Transistor pumps electrons one by one

Scientists have now pumped electrons with a silicon transistor more accurately than ever before. This device can potentially be used to set a new definition for electric current, the ampere. The results were recently published in Nano Letters.

Accurate and fast electron pumping has been an important scientific and technological goal for decades. Now scientists have pumped 500 million electrons per second with 99.997% accuracy. The electron pump was a quantum-dot transistor fabricated using scalable silicon technology.

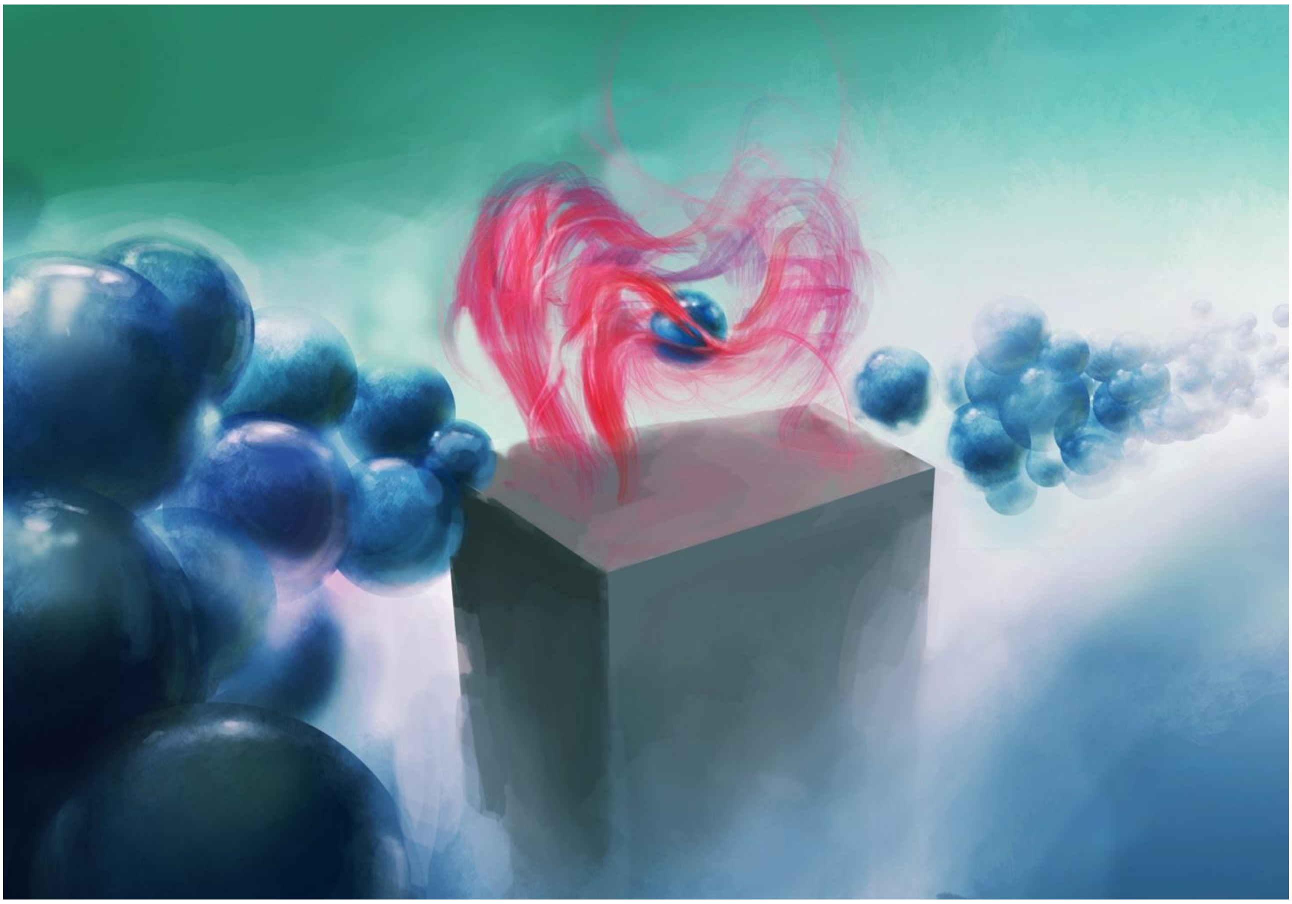

Figure 1. Artistic illustration of the electron pump. Credit: Heikka Valja.

Full-resolution image at http://physics.aalto.fi/wp-content/uploads/2014/05/elektronipumppu.jpg

“We have now a very strong position in the worldwide race for a practical quantum current source. It feels great!”, says a happy Dr. **Mikko Möttönen** from Aalto University, Finland.

Electron pumps promise higher accuracy and stability for electric current than any other device. They can trigger a revolution in the international system of units whose definition of the electric current, the ampere, is still unsatisfactory.

“A change in the international system of units would be an historic event.”, says Prof. **Andrew Dzurak** from the University of New South Wales (UNSW) in Sydney, Australia. “We are very close.”, he continues.

Although the silicon electron pump is fast enough, its accuracy still needs to be improved before it can serve in the redefinition of the ampere. To this end, there are no obstacles in sight. In fact, the accuracy of the pump may already be better than promised since statistical uncertainty prevented the researchers from observing higher accuracies than 99.997%.

“We are all set for an amazing breakthrough. Of course, we need hard work from scientists like Dr. **Alessandro Rossi** and **Tuomo Tanttu** who were very important in this research.”, says Dr. Möttönen.

