

Growth direction, Sn content and crystallinity of Au-Sn catalyzed $\text{Ge}_{1-x}\text{Sn}_x$ nanowires

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Introduction

$\text{Ge}_{1-x}\text{Sn}_x$ nanowire (NW) is a potential candidate material for fabricating next generation Si-compatible electronic and optoelectronic devices with its high carrier mobility and an opportunity for achieving a direct band gap structure by introducing Sn more than 6.5-11 at.% [1,2]. The practical use requires $\text{Ge}_{1-x}\text{Sn}_x$ NWs with controllable growth direction, high Sn content and good crystallinity.

Here, we investigated the growth direction, Sn content and crystallinity of $\text{Ge}_{1-x}\text{Sn}_x$ NWs as the function of Sn concentration over a wide range (0-86%). $\text{Ge}_{1-x}\text{Sn}_x$ NWs were grown using germane (GeH_4) precursor with Au-Sn catalysts via Vapor-Liquid-Solid (VLS) process. Sn concentration in catalysts was controlled by varying the ratio of deposited Au and Sn and metal Sn in catalysts was used as Sn source instead of precursor gas.

Experimental section

Sn nanoparticles and Au film were deposited on Si(111) substrates in sequence by thermal evaporation. The volume ratio of Au and Sn was controlled by varying the deposition thickness of each metal. Then, those samples were loaded into a chemical vapor deposition (CVD) chamber to perform VLS growth. $\text{Ge}_{1-x}\text{Sn}_x$ NWs were grown at the 320 and 360 °C for 20 min by using 10 sccm of GeH_4 as a precursor gas (Figure 1).

Results and discussion

Figure 2 show that the growth direction of $\text{Ge}_{1-x}\text{Sn}_x$ NWs changed from $\langle 111 \rangle$ to $\langle 110 \rangle$ as the increasing of added Sn concentration in catalysts. The Sn content and crystallinity of the NWs were confirmed by Raman spectroscopy. Figure 3a shows that the Ge optical phonon peak shift to the lower wavenumber on increasing Sn concentration in catalysts, indicating higher substitutional Sn content in NWs. FWHM of the Ge optical phonon shown in Figure 3b shows that the crystallinity was improved by adding Sn in catalyst (< 60 at.%) and increasing growth temperature.

[1] Gupta, S. et al. *J. Appl. Phys.* **113**, 073707 (2013).

[2] Lu Low, K. et al. *J. Appl. Phys.* **112**, 103715 (2012).

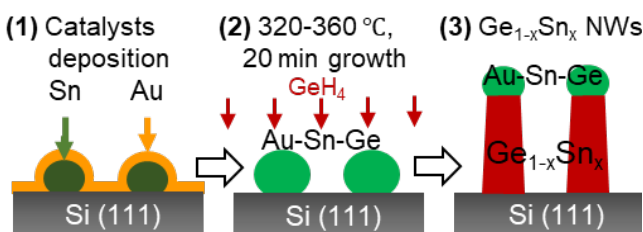


Figure 1. Schematic of experiment.

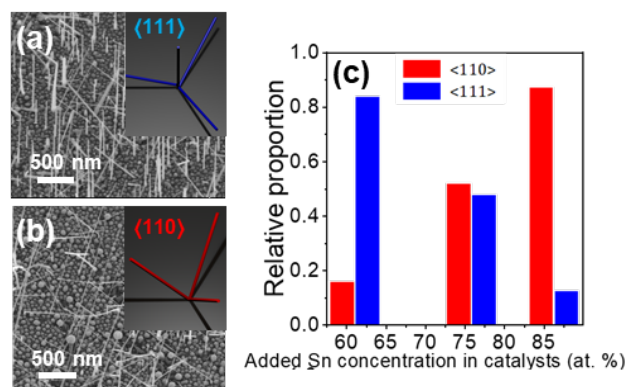


Figure 2. 30° tilted SEM images of $\text{Ge}_{1-x}\text{Sn}_x$ NWs grown at 320 °C using catalysts with Sn concentration of (a) 61% (b) 86% in catalysts. The insets show the schematic $\langle 110 \rangle$ and $\langle 111 \rangle$ -oriented NWs grown on Si(111) substrate.

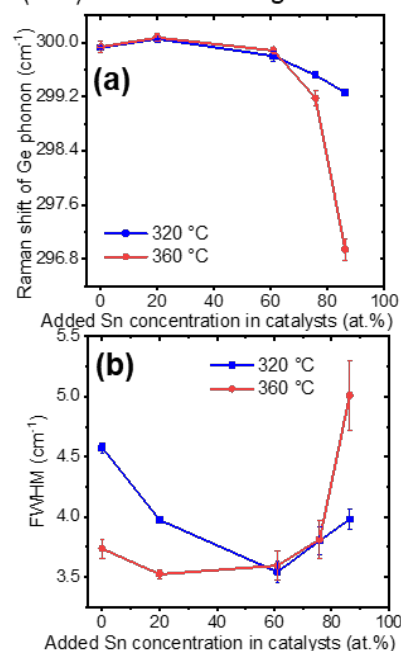


Figure 3. (a) Raman shift of Ge optical phonon peak of $\text{Ge}_{1-x}\text{Sn}_x$ NWs grown at 320 °C and 360 °C with different Au:Sn ratio in catalysts. and (b) corresponding FWHM.