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The metal-insulator transition in vanadium dioxide nanobeams[1]

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Solid materials in which electron-electron correlations are strong can exhibit dramatic phase transitions, at which an abrupt change in the electronic properties occurs with a small accompanying distortion of the lattice. Such transitions could be harnessed to make electronic or optoelectronic devices or sensors embodying different principles from those in present semiconductor technology. A famous example is the metal-insulator transition in vanadium dioxide which occurs at 67 °C at ambient pressure. VO_2 is a stable, strong material with a simple structure. Unfortunately though, applications and methodical studies of this and other phase transitions are hindered by broadening, hysteresis and mechanical degradation at the transition, caused by the inevitable domain structure. Nanostructures of the material which are smaller than the characteristic domain size do not show these problems. Using devices made from nanobeams of VO_2 we have been able to achieve good control of the transition and to determine a number of its properties for the first time. For instance, we find that the metallic phase can be supercooled by more than 50 °C; that the resistivity of the insulator in coexistence with the metal is independent of temperature; and that the transition occurs via the intermediate M2 phase. We also study nanoelectromechanical effects where reversible buckling of the nanobeam is coupled to the phase transition, and we investigate methods of controlling the phase transition, for example using a gate voltage.

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