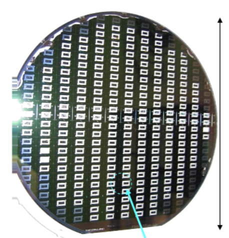
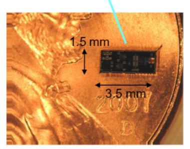
SAND2011-7790 C

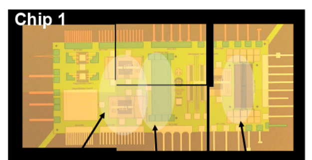
CINT Discovery Platforms™

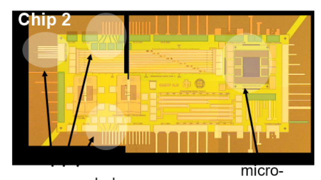
Nanomechanics and Thermal Transport Discovery Platform (NMTTDP)

The NMTTDP is a multipurpose chip that is designed for experimenters wishing to perform research in the areas of nanomechanics, nanoscale thermal transport, electrical transport, novel scanning probe technologies, chemical and biological sensing, microcalorimetry, magnetization studies, in situ TEM measurements, and the physics of coupled mechanical systems. The platform is the same size as typical atomic force microscope (AFM) chips, and it can be mounted in most AFMs. Unlike an AFM chip, this platform has multiple cantilevers projecting from all edges, and it contains special microelectromechanical systems (MEMS) test structures in the center.





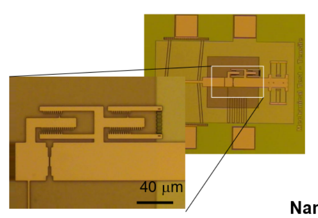




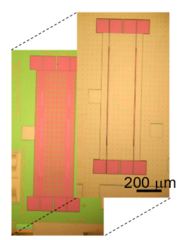
Material	Thickness	Length	Width	Freq. (calculated)	Freq. (measured)	% Difference
Poly-Si	2.25	590	30	8713		
Poly-Si	2.25	500	20	12132		
Poly-Si	2.25	420	30	17194	17190	-0.02
Poly-Si	2.25	350	20	24759		
Poly-Si	2.25	325	30	28715	28440	-0.9
Poly-Si	2.25	250	20	48528	48000	-1.1
Poly-Si	2.25	175	20	99037	96250	-2.8
Poly-Si	2.25	125	20	194112	184690	-4.9
Poly-Si	2.25	88	20	391658		
Poly-Si	2.25	350	10	24759		
Poly-Si	2.25	350	40	24759		
Poly-Si	2.25	350	100	24759		
Poly-Si	2.25	50	2	1213200	952000*	
Poly-Si	2.25	200	20	75825	72500*	
Poly-Si	2.25	300	30	33700	33130	-1.7
Si_3N_4	0.5	500	20	1968		
Si_3N_4	0.5	50	30	196800		
Si_3N_4	0.5	200	30	12300		
Si_3N_4	0.5	300	30	5467	5625	2.9
Si_3N_4	0.5	500	30	1968		

Beam Properties: This table shows some of the cantilever beam dimensions on the NMTTDP and the predicted and measured properties for some of the structures. The frequencies marked with "*" are for beams that are part of an array. The measured frequency refers to the lowest order mode of the whole array.

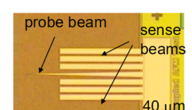
Comment on Q's: The Q's of polysilicon beams have been measured to be about 15,000 and the Q's of silicon nitride beams are about 4,000.



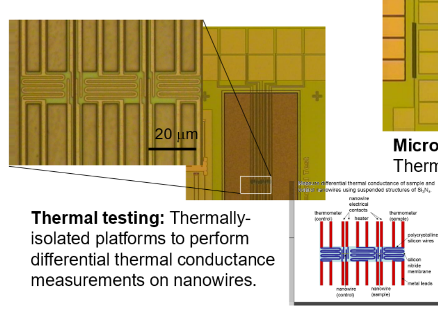
Electromechanical testing: Mechanical testing w/ simultaneous electrical testing.



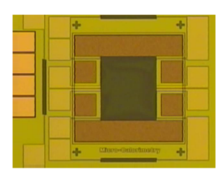
Nanowire electrical testing: Trenches w/ over-deposited contacts.



