The Department of Electrical and Computer Engineering

Announces the

Final Defense of Dissertation

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Title: **Electron Transport and Switching in Low-Dimensional Materials**

Abstract: This dissertation reports results of investigation of electron transport in two classes of layered van der Waals materials: quasi-one-dimensional (1D) transition metal trichalcogenides (TMTs) and quasi-two-dimensional (2D) transition metal dichalcogenides (TMDs). Practical motivations for this study include the search for (i) materials, which can be used in ultimately downscaled interconnects in the next generations of electronics, and (ii) materials revealing low power switching phenomena, which can be used in future logic circuits. TMTs have strong covalent bonds in one direction and weaker bonds in cross-plane directions. They can be prepared as crystalline nanoribbons consisting of 1D atomic threads, i.e. chains. I have examined the current carrying capacity of $ZrTe_3$ nanoribbons using structures fabricated by the shadow mask method. It was found that $ZrTe_3$ nanoribbons reveal an exceptionally high current density, on the order of ~100 MA/cm^2, at the peak of the stressing current. I have investigated the low-frequency electronic noise in such nanoribbons. The low-frequency noise data were used to determine the activation energy for electromigration. TMDs reveal interesting charge-density-wave (CDW) effects, which can be triggered by electric bias even at various temperatures. I investigated switching among three CDW phases – commensurate, nearly commensurate, incommensurate – and the high-temperature normal metallic phase in 1T-TaS_2 devices induced by application of an in-plane bias voltage. The switching among all phases has been achieved over a wide temperature range, from 77 K to 400 K. The electronic noise spectroscopy has been used as an effective tool for monitoring the transitions. The noise exhibits sharp increases at the phase transition points, which correspond to the step-like changes in resistivity. The possibility of the bias-voltage switching among four different phases of 1T-TaS_2 is a promising step toward nanoscale device applications. The results also demonstrate the potential of noise spectroscopy for investigating and identifying phase transitions in the materials.