Nano-welds herald new era of electronics

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The world's smallest construction site is taking shape in a laboratory in Switzerland, thanks to the development of new welding techniques that work at scales of a billionth of a metre.

The researchers behind the techniques say they can be used to assemble electronic components at smaller scales than have ever been possible.

One technique, called "nanorobotic" spot welding, uses molten copper to join up objects in the same way that a human electrician might use solder. It was developed by Brad Nelson, Lixin Dong and Li Zhang at the Institute of Robotics and Intelligent Systems, Zurich, Switzerland and colleagues Xinyong Tao and Xlabin Zhang at Zhejiang University, China.

"We position a 50-nanometre-wide carbon nanotube filled with copper inside a nanorobotic manipulator, and run a small voltage through it to melt the copper," explains Dong. In experiments the researchers positioned the manipulator so the melting metal connected one carbon nanotube to another.

Dong says he expects the technique to be useful for building electronic devices. "The copper can be used to make electrical connections with low resistance," he told **New Scientist**. That could connect nanotubes into tiny transistors, the current-switching building blocks of most electronic devices, he says.

Multiple joins

The circuits would be made by running voltage through a copper-filled nanotube lying across two electrodes – the melting copper would then cement the nanotube in place. "That would be easier and take less energy than having to pattern extra electrodes on top, as people do now," says Dong.

Because electricity drives the welding technique it could be possible to make lots of joins at once, says Dong. "We could run a voltage through a structure of nanotubes put together by self assembly or using electric fields," he explains: "It would weld them all into place."

Sergey Gordeev works on nanotechnology at Bath University, UK, and says the copper-melting method will be useful. "But only a very small number of labs in the world have access to nanorobotic manipulators," he points out.

Amorphous carbon

Gordeev, along with colleagues Andy Moskalenko, Dan Burbridge and G Viau has developed another nanowelding method he says is within reach of more researchers worldwide. "It only requires an electron microscope," he explains.

It exploits an effect that is usually a problem for researchers using electron microscopes. Inside the microscope, the electron beam transforms tiny amounts of carbon-based contaminants into unwanted amorphous carbon around the sample being examined.

"We realised that could actually have interesting applications," explains Gordeev, who has shown that the effect can be used to weld nano-sized objects onto a surface or even to build objects from scratch.

Electrons from the microscope's beam are scattered by the sample and the surface the sample stands on. "They transform the contaminants into amorphous carbon – it's quite similar to diamond," says Gordeev.

"We can create any 3D shape by varying the beam and rotating the target," he adds. Using this technique, the researchers have already made nano-scalpels 10 nm by 20 nm across and just a few nanometres thick. These scalpels can be used for cutting into living cells.

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