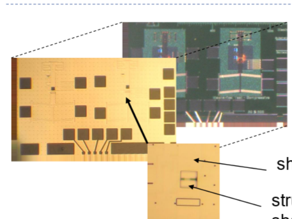
Coupled beam AFM test structure: Probe beam mechanically-coupled to sense beams.



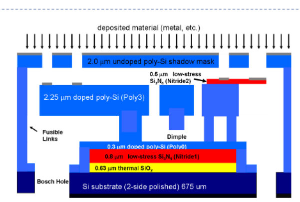
Thermal testing: Thermally-isolated platforms to perform differential thermal conductance measurements on nanowires.



Microcalorimetry: Thermally-isolated platform w/ temp. sensing.



Integrated shadow mask layer: A top layer of patterned silicon is suspended over the structures, enabling custom deposition of metal on to specific regions of the test structures.



cross-section of the NMTTDP

Contacts:

- ***For additional information regarding this poster or the Nanomechanics or Electrochemical Discovery Platforms, contact John P. Sullivan (SNL), 505-845-9496, jpsulli@sandia.gov***
- ***For information on the Nanowire Discovery Platform contact John Sullivan (above) or Tom Picraux (LANL), 505-665-8554, picraux@lanl.gov***

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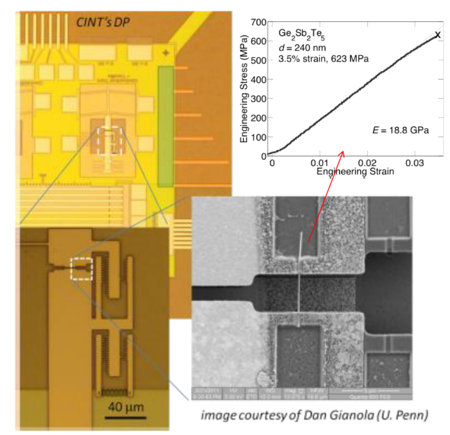
What are CINT Discovery Platforms?

CINT Discovery Platforms are chip-based platforms designed to measure properties at the nanoscale and/or to measure the properties of nanoscale samples. These platforms fill the needs of many nanoscience experiments that require microscale or nanoscale probes in order to acquire small signals (e.g. micro-cantilevers for sensing small forces) or to make contact to nanoscale samples (e.g. electrical contacts to a nanowire). Our philosophy is to make the Discovery Platforms versatile, satisfying the needs of many different types of experiments. We currently offer the Nanomechanics and Thermal Transport Discovery Platform and the Nanowire Discovery Platform. The TEM Electrochemical Cell Platform will be available early 2012.

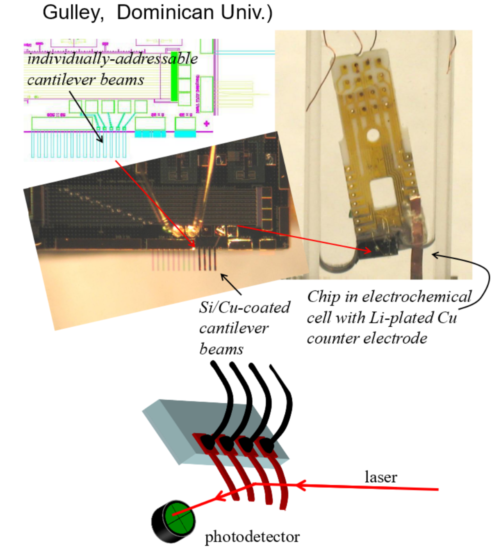
Research Examples Using the NMTTDP

Measuring the electrical and mechanical properties of phase change nanowires (Prof. Dan Gianola, U. Penn)



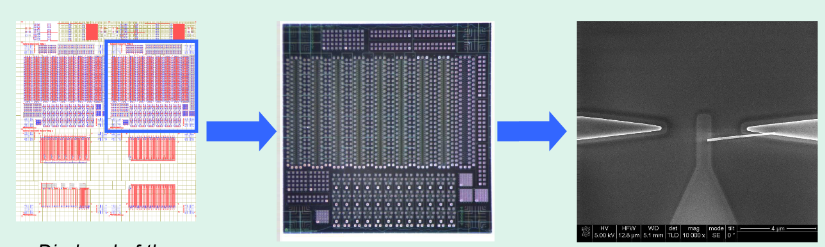
(See Gianola et al., 2011 Fall MRS & 2011 SES)

Measuring the lithiation-induced strain in silicon Li-ion battery anodes (Prof. Gerald Gulley, Dominican Univ.)



