DNA-templated Assembly of Nanoscale Circuit Interconnects

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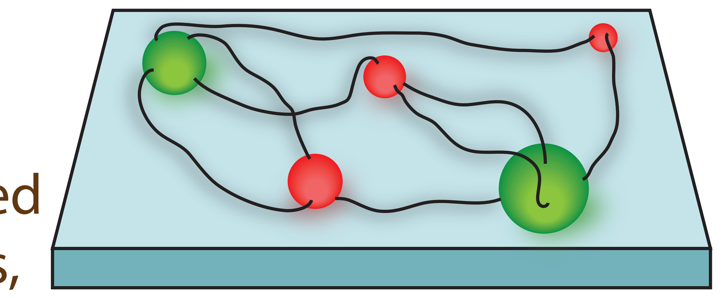
Abstract

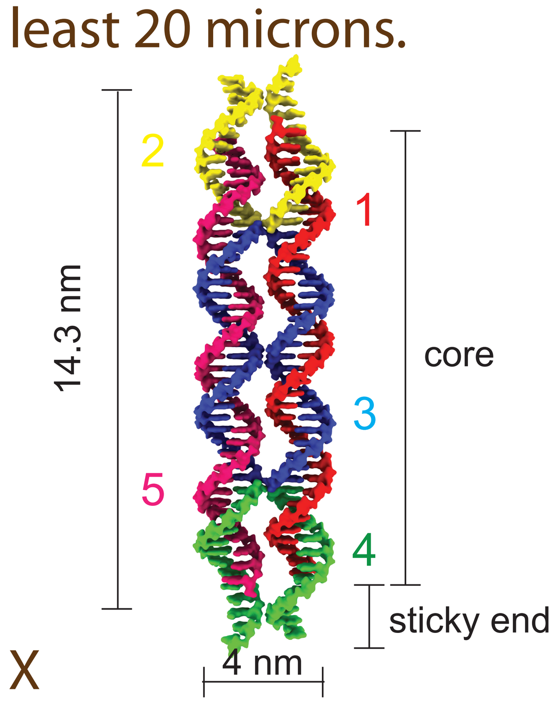


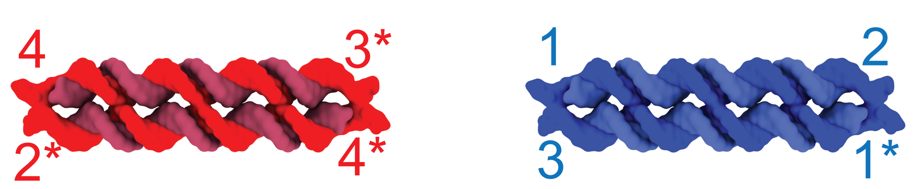
The essential problem with connecting things like self-assembled nanostructures is that to form a circuit using top down methods, either the connector or the components of the circuit must be positioned precisely in order to form a circuit. This positioning is challenging because for nanometer scale terminals, nanometer scale positioning accuracy is required. We propose to develop a bottom-up method for interconnect assembly where chemical tags located at terminals guide interconnect self-assembly.

We design and construct DNA origami seeds that serve as nanotube nucleation templates to control DNA nanotube assembly. We demonstrate that when these seeds are affixed to nearby surfaces, DNA nanotubes grown from these points join together to create point-to-point interconnects with lengths varying from tens of nanometers up to at least 20 microns.

