

Electrical measurements and chip repair with nanoscale probes

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outline

Is there a future for non-silicon nanostructures in electronics?

An electrical probe station for evaluating nanostructures

Scanning multi-tip electrical measurements.

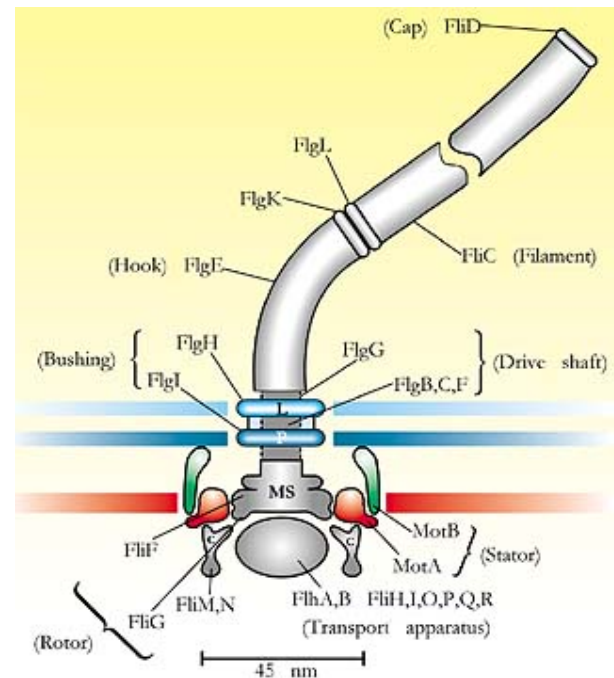
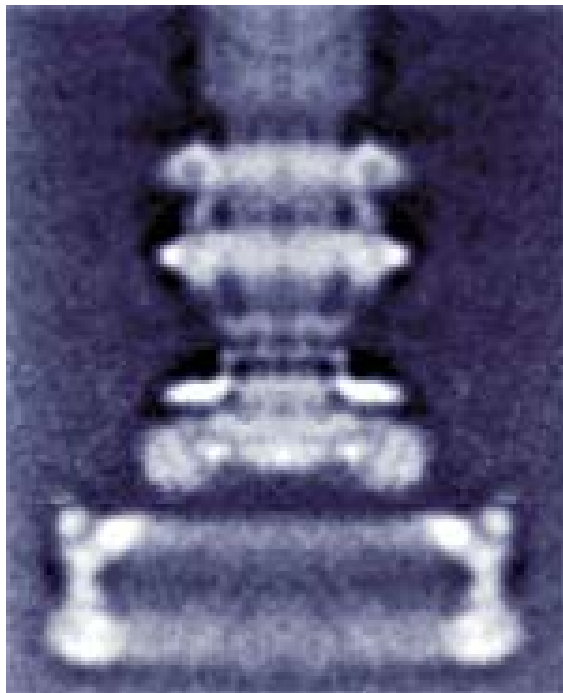
Scanning noise measurements

Electric Discharge Machining

Nanostencil deposition

motivation

The miniaturization of electronics will end with CMOS.
At that point, devices will be approximately the size of large molecular assemblies.



Can we get nanowire pn junctions to similarly insert themselves into a film?

motivation (2)

