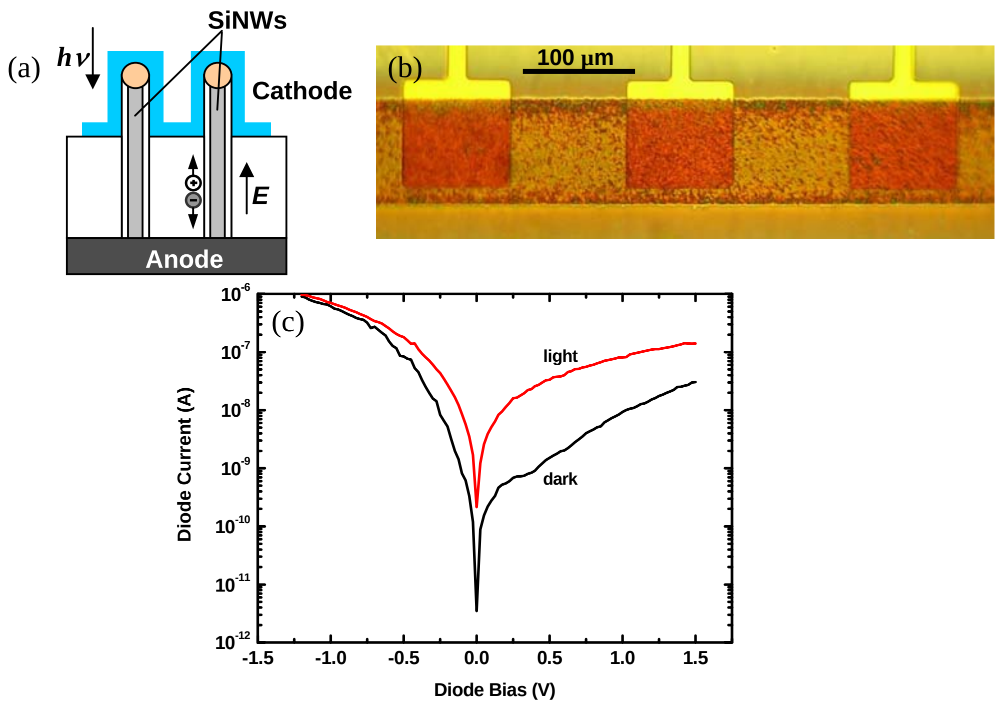

Fig. 1. (a) Schematic cross-section, (b) photomicrograph, (c) measured current-voltage characteristics of the ITO/SiNW photodiodes under dark and light conditions.

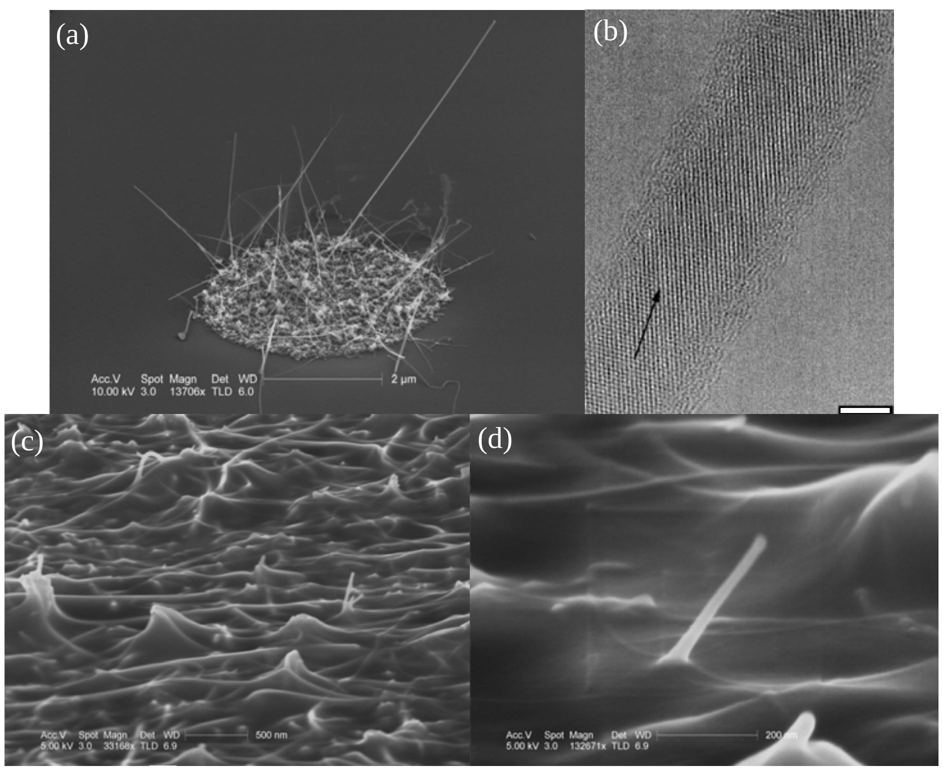

Fig. 2. (a) SEM image of SiNWs grown from a catalyst island, (b) HRTEM image of PECVD grown SiNWs (scale bar: 3 nm, arrow: <111> direction), (c), (d) SEM images of SiNW nanocomposite.