1
00:00:00,000 --> 00:00:08,000
[SFX: Digital Beeping]

2
00:00:08,000 --> 00:00:09,000
[SFX: Scribbling]

3
00:00:09,000 --> 00:00:15,000
[SFX: Deep Bass]

4
00:00:16,500 --> 00:00:18,600
[Music]

5
00:00:18,700 --> 00:00:23,600
As part of NASA's Earth Observing Fleet
Landsat has been monitoring the planet's health

6
00:00:23,670 --> 00:00:29,770
for over 40 years. With stunning images in
multiple wavelengths, Landsat provides valuable

7
00:00:29,770 --> 00:00:36,250
data to farmers, scientist, city planners,
as well as the public. And behind these images

8
00:00:36,250 --> 00:00:42,040
lies QWIP, the Quantum Well Infrared Photodector,
which is processed here in the Detector Development

9
00:00:42,040 --> 00:00:47,370
Lab at NASA Goddard. Similar to the sensor
in your digital camera or cell phone, the

10
00:00:47,370 --> 00:00:52,360
QWIP detector is designed to be more sensitive
and to detect specific wavelengths. Let me

11
00:00:52,360 --> 00:00:58,400
show you how these high-end detectors are
created. The spectrum of light contains many

12
00:00:58,400 --> 00:01:03,710
wavelengths of which the colors of visible
light are a small portion. We have built and

13
00:01:03,710 --> 00:01:10,440
packaged detectors to cover wavelengths from
Microwave to X-ray The basic goal of a detector

14
00:01:10,440 --> 00:01:15,440
is to absorb the energy from a region of these
wavelengths of light and turn it into an electrical

15
00:01:15,440 --> 00:01:21,640
signal. The first step for us is to take the
wavelength, resolution, and sensitivity requirements

16
00:01:21,640 --> 00:01:27,970
of the mission and turn that into a detector
design using CAD software. The layout is sliced

17
00:01:27,970 --> 00:01:32,730
into individual layers or masks that will
be combined during fabrication to create the

18
00:01:32,730 --> 00:01:39,730
final detector device. Welcome to the Detector
Development Lab. This is a unique, Class 100

19
00:01:39,960 --> 00:01:46,170
clean room where we have the agility and technology
to develop first-of-a-kind detectors as well

20
00:01:46,170 --> 00:01:51,670
as the experience and the process control
to turn those into flight qualified products.

21
00:01:51,670 --> 00:01:57,140
All of the specialized equipment in this lab
is used for 1 of 3 general purposes - Lithography,

22
00:01:57,140 --> 00:02:04,140
Etching, and Deposition. Together these 3
processes make up our basic toolset. The first

23
00:02:05,210 --> 00:02:10,300
basic process is called Lithography. Don't
adjust your picture, the yellow lights provide

24
00:02:10,300 --> 00:02:15,280
protection for photoresist, a photosensitive
polymer that is used to define the detector

25
00:02:15,280 --> 00:02:21,330
geometries to as small as 1 micron. The first
step in lithography is to apply photoresist

26
00:02:21,330 --> 00:02:26,220
to the substrate. This is done by spinning
on a liquid suspension of the polymer in the

27
00:02:26,220 --> 00:02:31,849
spin-coater. The coated wafer is taken to
the photo-mask aligner, where the chrome-on-quartz

28
00:02:31,849 --> 00:02:36,510
mask that was created by the design and layout
is placed in extremely close proximity to

29
00:02:36,510 --> 00:02:43,209
the substrate and aligned to existing patterns
with in a micron of accuracy. A UV light source

30
00:02:43,209 --> 00:02:50,209
exposes the photoresist through the mask,
transferring the pattern into the photoresist.

31
00:02:50,700 --> 00:02:56,290
Finally the substrate is developed, rinsing
away the exposed areas of the photoresist.

32
00:02:56,290 --> 00:03:02,029
The next step is to use this protective mask
and etch to remove material from the exposed

33
00:03:02,029 --> 00:03:08,769
areas of the substrate. We have a wide variety
of methods for removing materials including

34
00:03:08,769 --> 00:03:15,769
wet chemical etchants, reactive plasmas, and
ion sputtering. In one of the most fascination

35
00:03:17,260 --> 00:03:22,430
examples, the Deep-Reactive-Ion Etcher uses
short etching and passivation cycles in a

36
00:03:22,430 --> 00:03:29,430
high-power ICP chamber to etch silicon 100's
of microns deep with 100:1 aspect ratios.

37
00:03:29,909 --> 00:03:34,540
After etching, the photoresist mask is stripped
off in a solvent and the substrate is ready

38
00:03:34,540 --> 00:03:41,540
for deposition of the next layer of material.
Deposition is the third basic process in our

39
00:03:42,529 --> 00:03:49,529
toolset and it covers a wide range of specific
processes and materials. During deposition,

40
00:03:50,169 --> 00:03:55,290
a thin film of material is added back to the
surface of the detector's substrate. Materials

41
00:03:55,290 --> 00:04:00,379
run the gamut from insulating dielectrics
to metal-nitrides, to pure metals and even

42
00:04:00,379 --> 00:04:06,099
superconductors. Here in the Atomic-Layer-Deposition
system, single atomic layers of materials

43
00:04:06,099 --> 00:04:12,709
can be built up one-by-one for precise control
of thickness and uniformity. Once the deposition

44
00:04:12,709 --> 00:04:19,199
is complete the substrate goes back to lithography
to pattern the new layer of material. In building

45
00:04:19,199 --> 00:04:25,350
up the designed detector we start with a substrate
such as silicon or gallium arsenide wafers.

46
00:04:25,350 --> 00:04:31,780
Next, numerous iteration of these 3 basic
process steps are applied to the substrate

47
00:04:31,780 --> 00:04:36,450
in order to build up the materials and geometry
needed to detect the energy of interest such

48
00:04:36,450 --> 00:04:42,280
as IR, define the pixels and allow electrical
read-out, while meeting all the scientific

49
00:04:42,280 --> 00:04:48,660
requirements for the mission. Here is a gallium
arsenide wafer with 16 QWIP arrays that has

50
00:04:48,660 --> 00:04:54,660
completed fabrication. The substrate is taken
to our packaging lab where it is diced into

51
00:04:54,660 --> 00:05:00,620
individual dies. The die are screened, then
meticulously cleaned and indium-bump bonded

52
00:05:00,620 --> 00:05:06,030
directly to a specialized Read-Out Integrated
Circuit, which converts the raw electrons

53
00:05:06,030 --> 00:05:10,700
generated in each detector pixel to a signal
that can be interfaced to the instrument's

54
00:05:10,700 --> 00:05:17,700
computers. Finally, the detector and ROIC
are bonded to the necessary fixtures and PC

55
00:05:17,700 --> 00:05:23,010
boards and the detector subsystem is ready
for integration with the rest of the scientific

56
00:05:23,010 --> 00:05:29,130
instrument. The QWIP detector on Landsat 8
is just one example of many missions supported

57
00:05:29,130 --> 00:05:35,260
by the DDL. We have built and packaged detectors
to cover wavelengths from X-ray to microwave,

58
00:05:35,260 --> 00:05:42,260
in support of missions such as ASTRO-H, SWIFT,
HAWC, Suzaku, and JWST. Each detector was

59
00:05:44,910 --> 00:05:50,260
specifically designed to meet the science
and mission requirements, developed, fabricated,

60
00:05:50,260 --> 00:05:55,960
packaged, tested, and delivered for integration.
These unique capabilities at Goddard have