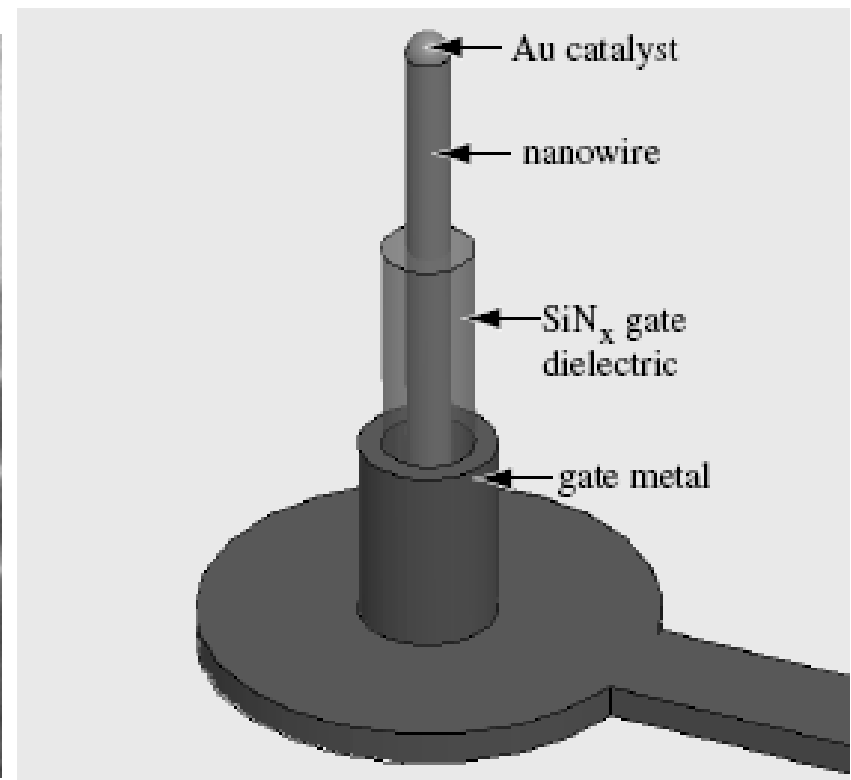
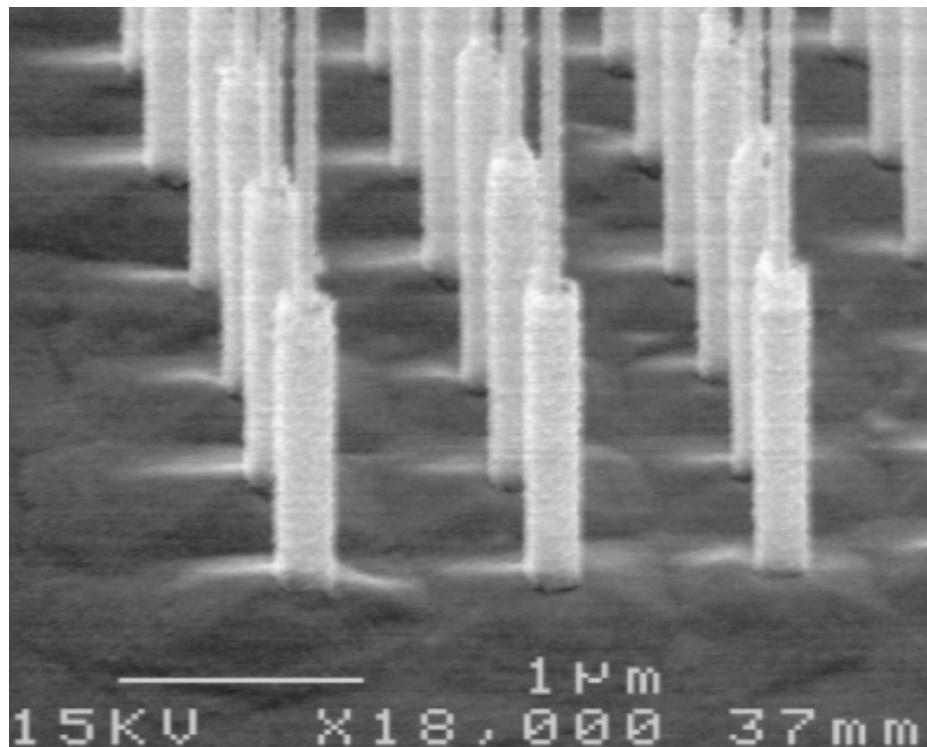
Roughly 10^{10} times more nanostructures can be made in a chemical process than on a wafer.

Allowable processes in wafer-level fabrication limited.

Chemically synthesized nanostructures can be fabricated separately and then assembled into a circuit.

Vertical wrap-gated nanowire transistors

Tomas Bryllert^{1,2,3}, Lars-Erik Wernersson^{1,2}, Truls Löwgren^{1,2} and Lars Samuelson^{1,2}



