“Plateau–Rayleigh” crystal growth is a technique that can be used to synthesize 1D materials. Here, periodic shells develop along a nanowire core to form nanostructures whose diameters can be modulated. A team of researchers at Harvard University has now extended this concept by making heterostructures in which one semiconductor (germanium or silicon) is deposited on a core of the other semiconductor to produce complex nanowire 1, 2 and 3D shapes. The materials created could be used in advanced electronics and optoelectronics devices.

1D nanowire materials can be used in a wide range of areas, ranging from energy conversion, thermal and optical devices, but such applications require wires whose structures and properties can be controlled while they are being made. Heterostructure growth (that is, growing one material on top of a different material) on 1D architectures like nanowires can generate new structures and shapes that cannot be produced during heterostructure growth on 0D nanoparticles or on bulk growth substrates.

A team led by Charles Lieber (http://cml.harvard.edu) previously found that a technique called Plateau–Rayleigh (P–R) crystal growth can be used to produce homostructures (that is, where one material is grown on top of the same material). Here, the material spontaneously arranged itself into isolated, periodic shells on nanowire substrates. “For P–R crystal growth of heterostructures, periodic shells can only form on one side of a nanowire,” explains team member Robert Day (http://chemistry.harvard.edu/people/robert-day), “and the nanowire can strain or bend itself to relieve the stress incurred during this one-sided growth. Because the periodic shells stress only one side of the nanowire, and because stress causes bending, 2D and 3D morphologies like spirals and helical coils can spontaneously form.”
Complex nanowire morphologies

The researchers used the concept to deposit germanium (or silicon) on silicon (or germanium) 1D cores to generate complex nanowire morphologies in 1, 2 and 3D. Depositing germanium (in the form of germanium hydride) on 50 nm silicon cores at a constant pressure yields a single set of periodic shells around the nanowire, while varying the pressure can produce multi-modulated 1D nanowires with two distinct sets of periodic shells. P–R growth on 30 nm cores also produces 2D loop structures, in which Ge (Si) shells lie mainly on the outside (inside) of a very curved Si (Ge) core.

“Our results suggest that nanowires are interesting and promising substrates for growing heterostructures,” Day tells nanotechweb.org. “Heterostructuring is a way to create materials that have the properties of the two separate materials combined into one, or to create materials with new or enhanced properties for various applications.”

The team, reporting its work in Nano Letters DOI: 10.1021/acs.nanolett.6b00629 (http://pubs.acs.org/doi/abs/10.1021/acs.nanolett.6b00629), says that it is now looking to combine different semiconducting compounds other than Si and Ge, and in the solution phase rather than the gas-phase (as was done in the present work). “We are also investigating the material properties, such as electrical and optical characteristics, of the strained and highly curved structures we have produced to see how much better they are compared to straight, unstrained nanowires,” says Day.

About the author

Belle Dumé is contributing editor at nanotechweb.org

Further reading

Nanotechnology announces the first winner of the Young Researcher Award (Feb 2016) (http://nanotechweb.org/cws/article/tech/64002)
Nanowire nanocomputer in new complexity record (Feb 2014) (http://nanotechweb.org/cws/article/tech/56118)