Aerosol synthesis of semiconductor nanowires

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Semiconductor nanowires are key building blocks for the next generation of light-emitting diodes (Qian *et al*, 2005), solar cells (Wallentin et al, 2013) and batteries (Chan *et al*, 2008). To fabricate functional nanowire-based devices on an industrial scale requires an efficient methodology that enables the mass production of nanowires with perfect crystallinity, reproducible and controlled dimensions and material composition, and low cost. So far there have been no reports of reliable methods that can satisfy all of these requirements. Here we show how aerotaxy, an aerosol-based growth method (Deppert and Samuelson, 1996), can be used to grow nanowires continuously with controlled nanoscale dimensions, a high degree of crystallinity and at a remarkable growth rate.

In our aerotaxy approach, catalytic size-selected Au aerosol particles induce nucleation and growth of GaAs nanowires with a growth rate of about 1 micrometre per second, which is 20 to 1,000 times higher than previously reported for traditional, substrate-based growth of nanowires made of group III–V materials (Borgström *et al*, 2007, Joyce *et al*, 2009, Ramdani *et al*, 2010). We demonstrate that the method allows sensitive and reproducible control of the nanowire dimensions and shape—and, thus, controlled optical and electronic properties—through the variation of growth temperature, time and Au particle size. Photoluminescence measurements reveal that even as-grown nanowires have good optical properties and excellent spectral uniformity. Detailed transmission electron microscopy investigations show that our aerotaxy-grown nanowires form along one of the four equivalent 〈111〉B crystallographic directions in the zincblende unit cell, which is also the preferred growth direction for III–V nanowires seeded by Au particles on a single-crystal substrate. The reported continuous and potentially high-throughput method can be expected substantially to reduce the cost of producing high-quality nanowires and may enable the low-cost fabrication of nanowire-based devices on an industrial scale (Heurlin *et al*, 2012).

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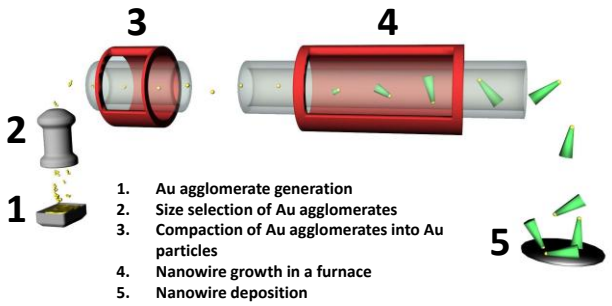

Figure 1. Schematic of the aerotaxy process.

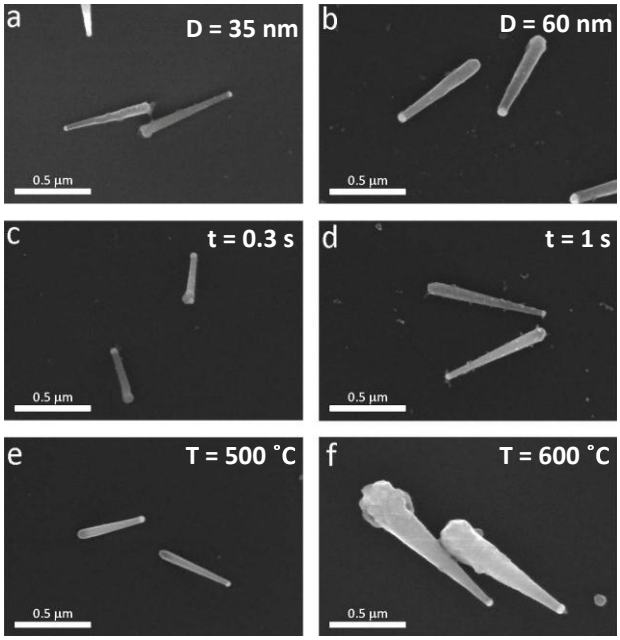

Figure 2: Snapshots of fabricated nanowires under different conditions.

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