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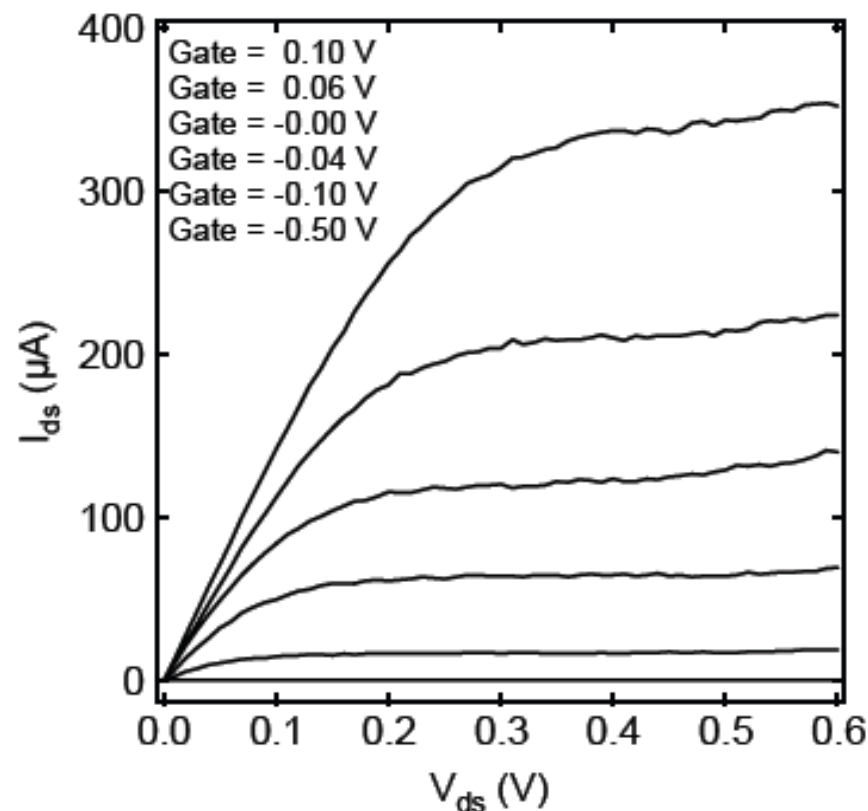
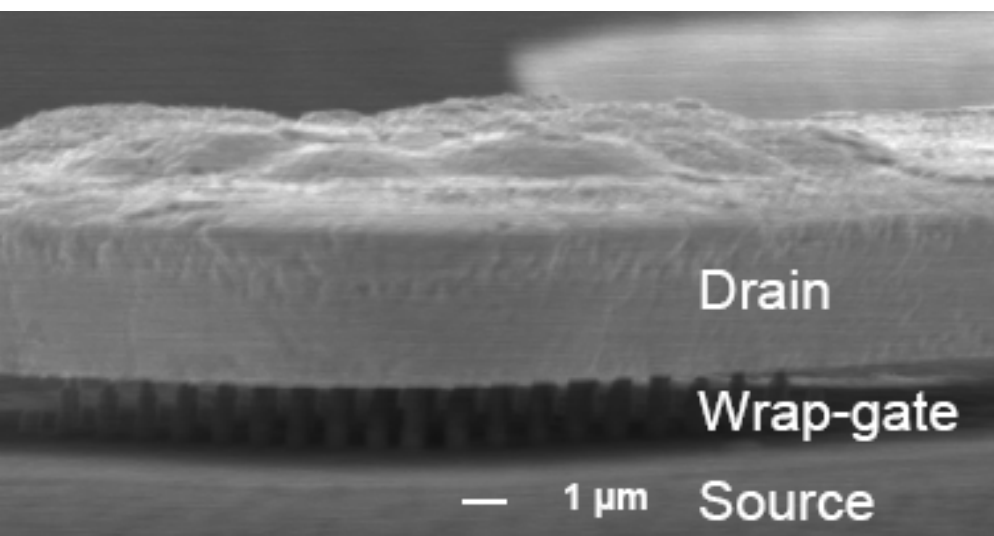


Fig 4. Room temperature current vs voltage for a transistor with about 40 channels. The measurement is made with the substrate as source contact.

