Al-Catalyzed Si Nanowires for Photovoltaic Application

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Nanowires (NWs) have been the focus of attentions for future devices due to their unique physical properties which have great potentials for fabrication of NW-based solar cells [1,2]. Vapor-liquid-solid (VLS) mechanism using nanocluster catalysts of chemical-vapor-deposition (CVD) technique is one of candidates to create high-quality NWs with single crystalline structures and in large quantities [3]. From our previous report [4], we presented SiNW formed by VLS growth using Al which has been recently proposed as a new alternative catalyst [5,6]. The effects of substrate temperature on Al-catalyzed SiNW formation have been discussed. In this study, light reflectance of Al-catalyzed SiNWs was further examined. Al removal from SiNWs by diluted HF after CVD growth was observed and SiNW-based solar cells were demonstrated.

All SiNW samples were carried out using n-Si(111) substrates and the 50-nm-thick Al-catalyst films were prepared using sputtering. SiNW formation was performed with various substrate temperatures of 600 °C, 650 °C, 700 °C and 750 °C. SiH_4 gas flow was controlled at 19 sccm under chamber pressure of 800 Pa with fixed deposition time of 30 min during CVD process. According to the previous report [4], we found that SiNWs could be formed at 650 °C. Vertical taper-shaped NW structures were achieved at 700 °C and adding of non-directional SiNW branch was more obvious at 750 °C. Nanodot (ND) formation on surrounding surface of all SiNWs was observed. Fano-effect was detected in Si optical phonon peak indicated Al doping in SiNWs. In this study, light reflectance of SiNWs was investigated prior to apply these SiNWs for solar cell fabrication. Reflectance spectra of SiNWs were decreased with increasing formation temperature. The samples grown at 650 °C and 700 °C had reflectivity lower than 20% for entire spectral response wavelength corresponding to their NW structures as shown in Fig. 1. Both of these SiNWs will be used as substrates for SiNW-based solar cell fabrication further.

Figure 2 showed TEM images of Al-catalyzed SiNWs formed at 700 °C (a) without and (b) with 1%HF dipping for 5 min. The removal of Al after CVD growth by dipping in diluted HF could be successful. EDX images showed no detection of Al on SiNW tip and surface with maintained ND structure. The p-i-n SiNW-based solar cell structures are in progress.

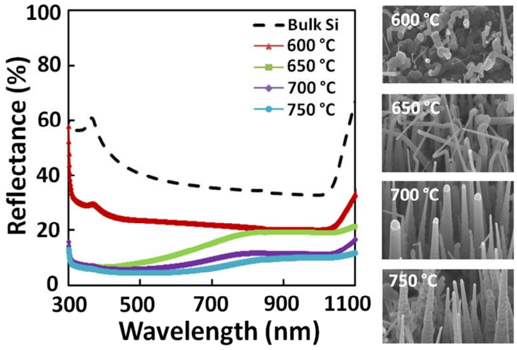

Fig. 1 SEM images of Al-catalyzed SiNWs with various formation temperatures and reflectance spectra compared to bulk-Si.

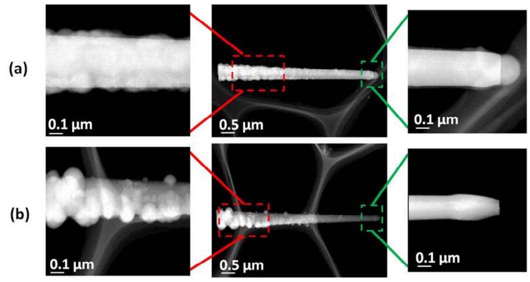

Fig. 2 TEM images of Al-catalyzed SiNWs formed at 700 °C (a) without and (b) with HF dipping.

These Al-catalyzed SiNW formations and their solar cell fabrications are promising for future devices. However, other parameters for improving of SiNW structures and device performances have to be further investigated.

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