Why We Need To Replace the Transistor, and What Would be the Newly Required Material Properties?

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In contemplating the headlong rush toward miniaturization represented by Moore's Law, it is tempting to think only of the progression toward molecular sized components. There is a second aspect of Moore's Law that is sometimes overlooked. Owing to miniaturization, the energy efficiency of information processing has steadily improved. But there is an inefficiency for internal communications in a chip. It is caused by the difference in voltage scale between the wires and the transistor switches. Transistors are thermally activated, leading to a required voltage >>kT/q. Wires are long, and they have a low impedance, allowing them to operate efficiently even at a few millivolts. Thus the main Figure-of-Merit for future transistors is low operating voltage or sensitivity, NOT mobility.

The challenge then is to replace transistors with a new low-voltage switch that is better matched to the wires. I will present the new material quantum level properties, which are being explored by the NSF Science & Technology Center for Energy Efficient Electronics Science.