ST-001

Direct observation of delocalized exciton state in Ta_2 $NiSe_5$: direct evidence of the excitonic insulator state

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The excitonic insulator (EI), which is one of fundamental insulators, was theoretically proposed in 1967 but its material realization has not been established well. Only a few materials were proposed as EIs but their experimental evidences were indirect such as the renormalization of band dispersions or an anomaly in electrical resistivity. We conducted scanning tunneling microscopy / spectroscopy measurements and found out that Ta_2 $NiSe_5$, which was the most recently proposed as an EI, had a metal-insulator phase transition with the energy gap of 700 meV at 78 K. Moreover, the spatially delocalized excitonic energy level was observed within the energy gap, which could be the direct evidence of the EI ground state. Our theoretical model calculation with the order parameter of 150 meV reproduces the spectral function and the excitonic energy gap very well. In addition, experimental data shows that the band character is inverted at the valence and conduction band edges by the exciton formation, indicating that the mechanism of exciton condensation is similar to the Bardeen-Cooper-Schrieffer (BCS) mechanism of cooper pairs in superconductors.

Keywords: Excitonic Insulator, scanning tunneling microscopy, layered material

ST-002

Influence of transient surface hydrogen on Aluminum catalyzed Silicon nanowire growth

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Semiconductor nanowires are essential building blocks for various nanotechnologies including energy conversion, optoelectronics, and thermoelectric devices. Bottom-up synthetic approach utilizing metal catalyst and vapor phase precursor molecules (i.e., vapor − liquid − solid (VLS) method) is widely employed to grow semiconductor nanowires. Al has received attention as growth catalyst since it is free from contamination issue of Si nanowire leading to the deterioration of electrical properties. Al-catalyzed Si nanowire growth, however, unlike Au-Si system, has relatively narrow window for stable growth, showing highly tapered sidewall structure at high temperature condition. Although surface chemistry is generally known for its role on the crystal growth, it is still unclear how surface adsorbates such as hydrogen atoms and the nanowire sidewall morphology interrelate in VLS growth. Here, we use real-time in situ infrared spectroscopy to confirm the presence of surface hydrogen atoms chemisorbed on Si nanowire sidewalls grown from Al catalyst and demonstrate they are necessary to prevent unwanted tapering of nanowire. We analyze the surface coverage of hydrogen atoms quantitatively via comparison of Si-H vibration modes measured during growth with those obtained from postgrowth measurement. Our findings suggest that the surface adsorbed hydrogen plays a critical role in preventing nanowire sidewall tapering and provide new insights for the role of surface chemistry in VLS growth.

Keywords: in situ, infrared spectroscopy, nanowire, surface chemistry