“We have realized a nano-device that has the capability of generating a highly stable macroscopic current by governing the motion of individual electrons.”, says Dr. Rossi.

Just a couple of days ago the Academy of Finland awarded a research grant of 260 000 € to Dr. **Kuan Yen Tan** to work in this electron pumping collaboration at QCD Labs, Aalto University. The Australian part of the research is supported by the Australian Research Council (ARC) through a discovery project led by Prof. Dzurak and Dr. Möttönen. They, along with Dr. Rossi, have also applied for new ARC funds to improve the accuracy of the pump such that it can serve as the realization of the quantum current standard.

“Our collaboration with the Centre for Metrology and Accreditation, MIKES, has been very important in confirming the accuracy of our pump.”, says Möttönen.

The work on the electron pump was published in

An accurate single-electron pump based on a highly tunable silicon quantum dot

Alessandro Rossi, Tuomo Tanttu, Kuan Y Tan, Ilkka Iisakka, Ruichen Zhao, Kok Wai Chan, Giuseppe Carlo Tettamanzi, Sven Rogge, Andrew S. Dzurak, and Mikko Möttönen

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Matching press releases for different regions (languages)

Australia (English), Finland (Finnish)

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Figure credit: Aura Möttönen

Mikko Möttönen was the leader of the measurement part of the research. The published experimental data were obtained in QCD Labs, Aalto University, Finland.

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Andrew Dzurak led the device fabrication and engineering. The published experimental results were obtained using a device fabricated in the Australian National Fabrication Facility at UNSW, Australia.

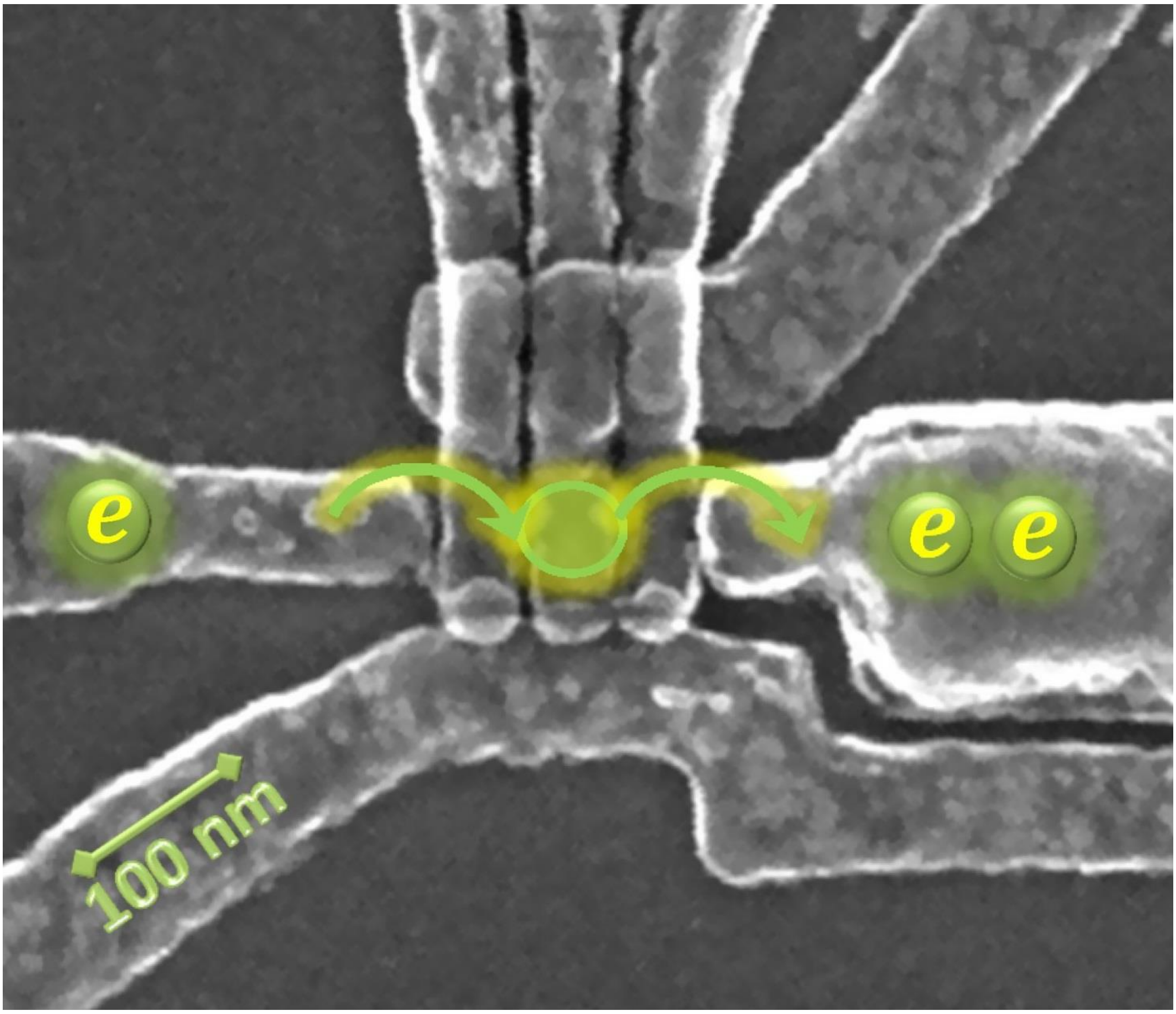

Figure 2. Scanning-electron-microscope image of the device with schematics of the electron flow. The quantum dot is illustrated by the circle in the middle of the image and the arrows denote the direction of the electron flow. Credit: Alessandro Rossi