The Effects of CVD Deposition Time on Al-Catalyzed SiNW Formation

NIMS, °Wipakorn Jevasuwan, Junyi Chen, Thiyagu Subramani,
Ken C. Pradel, Toshiaki Takei and Naoki Fukata
E-mail: JEVASUWAN.Wipakorn@nims.go.jp

Photovoltaic devices using silicon nanowires (SiNWs) have received much attention due to their excellent optical and electrical characteristics [1,2]. From our previous reports, we presented SiNWs formed by vapor-liquid-solid (VLS) growth using Al which has been recently proposed as a new alternative catalyst [3,4]. The effects of substrate temperature on SiNW formation were discussed and the SiNW-based solar cells were demonstrated. In this study, the effects of deposition time on SiNW formation were further investigated. Reflectance and absorbance properties of SiNWs with various deposition times were observed. Performances of radial p^+-p-n-junction solar cell were also reported.

Fabrication of SiNW samples was carried out using n-Si(111) substrates. Prior to VLS process, 50-nm-thick Al-catalyst films were prepared using sputtering followed by 0.5% HF etching for 30 s to remove Al_2O_3. Then, the samples were loaded immediately into a chemical vapor deposition (CVD) chamber. In this study, SiNW formations were performed with various CVD deposition times of 10, 20, and 30 min. SiH_4 gas flow was controlled at 19 sccm under chamber pressure of 800 Pa with a fixed substrate temperature of 700 °C. For growth of SiNW solar cells, p^+-Si shell layer was deposited at 750 °C for 5 min with a boron concentration of ~4×10^{19} cm^{-3} [5]. Sputtering of a 100 nm-thick ITO film followed by a 200 nm-thick Al with a finger-grid pattern for front electrode, and a 150 nm-thick Ag back contact of solar cells were performed.

Schematics of Al-catalyzed SiNW formation by VLS process and SEM images of SiNWs with various CVD deposition times were shown in Fig. 1. SiNW formation starts from the vapor phase diffusion through the liquid Al catalyst droplet and ends up as solid Si wire. From SEM images, taper-shaped SiNW structures were formed and mostly grown along [111] direction. Increasing of SiNW conical diameter and height (from 1 to 7 μm) was observed with longer deposition time indicated that VSS process was also preceded at the meanwhile. The reflectance spectra of these SiNWs were constant around 10 % in the

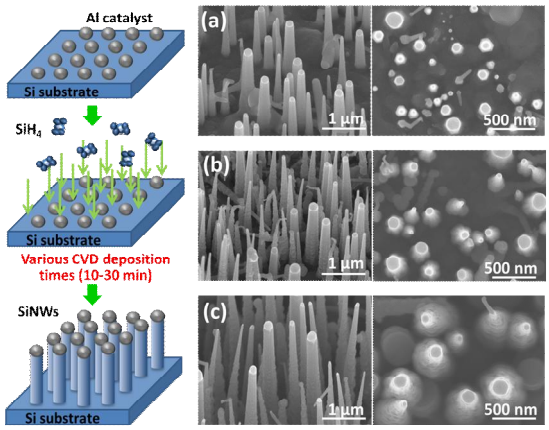

Fig. 1 Schematics of Al-catalyzed SiNW formation by VLS process and SEM images of SiNWs formed at 700 °C with various CVD deposition times of (a) 10, (b) 20, and (c) 30 min.

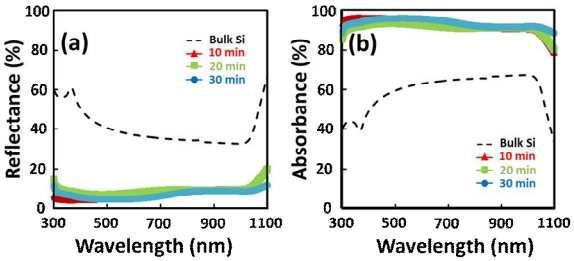

Fig. 2 (a) Reflectance and (b) absorbance spectra of Al-catalyzed SiNWs formed at 700 °C with various CVD deposition times of 10, 20 and 30 min compared to bulk-Si.

wavelength range corresponding to the spectral response of solar cell as shown in Fig. 2. SiNW-based solar cells fabricated using p^+-p-n structure were realized and the maximum conversion efficiency of 5.7% was achieved from 10-min CVD deposition time. Shorter CVD deposition led to smaller SiNW structure resulting in better solar cell junction and electrode formations. However, other parameters of SiNW formation should be further investigated to improve SiNW structures and device performances.

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