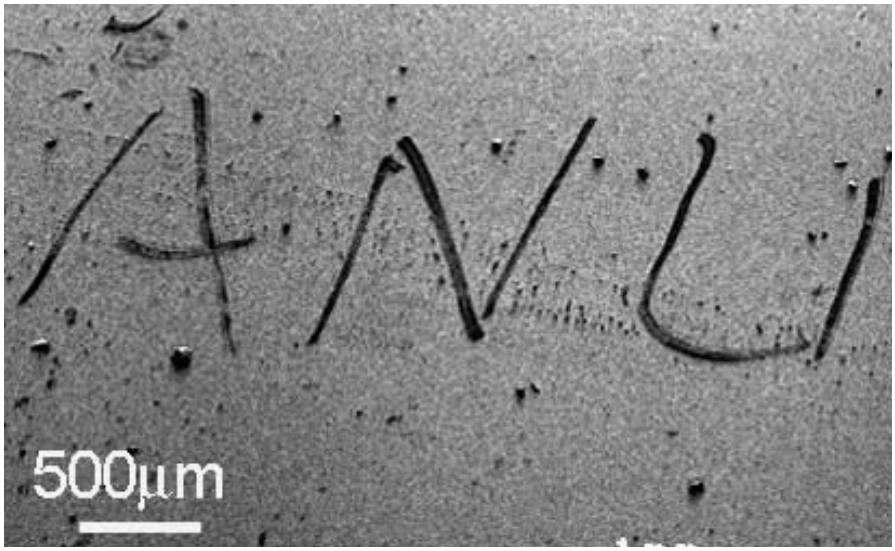
More than a hairy scratch

The letters A, N and U pictured to the right are each just under a millimetre in width. That's small but not particularly noteworthy. However, when you ramp up the magnification a couple of orders of magnitude the magic of the letters starts to become apparent because these letters are actually composed of millions of nanoscale hairs or tubes growing out from scratches on the surface of a silicon wafer. Indeed this is a patterned growth of carbon nanotubes on silicon and it's a world first for Associate Professor Ying Chen and his team in the Department of Electronic Materials Engineering (RSPSE).



"Growing large quantities of carbon nanotubes on predesigned patterns and at desired locations on different substrates is an important part of integrating nanotubes into nanoscale devices and sensors at a commercial scale," says Chen. "While there's been some success growing nanotubes on silicon dioxide substrates primed with metal catalysts using chemical vapour deposition, it hasn't been achieved on pure silicon substrates."

Ying Chen's team achieved the feat using the ball milling technique that Chen has developed in recent years. Ball milling involves grinding the precursor materials that will make the nanotubes into an ultra-fine powder in a revolving chamber full of ball bearings. In this case, a couple of grams of iron phthalyocyanine (a material that contains both the carbon source and the metal catalyst required for carbon nanotube growth) is ground up in a ball mill for 100 hours (at room temperature in argon gas at a pressure of 300kPa). The argon prevents oxidation during the milling process.

The milled sample is then placed in a quartz furnace next to a silicon wafer with a pattern scratched onto it using a diamond pen (in this case the letters A, N and U). The milled power is then heated converting it into a vapour which is then carried in a stream of argon and helium to be deposited on the wafer. Further heating results in carbon nanotubes growing from the scratched portions of the silicon wafer but no where else on the wafer.

When examined with a transmission electron microscope the nanotubes were shown to be multi-walled cylinders measuring some 50 nanometres in diameter.

"The selective growth of the carbon nanotubes over the scratched surface on the silicon substrate is a typical self-assembly process possibly driven by capillary force," says Chen.

Their technique for growing patterned carbon nanotubes on silicon substrates has been published in the July issue of Applied Physics Letters.

More info: Ying.Chen@anu.edu.au