Applications driving the bottom-up approach

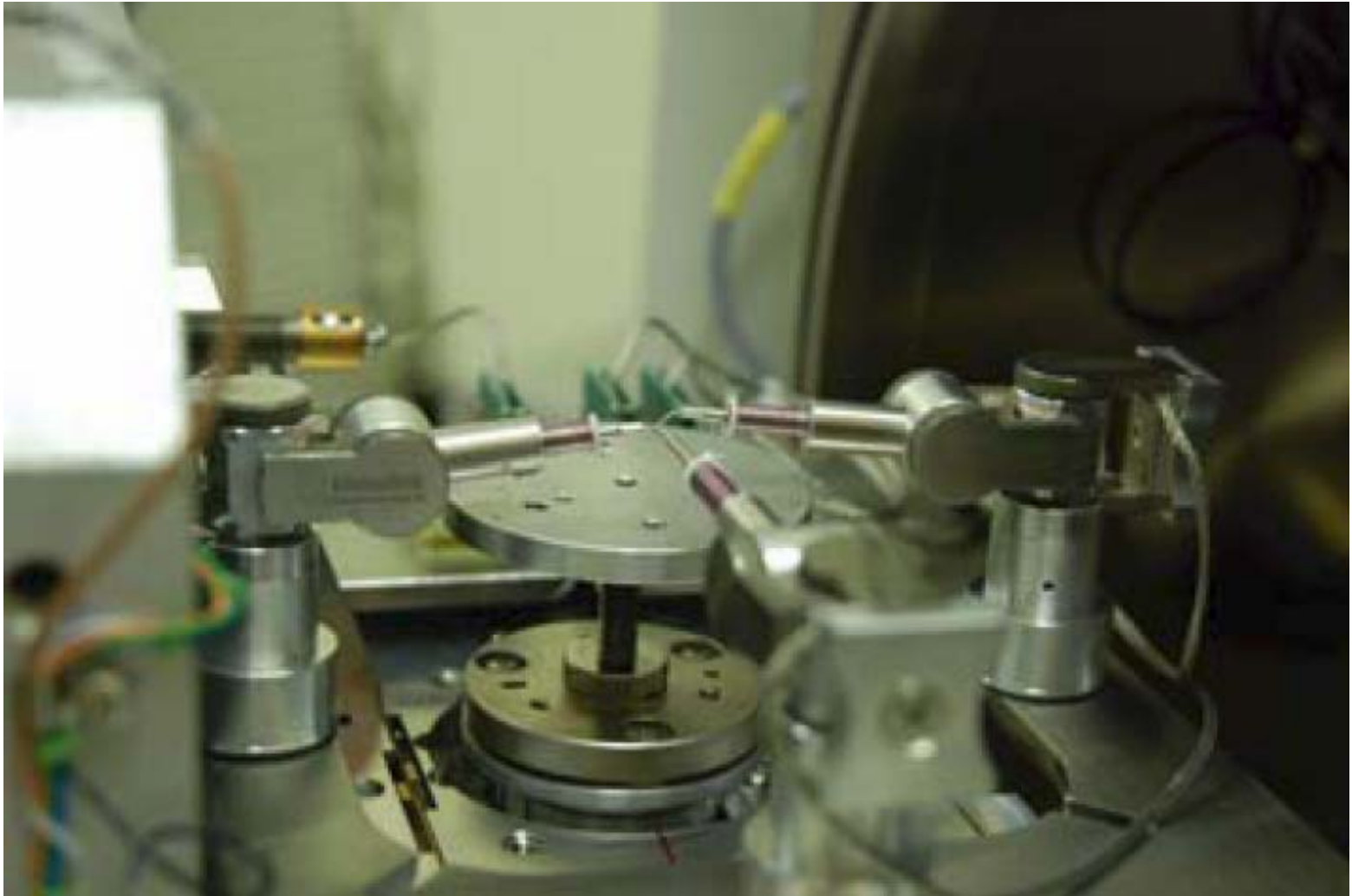
First applications for assembled nanostructures will be large area electronics: solar cells, solid-state lighting, displays.

Specialty silicon chips

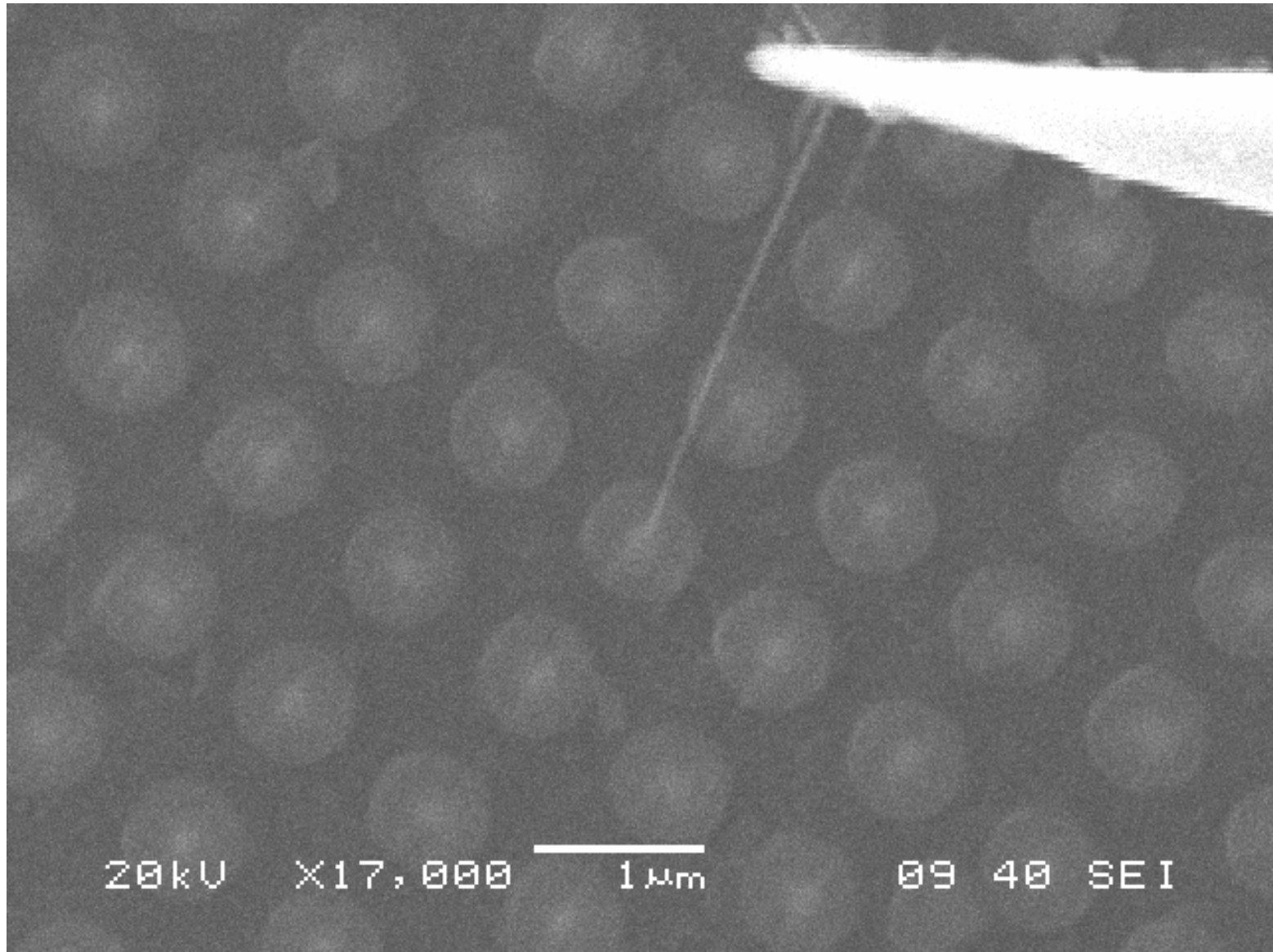
III-V nanowire arrays for optoelectronics