Design of DNA nanotube tiles

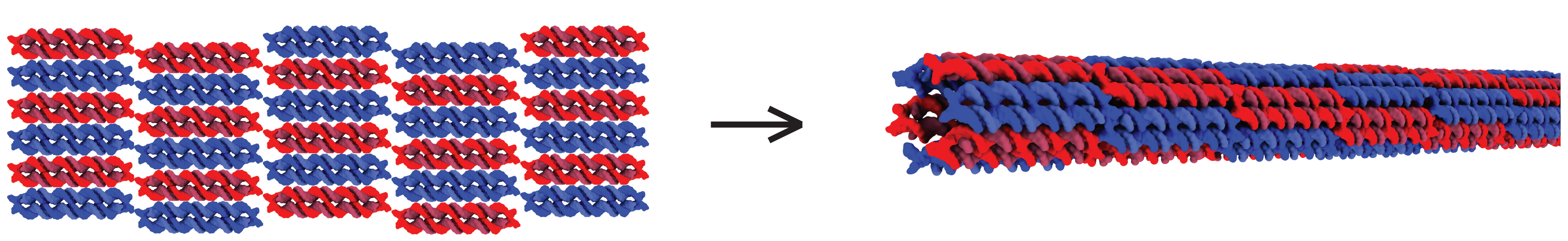
A tile consists of 5 single stranded DNA (shown with different colors). Since, Watson-Crick complementary sequences prefer to hybridize, the tile core is double stranded. The helix ends are single stranded (sticky ends), which allow them to interact with sticky ends on other tiles.





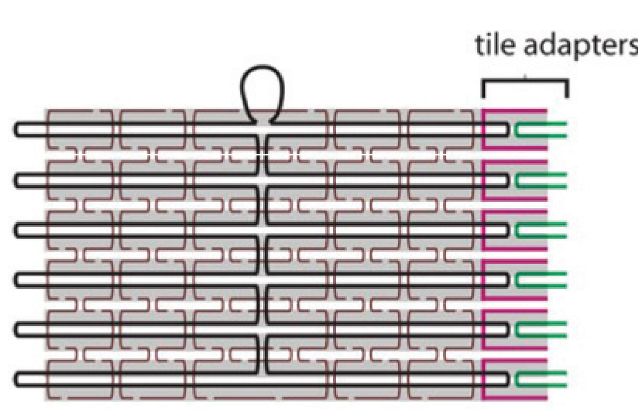
X* is complementary to X

The colors (Red and Blue) distinguish the two tile types each of which have a different core. The tile sticky ends are programmed such that, the two tile types when mixed together, assemble into a lattice with diagonal stripes.



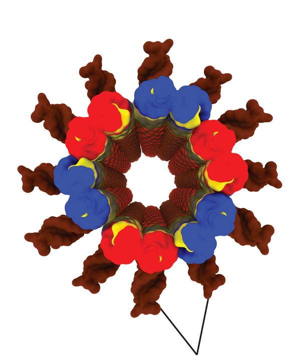
The lattice cyclizes to form a nanotube due to the inherent curvature of tiles (~150° ± 10°).

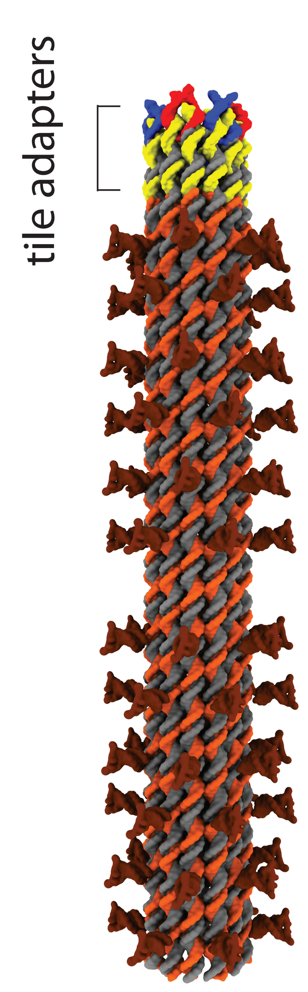
An origami seed



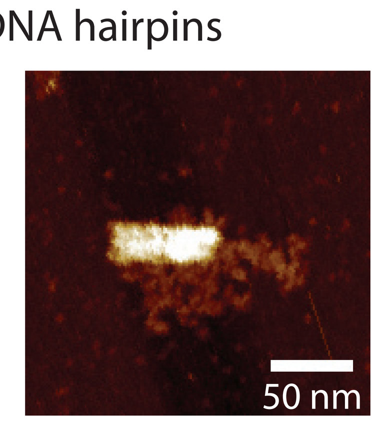
Origami seed consists of a scaffold strand (black) running through all the helices in a raster fill pattern and short strands (staples) that hold the scaffold in place.

