Wafer Scale Growth of Isotopically Purified Polytype Silicon Nanowires and Polymorphs

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Introducing periodic stacking faults, such as polytypes or twinning superlattices, into the crystal structure of semiconductors, has been widely used to alter the latter physical properties [1]. Recently, remarkable control over the crystalline structure of group III-V NWs was demonstrated, enabling the fabrication of twinning superlattices with nano-scale control [2-3]. Despite the promising potential for band gap engineering, the study of polytype inclusion into Si is naturally limited, due to their rareness and challenging characterization. In that respect, vapor-liquid-solid (VLS) grown SiNWs, enabling longitudinal polytype inclusion, present a unique system facilitating both the study and the utilization of Si with distinguished properties such as reduced momentum transfer in rhombohedral Si or increased optical gap in hexagonal Si [4-5]. Nevertheless, the lack of a reproducible fabrication procedure of polytype SiNWs holds back further progress in their study. So far only a few studies were dedicated to polytype SiNWs identification [6-8] and generation mechanism [9], whereas their properties are still essentially unknown.

Herein we report wafer-scale growth of isotopically purified polytype ^{30}SiNWs with high level of hexagonallity as well as of rhombohedral Si polymorphs. The pronounced Raman shift of the isotopically purified ^{30}SiNWs enabled wafer scale study of their yield and distribution on the Si growth substrate by scanning micro-Raman spectroscopy which revealed the strong dependency of the polytype inclusion upon growth temperature. Correlated TEM-Raman studies of single polytype NWs were carried out either on TEM grids or on GaAs wafer (by FIB sample preparation process). The latter superior thermal coupling enabled detailed Raman characterization of both the exciting laser wavelength dependency of the polytype SiNW Raman spectra and their polarization effects, leading to new interpretations of polytypes and polymorphs optical properties.

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