functionalized nanowires/nanotubes as sensors

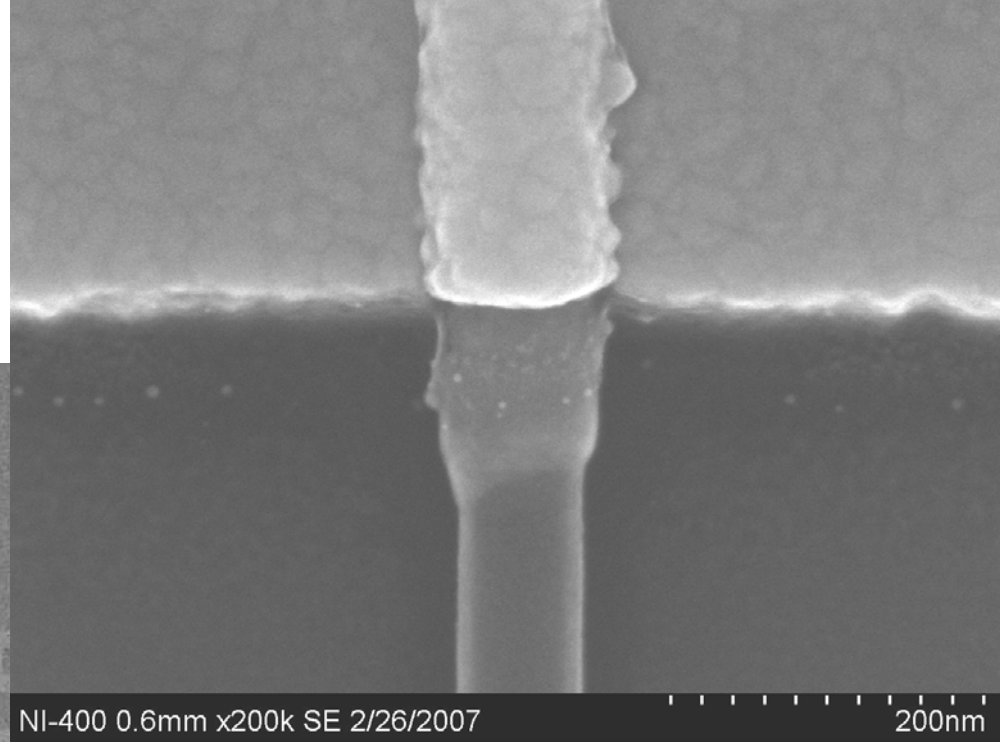
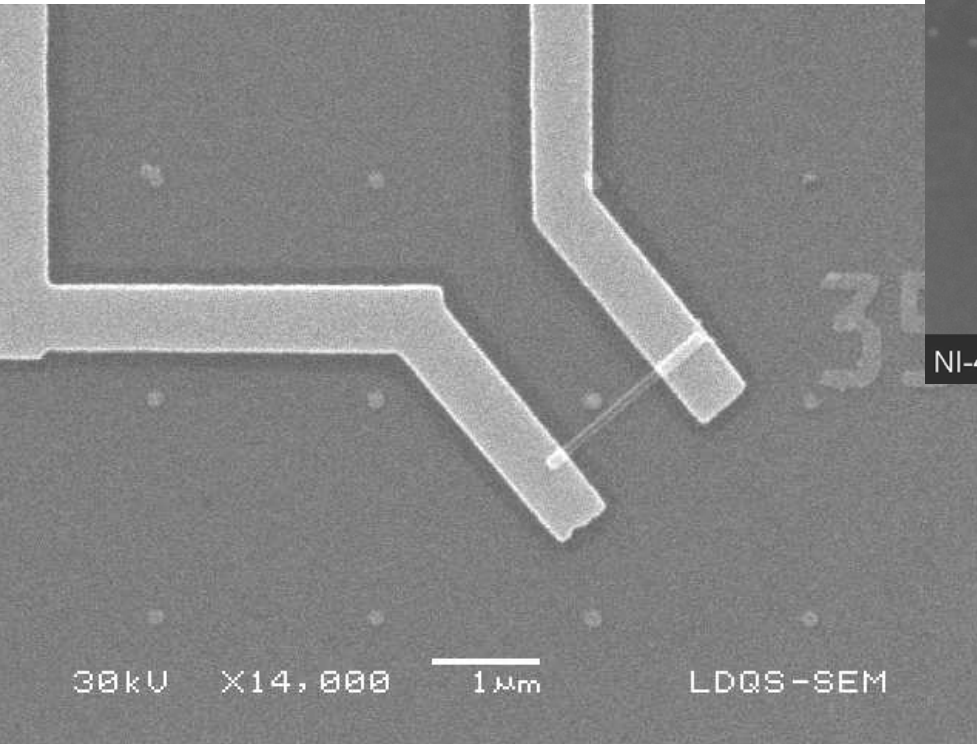
Probe station in a SEM



