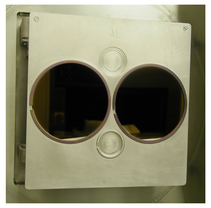
LBNL MICROSYSTEMS LABORATORY

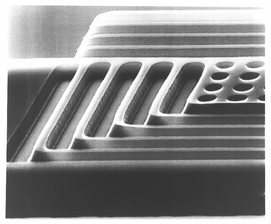
FACILITY DESCRIPTION

The LBL Microsystems Laboratory (MSL) is a semiconductor processing facility specializing in the fabrication of various types of radiation detectors and integrated electronics on high resistivity silicon. The facility consists of 700 sq. ft. of Class 10 clean room space with a dedicated HVAC system providing environmental control of +/-1 F and +/- 2% relative humidity. Devices are fabricated using techniques common to the silicon wafer integrated circuit industry. Employment of established, mature processes using standard production equipment contributes to high device yields. Process capabilities include high temperature oxidation, deposition of thin films, and diffusion of impurity dopants, dry plasma etching, wet chemical etching and cleaning operations, and photolithography. Located in on the 4th floor of Building 70A, a schematic footbprint of the MSL is shown below highlighting processing equipment.



THIN FILM DEPOSITION

- KDF 603i batch sputter deposition system
- Aluminum thin film metallization
- Optical thin film coatings: indium tin oxide and silicon dioxide

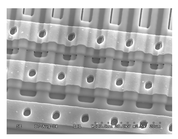


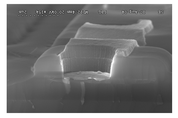
PHOTOLITHOGRAPHY

- Yield Engineering LP3 vapor priming
- Rite Track photoresist coat and bake track
- Beta Squared 1:1 projection mask aligner
- 1.25 micron linewidth resolution
- 0.5 micron layer-to-layer registration accuracy

PLASMA ENHANCED CVD

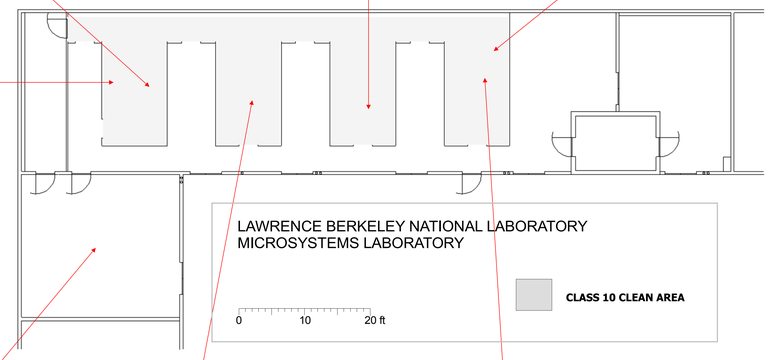
- Advanced Vacuum Vision 300
- Deposition of silicon dioxide and nitride
- Films provide front and back side device protection





DRY ETCHING

- Two Lam 4400 Series Etchers
- Dedicated poly-Si and SiO_2 etching tools
- High selectivity processes for:
  polysilicon CCD gates
  silicon dioxide contacts



WATER PURIFICATION

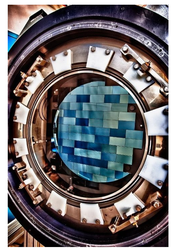
- 18 Mohm-cm resistivity
- < 100 ppt metal impurities
- 1500 gallon capacity
- Continuously recirculating loop into MSL

WET CHEMISTRY

- Santa Clara Plastics wet benches
- Dedicated filtered and temperature controlled baths
- Full RCA pre-furnace megasonic wafer cleaning
- Photoresist develop and thin film wet etching of aluminum, silicon, silicon dioxide and nitride

THERMAL PROCESSING

- Thermco TMX horizontal furnaces
- Six independent process chambers
- Wet & dry oxidation and diffusion
- Chemical vapor deposition
  poly-Si, silicon dioxide and nitride



75 MSL CCDs ASSEMBLED INTO THE DES FOCAL PLANE BY FERMILAB

MSL CCD IMAGE OF DUMBELL NEBULA N27 FROM THE WIYN OBSERVATORY

Photo credit: NOAO/AURA/NSF
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Keck 10m telescope LRIS spectrograph

