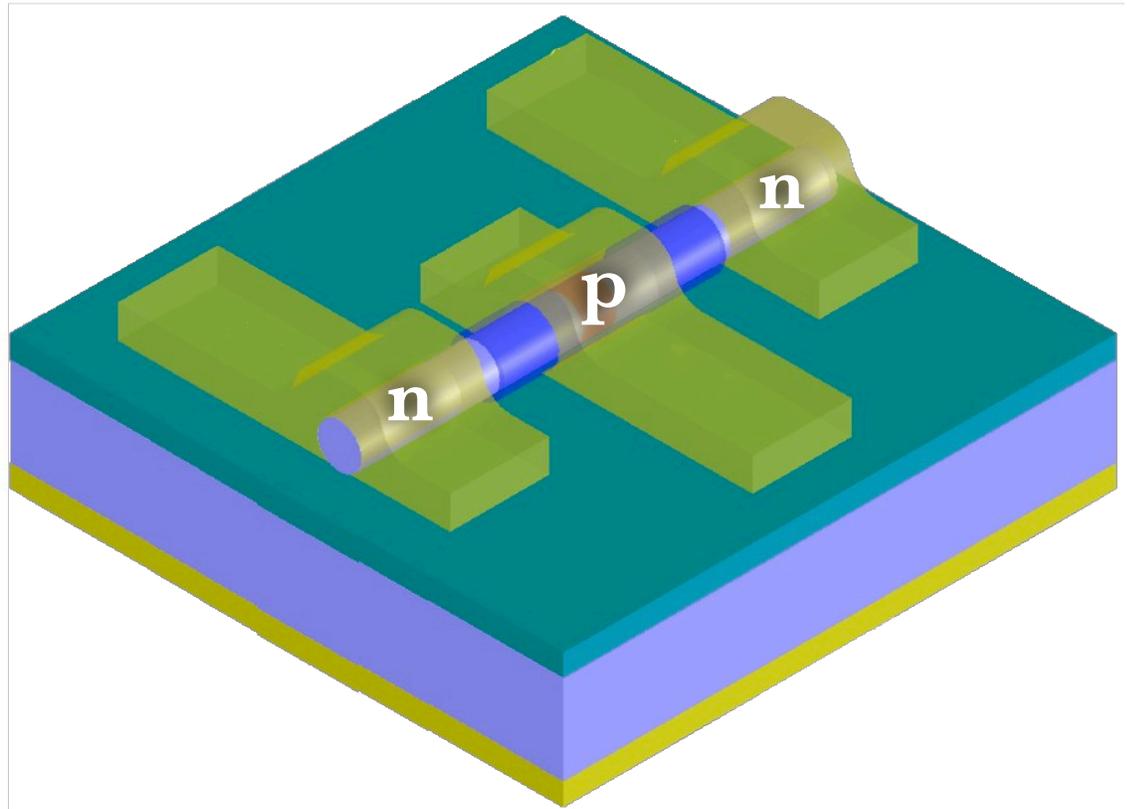


# INVERSION WNODE

Penn State MRSEC



By varying the type of doping along the length of a nanowire 80 nm in diameter, the contacts at either end can be made highly conductive while the channel region in the middle is easily turned on and off while carrying large currents.



## Inversion mode nanowire transistors a switch on its head

IRG3

In traditional uniformly doped nanowire transistors, a so-called Schottky barrier at the source contact prevents the smooth flow of current into the transistor. MRSEC researchers have achieved improved the performance of nanowire transistors by varying the form of doping along the length of the nanowire.

High n-type doping ( $\rho \sim 10^{-3} \Omega\text{-cm}$ ) at both ends of the wire (the “source” and “drain” regions) promotes increased current transport from the metallic contacts into the nanowire device. Lower p-type doping ( $\rho \sim 10^4\text{-}10^5 \Omega\text{-cm}$ ) in the central “channel” region of

the nanowire allows one to achieve strong current modulation, with a so-called inversion layer. Previous nanowire transistors operated in “depletion mode,” wherein the transistor is on by default, and a voltage applied to the gate removes charge carriers from the nanowire and so turns the transistor *off*. The nanowire transistors fabricated in the MRSEC operate in inversion mode: the gate voltage turns the device *on*, the same method used in current silicon-based integrated circuits. These devices modulate the on/off current by ten million times, shifting by tenfold for an

increment of only 0.25 volts at the gate, with up to one micro-amp of current flowing through the nanoscale device. Measurements using test structures that separately probe the n+ and p- regions confirm that the two regions do not overlap, explaining how we achieve such a large modulation in the channel conductance with a low source/drain resistance. This demonstration of carrier inversion in the nanowire channel is a significant advance over prior depletion-mode devices and provides data for device modeling to compare performance across platforms.