Scanning Voltage Measurements

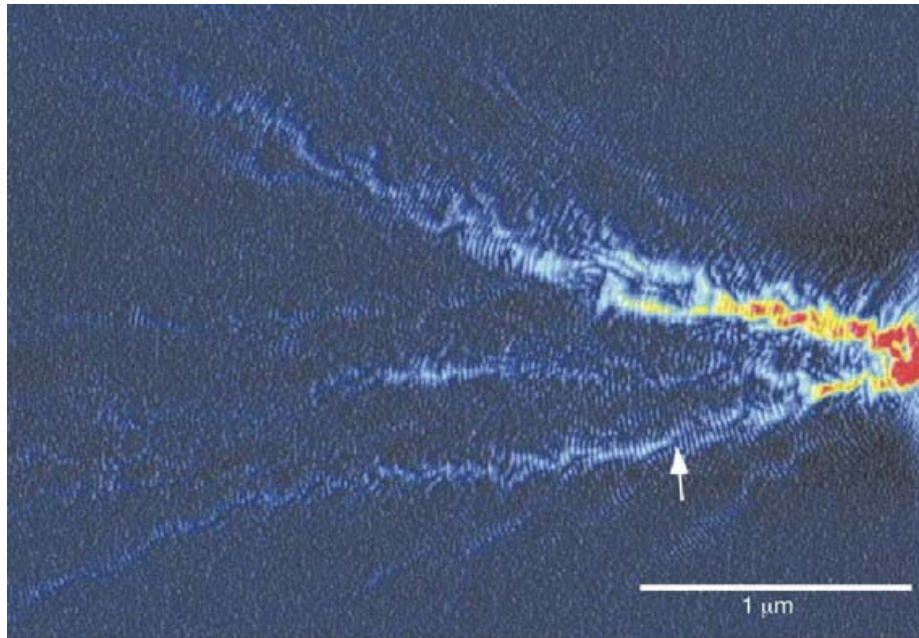


Si-Ge nanowire

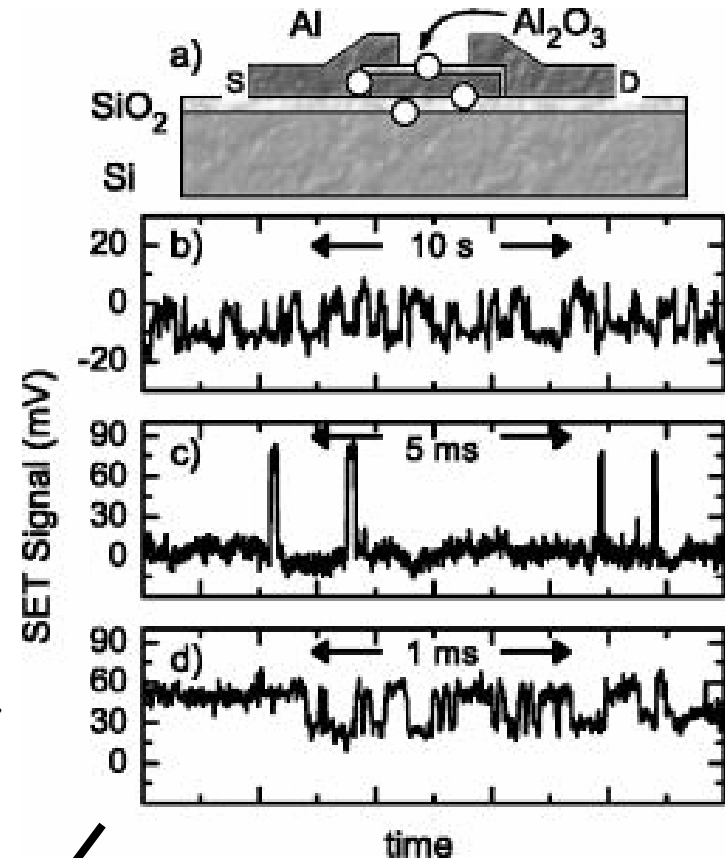


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Conductance/noise maps