Kitt Peak/Mayall 4m Mars and RC spectrographs

MMT 6.5m/Mt. Hopkins Red Channel spectrograph

Lick Obs./Mt. Hamilton Hamilton Echelle spectrograph

Palomar Hall 200" SWIFT spectrograph

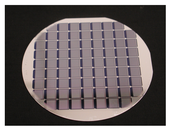
SDSS 2.5m telescope BOSS spectrographs

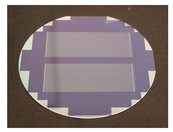
GROUND-BASED DEPLOYMENTS OF MSL CCDS

MSL P-I-N DETECTORS ON-BOARD THE THEMIS MISSION

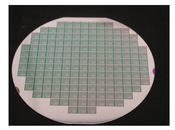
MSL ACCOMPLISHMENTS AND GROWTH

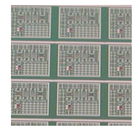
Since its commissioning in 1990 under the leadership of Helmuth Spieler and David Nygren, the MSL has supported a variety of scientific projects with custom silicon devices. Initial work focused on pixel and strip detector development for high energy physics applications. These p-i-n diodes exhibited very low reverse leakage current (<1nA/cm2) and established the baseline for more complex future device designs. In the following years, the MSL continued to expand its process repertoire and tool set for pursuing more challenging device structures. By the mid-1990s, the MSL successfully fabricated transistors on high resistivity silicon for monolithic integration with p-i-n detectors and developed etching techniques for polysilicon gates on multilayer dielectric structures. Collaboration with Life Sciences for medical imaging applications led to the fabrication of photodiodes employing a patented process (Holland) for creating a low noise device with backside illumination and high quantum efficiency. These development efforts culminated in the successful design and fabrication of a backside illuminated charge-coupled device (CCD) on high resistivity silicon in 1996. The long wavelength sensitivity of these CCDs were well-suited to applications in astronomy and astrophysics and aligned with LBNL's successful astrophysics group. Over the next decade, the MSL fabricated CCDs of larger size (16 megapixel) and complexity. LBNL high resistivity CCDs are now deployed in telescopes internationally, including a 570 megapixel focal plane for the Dark Energy Survey in Cerro Tololo, Chile. Interest in CCDs has expanded beyond astronomy with MSL CCDs being developed for x-ray detection at the LBNL Advanced Light Source. Other applications include homeland security and direct detection of positrons for possible medical imaging applications. In parallel with CCD fabrication, the MSL (Tindall) has fabricated detectors for a variety of space missions in collaboration with the UC Space Sciences Lab including the STEREO, THEMIS, CINEMA and MAVEN projects.



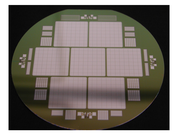


FIRST MSL FABRICATED DEVICES: STRIP DETECTORS ON 100MM WAFERS



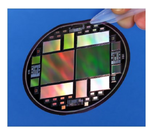


TRANSISTORS FABRICATED ON HIGH RESISTIVITY SILICON

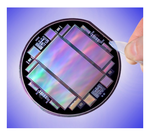


PHOTODIODES FOR MEDICAL IMAGING

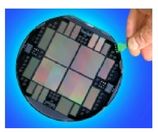
1996 **- FIRST MSL CCD 40K PIXELS**



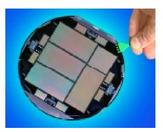
1998 **- FIRST LARGE FORMAT CCD 4M PIXELS**



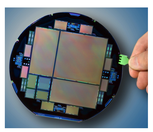
2000 **– 8M PIXEL CCD**



2002 **- FIRST MSL CCD ON 150MM WAFER 16M PIXELS FOR SNAP**

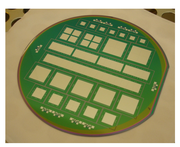


2006 **– 8M PIXEL CCD DARK ENERGY SURVEY PRODUCTION BUILD**

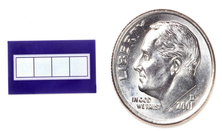


2007 **– 16M PIXEL CCD FOR BARYON OSCILLATION SPECTROSCOPIC SURVEY**

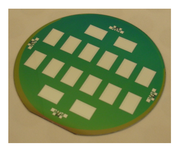
PROGRESSION OF CCD DEVELOPMENT IN THE MICROSYSTEMS LAB



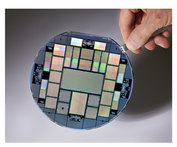
SILICON ON INSULATOR DEVICE FABRICATION



THIN WINDOW ELECTRON DETECTORS FOR NASA STEREO MISSION



90 DETECTORS SUPPLIED TO NASA THEMIS MISSION



2011 **R&D RUN WITH 12 DIFFERENT DESIGNS FOR FAST,LOW NOISE CCD READOUT AND SINGLE PHOTON DETECTION**