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# Growth of InAs NWs with controlled morphology by CVD

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**Abstract**: We report on the growth of single crystal InAs NWs on Si/$SiO_x$ substrates by chemical vapor deposition (CVD). By adjusting growth parameters, the diameters, morphology, length and the proportion of superlattice ZB InAs NWs (NWs) can be controlled on a Si/$SiO_x$ substrate. Our work provides a low-cost route to grow and phase-engineer single crystal InAs NWs for a wide range of potential applications.

## 1 Introduction

III-V InAs NWs have attracted much attention as a direct bandgap semiconductor with a small bandgap, a small effective mass and a high room-temperature electron mobility. Several novel functional devices have been realized with InAs NWs. Applications of InAs NWs in the future call for an effective control of their morphology and crystal structure during their growth.[1-3] Compared with other epitaxial methods, there are only limited reports of the effects of growth parameter on the morphology and structure of InAs NW.[4-7] While the understanding of the effect of the growth parameters is essential to achieve optimal control growth in CVD. This article demonstrate that the morphology, and the proportion of superlattice ZB InAs NWs can be effectively controlled on a Si/$SiO_x$ substrate using growth parameters in CVD.

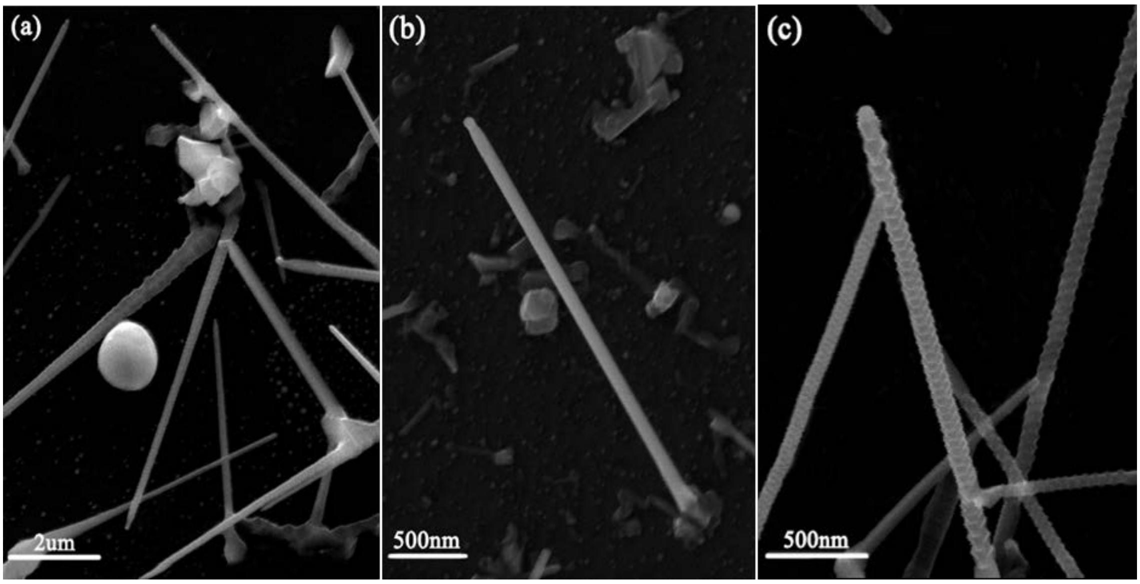


Fig. 1 the three morphology of InAs NWs (a) the taperd InAs NWs, (b) uniform InAs NWs, (c) twin superlattice NWs

## 2 Experimental details

Si/SiOx substrate was cleaned with ethanol, acetone and deionized (DI) water and then immersed in mercaptan-ethanol solution. Gold colloid of 5nm diameters were dispersed on the substrate. InAs powder (purity 99.999%) was placed at the spot to be heating up to 800 ºC in a tube furnace (Lindberg

TF55035KC). The growth substrate was placed near the end of the tube where the temperature was around 390 to 640 ºC during NW's growth. During the growth, the flow rate of $H_2$ carrier gas varied from 60 to 120 sccm (standard cubic centimeters per minutes). The pressure of the growth chamber was kept at 150 Torr. The growth time was about 40 minutes. The products was characterized using a field-emission scanning electron microscope (SEM, FEI Quant 600F, operated at 20 KV).

