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Realization of 2H-Si by Plateau-Rayleigh Instability (PRI) using Al Nanowires

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Extended Abstract

Nanomaterials enable innovative technological development in various industries. Finding clues that these nanomaterials affect microscopic crystal growth can provide a new paradigm of crystal growth. Therefore, in this study, we present a new mechanism for AlN nanowires formed through mixed-source hydride vapor phase epitaxy (HVPE) to affect the growth of 2H-Si microneedles and achieve ultrafast growth rate of 6.7×10^4 Å·s^{-1}. Mixed-source HVPE uses a metal mixing source (Si, Al, Ga) as a raw material and supplies HCl, NH_3, and N_2 gas at a growth temperature of 1250 °C. It was confirmed that AlN nanowires were formed due to the initial reactants and Plateau-Rayleigh instability (PRI), a natural phenomenon, occurred in the AlN nanowires, which had an important influence on the growth mechanism. Elliptical Al membranes with equal intervals are formed on the surface of AlN nanowires by PRI, and then Si droplets are formed in the elliptical Al membrane to induce the ultra-fast growth of 2H-Si microneedles. As a result of the experiment, a straight 2H-Si microneedle with a length of 40 mm could be obtained at a growth rate of 6.7×10^4 Å·s^{-1} during a growth time of 100 minutes. As a result of confirmation through field emission scanning electron microscopy, oval-shaped Al membranes with a length of 2.5 μm and a width of 1.5 μm were uniformly formed on the surface of AlN nanowires at an average interval of 4 μm. This clearly shows that PRI was utilized during the 2H-Si microneedle growth process. The 2H structural characteristics of the grown 2H-Si microneedle were confirmed through high-resolution transmission electron microscopy analysis, and a typical ABAB stacking arrangement of 2H was seen. In addition, it was confirmed that the Raman spectrum of 2H-Si appeared in Raman spectroscopy. In conclusion, the mechanism by which nanoscale materials develop into microscale crystals was confirmed through the mixed-source HVPE method. In addition, we propose a crystal growth method at a very high growth rate that cannot be realized with conventional growth methods.

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