"Adapter strands" are attached to origami in order to create a facet for nanotube growth. The adapter strands have sticky ends that interact with the sticky ends of nanotube tiles.

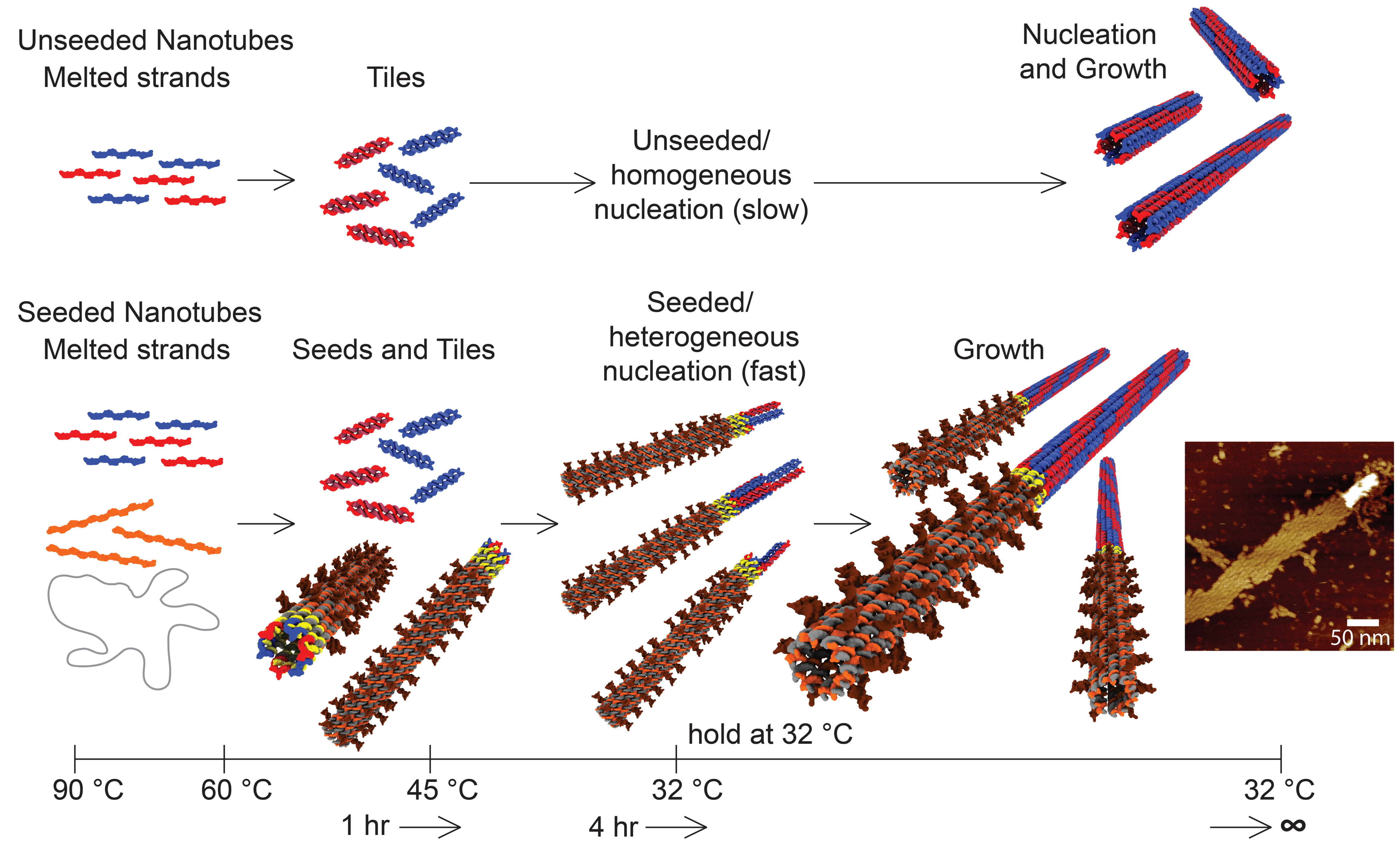




Staple strands of the top helix in the diagram also connect this helix to the bottom helix in the diagram. As a result, the origami seed forms a cylindrical structure.



