Ultra-thin van der Waals nanowire transistors

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Miniaturization of semiconductor devices has been a prime focus of the electronics industry to address the requirements of next generation electronic devices. One potential approach is to use one-dimensional (1D) van der Waals (vdW) wires, such as $M_2X_3Y_8$ (M= Ta, Nb; X= Ni, Pd, Pt; Y= S, Se) family of ternary transition metal chalcogenides. Here we present our study on one member, $Ta_2Ni_3Se_8$ (TNS), a semiconductor composed of molecular ribbons parallelly aligned and bonded via van der Waals interaction. Centimeters long TNS single crystals were synthesized with solid-state reaction. Nanowires down to 10nm were successfully prepared by mechanical exfoliation from the bulk. High resolution TEM studies show nanowires are composed of highly ordered chains, with no sign of oxidation. AFM topographical studies revealed that wires have uniform thickness. For probing the electrical properties, field effect transistors of TNS are fabricated with E-beam lithography. Transport measurements revealed that TNS nanowires are n-type semiconductors. The fabricated 1D transistors exhibit high switching performance, making TNS a promising candidate for nanoelectronics.