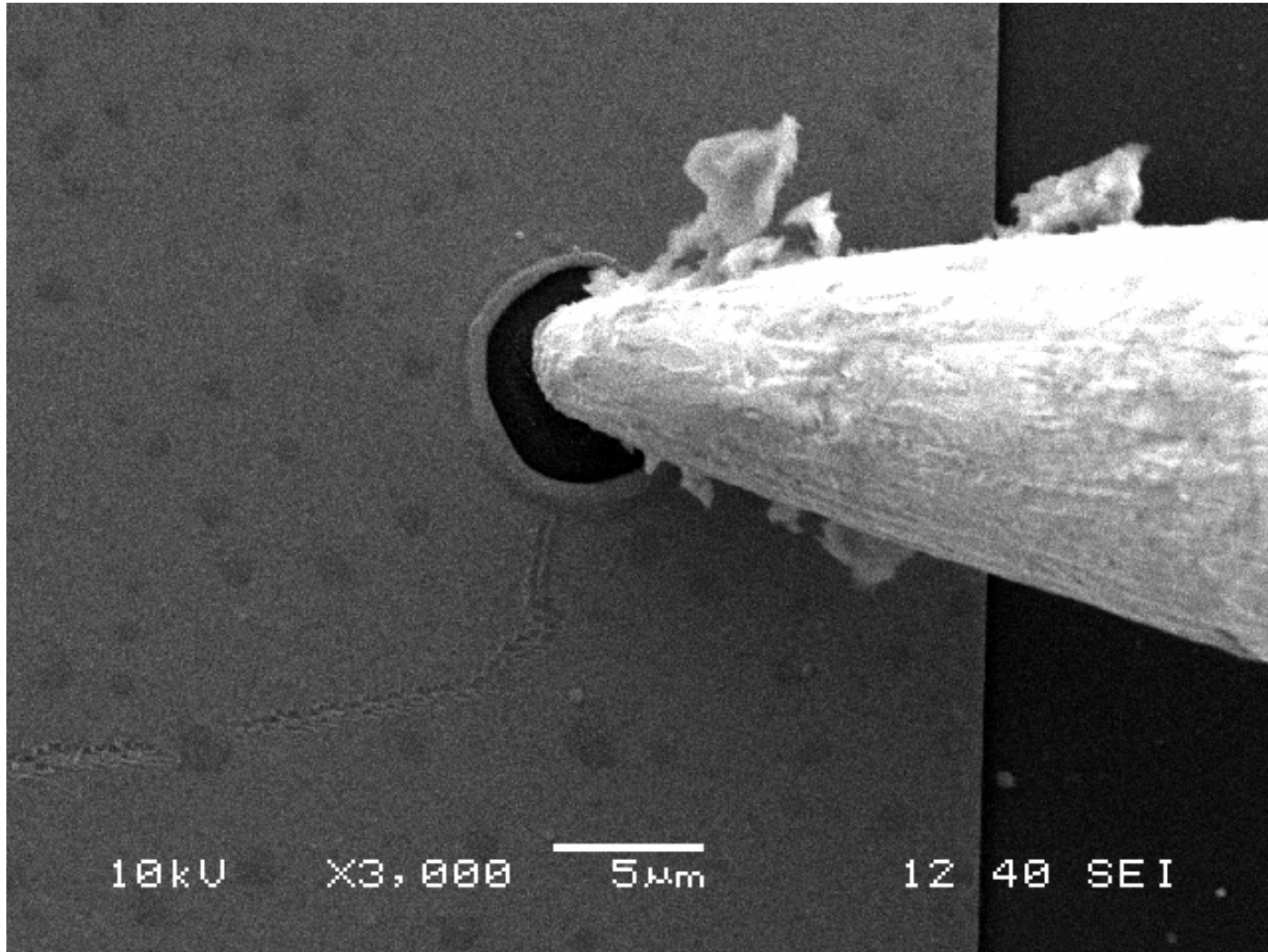


A scanning tip is used as a gate to locate noise sources. M. A. Topinka et al., *Nature* 410, 183-186(8 March 2001)