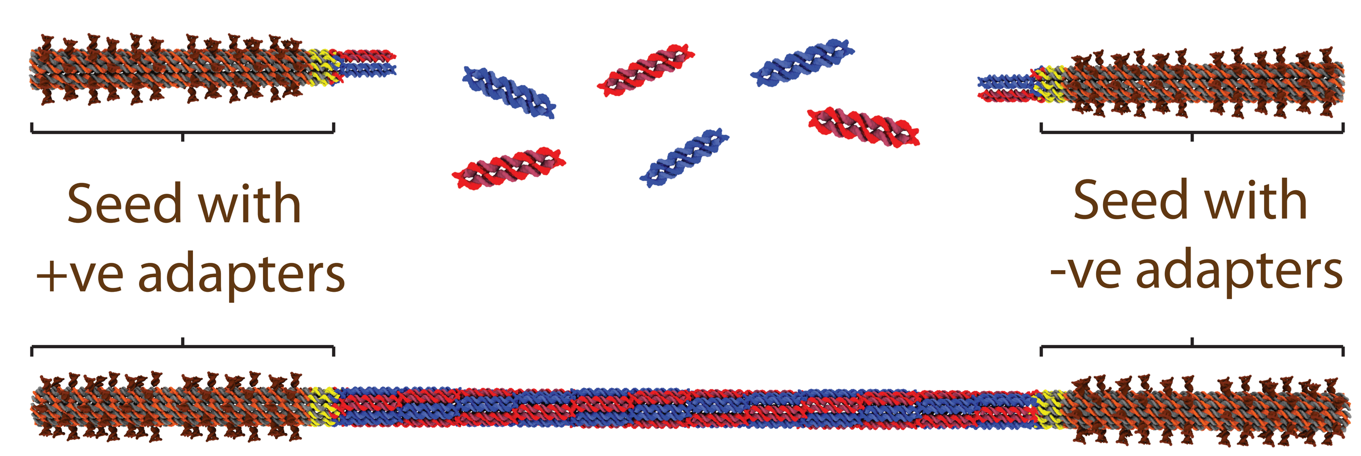
Seeds control DNA nanotube nucleation

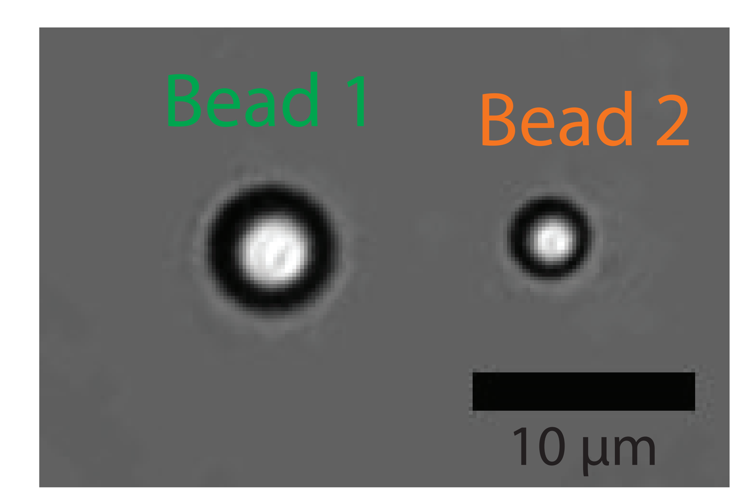


Because nanotubes growth from seeds is much faster than spontaneous nanotube nucleation, most nanotubes assemble grow from seeds.[1]