Nanowire Discovery Platform

The Nanowire DP includes special capabilities for integrating and characterizing the electrical properties of nanowires and for enabling nanowire-based sensing.

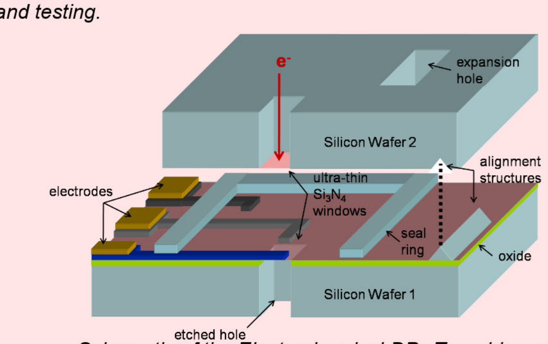


Die level of the lateral-design Nanowire Discovery Platform — *One module on the Platform: a dense array of contacts* — *Si NW on an electrode assembled by dielectrophoresis (DEP)*

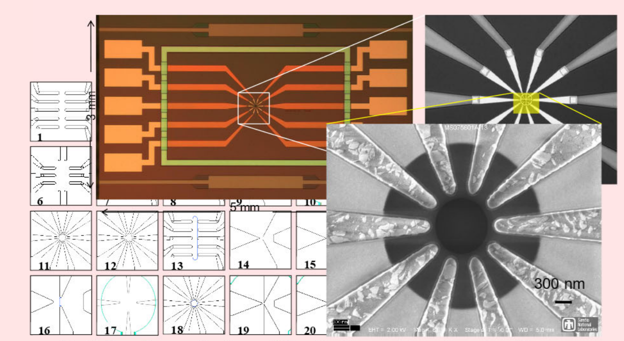
- The lateral-design Nanowire Discovery Platform provides high density electrical contacts and buried gates for electrical testing of nanowires.
  - *special electrodes for DEP*
  - *backgates for transistor structures*
  - *large arrays of electrodes with 100's of nm spacing*
- An additional design (available soon) features an integrated silicon nanowire with pre-fabricated gate electrodes.
  - *silicon nanowires fabricated by top-down approach*
  - *gate dielectric included for transistor function*
  - *structural, mechanical, and electrical diagnostics*

TEM Electrochemical Cell Discovery Platform

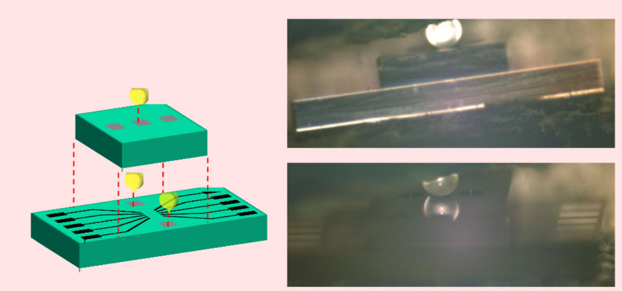
The TEM Electrochemical Cell Discovery Platform is designed to permit liquid chemical or electrochemical experiments to be performed inside a transmission electron microscope (TEM) – or other special instruments, such as x-ray beamlines. Volatile electrolytes are sealed between two chips that possess thin silicon nitride windows. A large variety of electrode designs permits flexibility in materials assembly and testing.



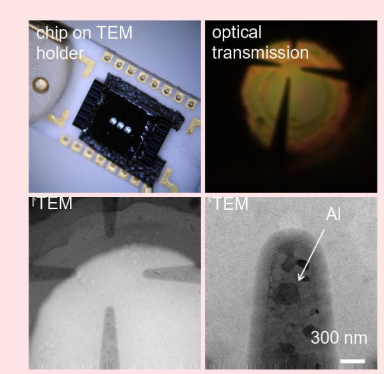
Schematic of the Electrochemical DP. Two chips are bonded together, sealing electrolyte between two thin (40 nm thick) silicon nitride windows.



Details of one design of the bottom chip, showing the electrodes on top of the silicon nitride membrane. Twenty electrodes are available (see background).



Chip alignment is achieved using micro-beads.



Electrochemical Discovery Platform mounted on a TEM holder with optical transmission and TEM images looking through the cell showing details of the aluminum electrodes.

Center for Integrated Nanotechnologies

Sandia National Laboratories