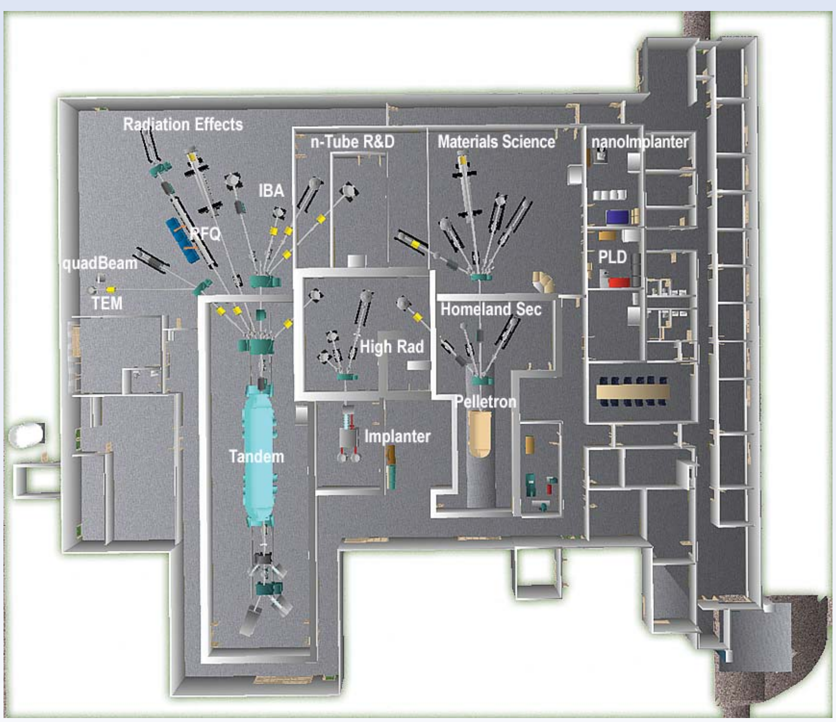
RADIATION-SOLID INTERACTIONS PHYSICS

Ion Beam Laboratory Capabilities and Applications

The management and staff of the Ion Beam Laboratory (IBL) at Sandia National Laboratories (SNL) aspire to make the IBL one of the best applied-nuclear-physics labs in the world. The facility is designed to take advantage of six particle accelerators, two of them new, that can provide beams of virtually any element to endstations in open areas, high radiation areas, and target rooms where classified experiments can be performed. Quantitative isotopic measurements are made in addition to the simulation of radiation effects.

Ion Beam Laboratory (IBL)

The principal mission of IBL is basic and applied research on topics critical to national security, primarily for nuclear weapons and homeland defense. Examples from an extensive list of applications include measurements certifying hydrogen isotope concentrations in nuclear weapon triggers, neutron-detector certification, and radiation-effects microscopy (invented by IBL staff), which is used to understand radiation-effects problems in weapon electronics.



IBL building layout

The accelerators in the IBL generate ions ranging from a few electron volts (eV) to almost one billion eV. At a few eV, a Pulsed-Laser Deposition (PLD) system can modify materials at the atomistic scale by increasing surface hardness through nanostructure self-assembly. At 100 kiloelectron volts (keV), the first nanoImplanter in the U.S. Department of Energy (DOE) can create structures in semiconductor devices in the 10 nanometer feature size range.

Silicon ions at megaelectron volt (MeV) energies are used to simulate neutron effects in transistors, and 400 MeV gold ions are used to simulate cosmic-ray effects in integrated circuits. Other ion-beam analysis techniques include backscattering, elastic recoiling, and nuclear-reaction analysis.

DEPARTMENT 1111

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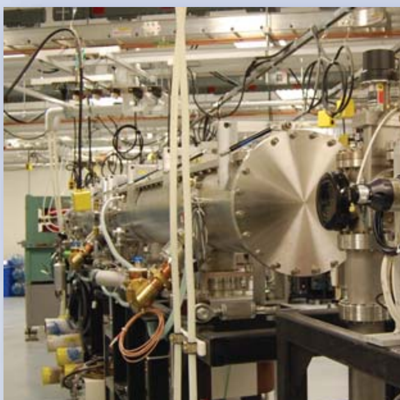
High-Voltage Tandem-Pelletron Accelerator

- **6 megavolt (MV) terminal voltage** *(maximum energy [q+1]*6 MeV)*
- **Up to 0.1 milliampere (mA) current to single ions** *(same for all IBL accelerators)*
- **Practically every element in periodic table**
- **Focused nuclear microprobe**
  - Routinely achieves < 1 micron (µm) resolution
  - 200 µm scan distance electrostatically; up to several inches mechanically (100 nanometer [nm] precision)
  - Collocated scanning electron microscope with Electron BackScatter Diffraction (EBSD)
  - 100 nm resolution navigation based on GDS II files
  - On-demand 100 nanosecond beam blanking
- **Radiation damage systems (semiconductors and metals)**
  - Simulation of neutron-induced displacement damage in semiconductor devices and metals
  - Equivalent neutron fluxes comparable to pulse-burst reactors
  - Mixed (neutron/gamma) programmable radiation simulation exposure system



Radio Frequency Quadrupole (RFQ) LINAC (1.9 MeV/amu)

- **Highest-possible linear energy transfers (charge injection)**
- **Greater ion range**
- **Ion-photon emission microscopes (single event upset-imaging)**
  - Approximately 1 µm resolution
  - Used with RFQ or Lawrence Berkeley National Laboratory Cyclotron

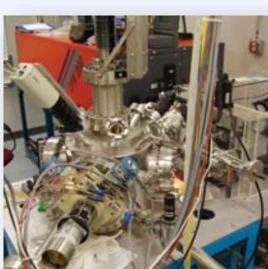
350 keV Implanter

- **Highly controlled deuterium/tritium (DT) neutrons for calibrations**
- **Implantations of virtually any element**
- **Single-ion 100 nanometer implants for quantum computers**

3 MV Pelletron

- **Beams of hydrogen, deuterium, helium-3, and helium-4**
- **Backscattering, nuclear reaction analysis, channeling**
- **Nuclear microscopy**
  - Oxford Microprobe
  - microPIXE
- **eXternal PIXE**

Pulsed-Laser Deposition (PLD)



- **eV energy ion-assisted deposition**
- **Thin films**
- **Nanoidentation system**

nanoImplanter (nI)

- **100 keV isotope-selectable implants**
- **10 nanometer resolution**
- **Single-ion capable**
- **Reactive ion etching and deposition**

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