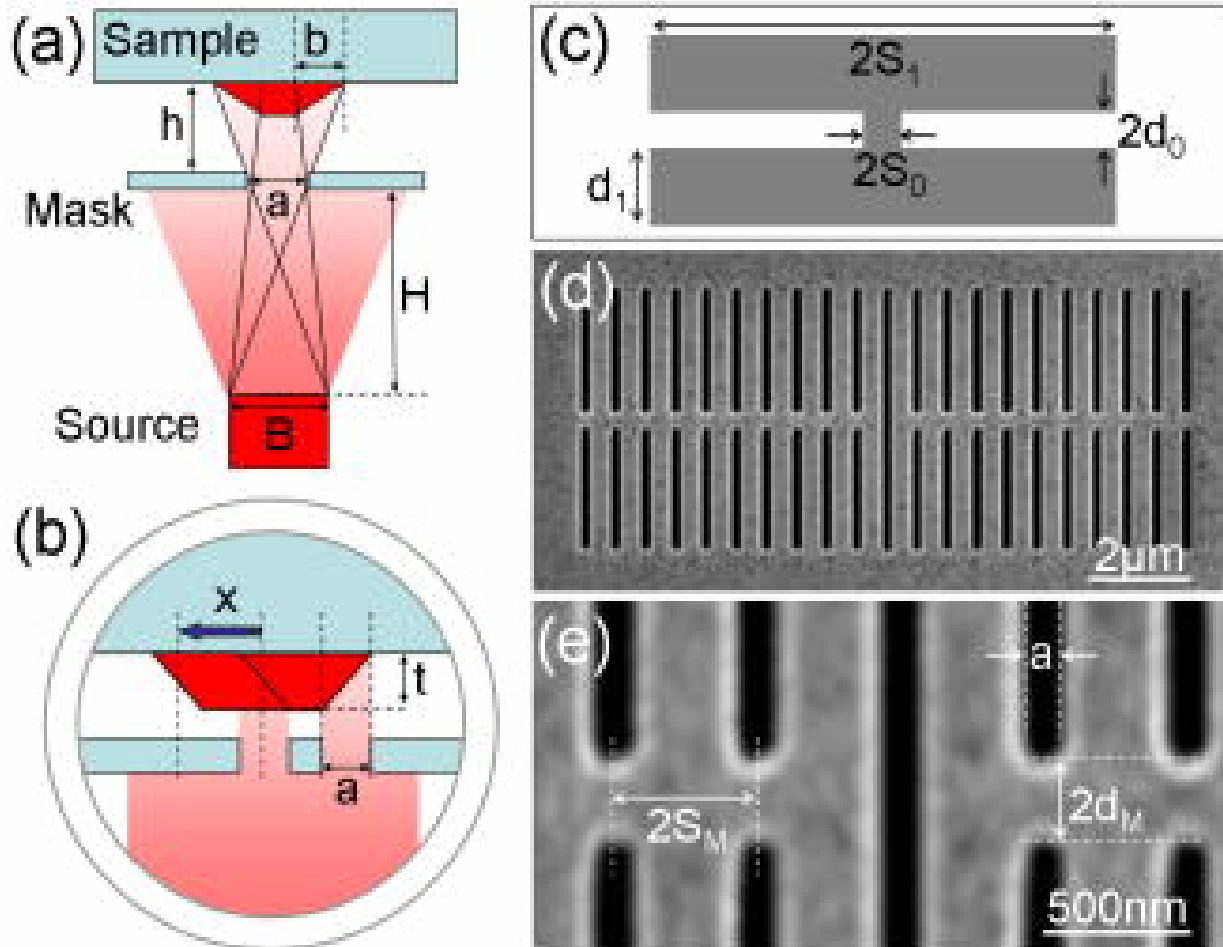
T. M. Buehler, D. J. Reilly, R. P. Starrett, V. C. Chan, A. R. Hamilton, A. S. Dzurak, and R. G. Clark, *Observing sub-microsecond telegraph noise with the radio frequency single electron transistor*, *Journal of Applied Physics* 96, pp. 6827-6830 (2004). DOI: 10.1063/1.1813619

Electric discharge machining



200 nm - 5 micron holes. Lines cut in masks and on chips

Nanostenciling



Haiming Guo, et al., Nanostenciling for fabrication and interconnection of nanopatterns and microelectrodes, *Applied Physics Letters* 90, 093113 (2007)

summary

The miniaturization of electronics will end with CMOS. At that point, devices will be approximately the size of large molecular assemblies.

Chemical synthesis of electronic devices and their self-assembly will improve the price/performance ratio of the final products.

Scanning voltage probe/scanning gate

Cutting and metal deposition capabilities similar to a FIB