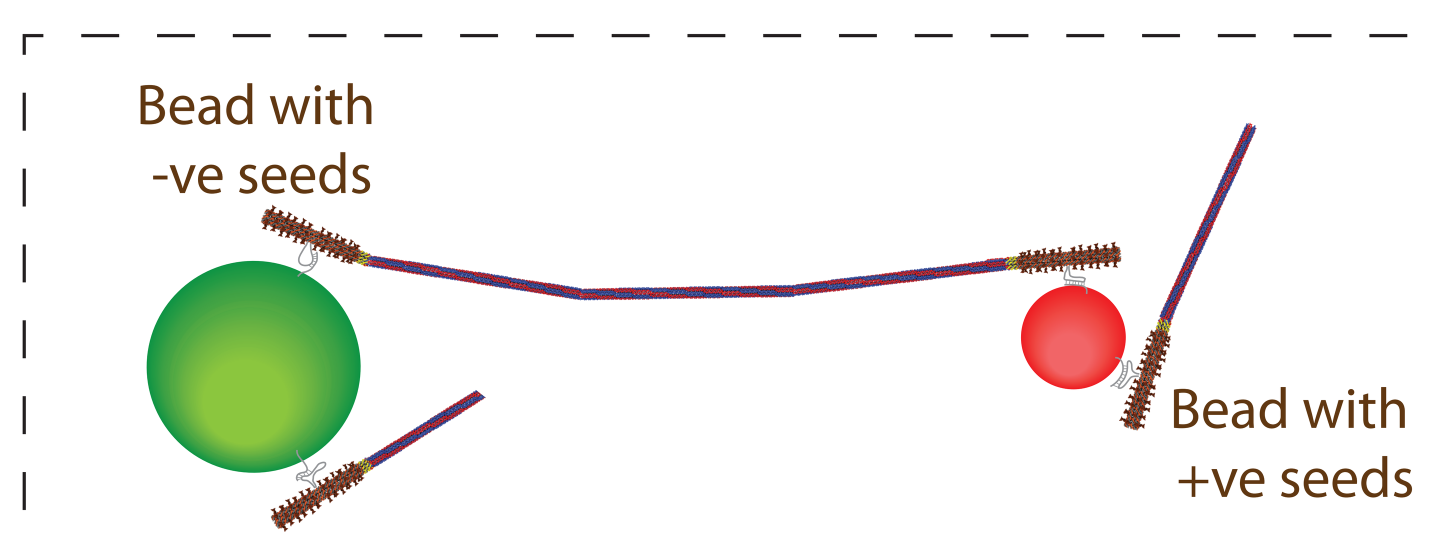
Point-to-point nanotube connections

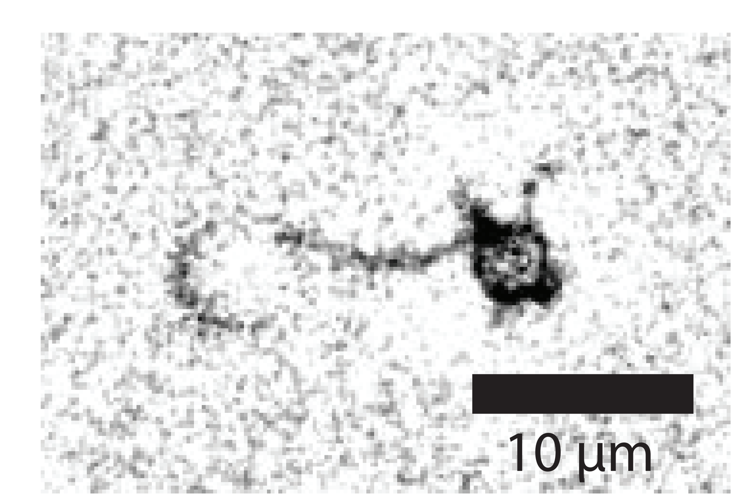
Two seeds nucleate nanotubes at opposite ends. As nanotubes grow from seeds, their ends diffuse. When the nanotubes grow long enough, their ends can join to form a connection.





Brightfield Image





Fluorescence Image

Reference

(1) Directing Self-Assembly of DNA Nanotubes Using Programmable Seeds; Abdul M. Mohammed and Rebecca Schulman; *Nano Lett.*, **2013**, 13 (9), pp 4006-4013.