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RESEARCH PAPER

Growth parameters and shape specific synthesis of silicon nanowires by the VLS method

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Abstract In this paper the effect of varying temperature, pressure and chemical precursors on the vapour–liquid–solid (VLS) growth of silicon nanowires (Si NWs) have been investigated. Some aspects of nucleation and growth mechanisms are discussed. Control on Si NW morphology by varying the choice of gaseous precursor (silane or dichlorosilane) at elevated temperatures is reported.

Keywords Silicon nanowires · Growth parameters · Gas precursor · Shape control · Synthesis · Surrounding environment

Introduction

Semiconductor nanowires have attracted a lot of attention in recent years due to their fascinating intrinsic properties and their potential applications in emerging nanoelectronics (Li et al. 2006; Lieber et al. 2007). Specifically, silicon nanowires (Si NWs) have been particularly studied due to the importance of silicon to the microelectronics industry. These nanowires have been employed as fundamental building blocks in various micro and nanoelectronics experimental devices and are expected to play a major role in the development of future electronics (Mc Alpine et al. 2007; Yu et al. 2007; Verplanck et al. 2007; Yang et al. 2006).

To date, a variety of methods have been employed for the synthesis of Si NWs. The most popular approach, vapour–liquid–solid (VLS) growth mechanism first reported 40 years ago by Wagner and Ellis (1964) requires the use of catalytic nanoparticles and a Si-containing gas precursor. Gold is the most commonly employed catalyst although other systems have proven to be effective (Kamins et al. 2001; Baron et al. 2006). Catalytic gold nanoparticles are generally obtained by two routes: dewetting of a gold thin film from a surface (Kwak et al. 2007) or deposition of colloidal gold (Cui et al. 2001). When the gold nanoparticles are present on the growth substrate, the VLS process proceeds in three main steps. Firstly, the alloying process consists of the formation of liquid droplet containing the metal catalyst and dissolved Si. For gold, the eutectic composition is obtained at 363 °C. Secondly, when the silicon concentration reaches the upper solubility limit, nanowire nucleation commences. At this stage, a three phase biphasic system (SiH_4 gas, Au/Si alloy and Si solid) may be attained, the Au/Si liquid droplet being intercalated between the gaseous and the solid

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