**3 Results and discussion**

The growth window of InAs NWs was found to within 390 ◦C and 640 ◦C. There are three kinds of InAs morphology, see Fig. 1, (a) the taperd InAs NWs, (b) uniform InAs NWs, (c) twin superlattice NWs. The structure and the composition of these InAs NWs has been reported in detail in Ref. 8. All the NWs are of zincblende structure. The InAs NW morphology as function of both the growth temperature and the flux rate of carrier gas was shown in Fig. 2. The tapering extent was exressed by color in Fig. 2 and the percentage represent the proportion of twin superlattice NW. Generally speaking, the InAs NWs grown on substrates are tapered at medium temperatures and become uniform at the lower temperature and higher temperature coupled with high flux rate. Radial growth is a thermally activated process, that is, kinetically limited. [9, 10] With the growth temperatures increasing, adatom diffusion rate and length increases and diffusing adatoms are more likely to incorporate into NW sidewalls and cause raxial growth by vapour-solid mechanism. While as the growth temperature increased further, the diffusion length increases and more adatom are able to diffuse long enough distances to the interface of Au nanoparticle and nanowire, this facilitating their incorporation at the NW tip instead of the NW sidewalls.

Twin-plane formation is less energetically favoured compared with ordinary plane nucleation and

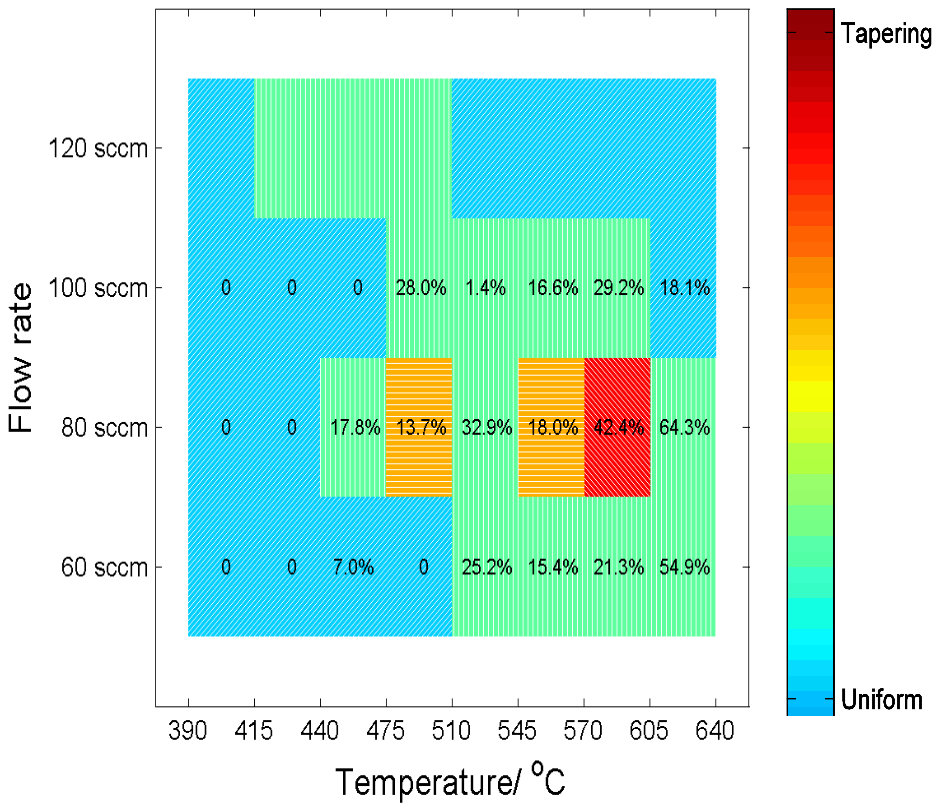


Fig. 2 InAs NW morphology as function of both the growth temperature and the flux rate of carrier gas

thus larger supersaturation is required. High flux rate, and fast growth rate promotes twin formation.[11-14] and therefore the proportion of superlattice NWs increase with increasing flux rate of carrier gas at certain growing temperature. As the flux rate increased further, the proportion of twin superlattice NWs then decrease. It is thought both As and In species reduce surface and interface tensions throughout growth[15], and this may be responsible for the reduction in twin superlattice when As and In precursor flow rates are high temperature and high flux rate. In conclusion, there are two opposing mechanisms that contribute to this result.

In summary, we have showed that the morphology and crystal structure can be controlled in the CVD growth of InAs NWs on Si/$SiO_x$ substrates. The lower growth temperature has significant advantages, namely the minimization of undesirable radial growth, elimination of twinning defects and tapering. The higher growth temperature has similar advantages but has the shortcoming, the maximum of radial growth and the dimeter distribution.

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