Painting nanowires into circuits

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Researchers from Harvard University, US, say they have made functioning, high-frequency circuits from nanoscale building blocks for the first time. They reckon the nanowire-based devices should find a use in lightweight, portable electronics.

"We set out to show that nanoscale crystalline wires of the semiconductor silicon – the mainstay of the computer industry – can be literally painted onto virtually any material to make fast electronic processors that rival those made in billion-dollar fabrication lines today," Michael McAlpine told *nanotechweb.org*.

McAlpine and colleagues made multi-nanowire transistors on glass substrates. They applied the nanowires to the substrate in solution and then used standard photolithography techniques to create circuits. Integrating two transistors made an inverter, while arranging three inverters in series resulted in a ring oscillator with a maximal oscillation frequency of 11.7 MHz.

The technique has the advantage of being suitable for use at low temperature, enabling its application to plastic or glass substrates.

"Similar efforts have been attempted with other low-cost materials, such as carbon nanotubes, organic semiconducting polymers, and low-grade silicon," said McAlpine. "However, the speed of the electronics was limited in those cases, either by lack of reliability ([in the case of] nanotubes), or by inherently slow shuffling of electrical current ([for] organics and low-grade silicon)."

McAlpine believes that nanowires combine the best of both worlds - high speed and reproducibility - allowing the scientists to "reliably create fast electronics on glass and flexible plastic".

"These advances could bring powerful electronics and computing to virtually all facets of life at low cost, and may open exciting doors for low-cost radiofrequency tags or high refresh-rate 'e-paper' displays which are fully integrated on a single piece of plastic or glass," said McAlpine.

The nanowire devices had much higher oscillation frequencies than circuits based on carbon nanotubes, which typically have oscillation frequencies of 5-220 Hz. Although the nanowire devices required supply voltages of 35 V or above to achieve stable oscillations, the researchers say that they could improve that figure by using better dielectrics, more advanced nanowire materials and reduced channel lengths.

"Further optimization of our device structures and the incorporation of new nanowire materials should allow us to achieve even higher device frequencies," said McAlpine. "By applying these advances to new substrates such as plastics and even paper or fabrics, we might take such low-cost electronics to true high-performance computing levels."

The researchers reported their work in *Nature*.

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