Growing Europe's nanowires

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(PhysOrg.com) -- European researchers have developed state-of-the-art nanowire 'growing' technology, opening the way for faster, smaller microchips and creating a promising new avenue of research and industrial development in Europe.

Nanowires are a promising new technology that could meet rapidly rising performance requirements for integrated circuit design over the next ten years. They are tiny wires just tens of nanometres in diameter and micrometers in length.

They could mean smaller, faster and lower power electronics, and lead to entirely novel architectures such as 3D microchips - a vertical stack of circuitry that can massively increase the size of circuits for the same footprint.

Nanowires are so narrow they are often called 'one-dimensional' structures because the width of the wire constrains the sideways movement of electrons as they pass through the wire. Also, the cylindrical geometry allows the most efficient electrostatic gating technology.

Unsurprisingly at this scale, nanowires demonstrate many characteristics that offer the potential for novel circuits and architectures, and physicists are very excited. The Japanese pioneered the field with the USA taking up the work, and with a few European teams entering soon after.

Raising nanowires... and patents

But the Europeans are on their way. Recent work at the NODE project led to world-class technology and 40 patents. "Silicon technology becomes very challenging when you get down to 10-15nm," explains Lars Samuelson, director of the Nanometer Structure Consortium at Lund University and coordinator of the NODE project.

"One of the problems of the [current] top-down approach is that it introduces harsh environments and you end up with devices that may be dominated by defects."

NODE's nanowires are 'grown' from the bottom up, like crystals, into vertical structures. "We call it 'guided self-assembly', and it is a 'bottom-up' process that can result in fewer defects," Samuelson says.

Vertical nanowires can consist of different materials, by simply altering the depositing material, so the wire takes on layers with different characteristics. "There are many potential opportunities for developing new technologies," he says. "This vertical arrangement may be the route to 3D circuit design as well as to realise monolithic on-chip optoelectronics."

NODE focused on combining silicon with indium arsenide (Si:InAs) and silicon with silicon germanium (Si:SiGe), two very promising materials. "Indium arsenide is inherently very fast and, as such, it was of particular interest to our work," remarks Samuelson.

Breakthroughs

The project looked at every link in the nanowire production chain, from growth, processing on an industrial scale, to characterisation and integration. "And one of the big challenges of the project was the integration of our work with current silicon processing technology, so there was a big effort on processing," Samuelson stresses.

For this, characterisation studies were important to examine the different materials used and the effects induced by the nanowire structure. NODE also examined the characteristics of potential devices, such as field effect transistors (FET). Finally, the team looked at integrating these devices into circuits.

It is a huge body of work and led to some real breakthroughs. "One of the breakthroughs was the... perfect deposition of high-K dielectrics coating the nanowires and serving as a dielectric in the wrap-gate transistors," reveals Samuelson. "We developed a very good technique for this."

High-K dielectrics overcome some of the limits of silicon dioxide at very small scales and are a promising strategy for further miniaturisation of integrated circuits.

"As part of this research, we have also encountered problems and possible roadblocks [to further] development, such as quite severe problems in growing Si nanowires using gold catalysts”, adds Samuelson.

State of the art

“This technology is not ready for industrial applications, and whether it will be three, six or nine years before it appears industrially, I cannot say,” Samuelson warns. “But we established the state of the art, we have the best results.”

The project has announced Europe’s entry into an exciting new field of nanotechnology and developed a core expertise on the continent. Over 100 scientific papers will emerge from the work when it finally winds down.

The development of European expertise could not come at a better time. Industrial players like IBM, Samsung and some of the leading Singapore labs began developing planar, or horizontal, nanowire technology shortly after NODE began their efforts. The technology is coming of age.

More information: NODE project -- www.node-project.com/

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