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INFOTRACKS

this issue:

X-Ray Radiography: Analog vs. Digital

[By Chris Henderson]

The two images on the right demonstrate the difference between analog and digital x-ray images. The image on the bottom is essentially 640 by 480 pixels, or approximately 300 kilo-pixels resolution, where the image on the top is 1280 by 1024 pixels, or approximately 1.3 mega-pixels resolution.

The quality difference explains why digital x-ray radiography has become the standard. Both analog and digital detection systems contain five elements: a sensor, an amplifier, an analog to digital converter, an image processing computer, and a display. Yet what makes digital x-ray radiography more effective?

The answer lies in the differences between the two detection systems. In analog x-ray detection, the sensor and the amplifier comprise the camera. An analog signal comes out of the amplifier, and, therefore, out of the camera. The computer takes the analog signal, digitizes it, and sends it to the image processing computer.

Since many customers require real-time imaging, the camera technology for analog detectors is similar to standard TV cameras. The image intensifier in an analog system works by placing an x-ray sensitive phosphor, such as cesium iodide, on a plate facing the x-ray tube. Any x-rays from the tube that have sufficient penetrating power to pass through a sample will impinge upon the phosphor. The phosphor converts the incoming x-ray photons into visible photons. These visible photons can then be seen and captured by an optical camera. This limits the image size to 640 by 480 pixels, or possibly 768 by 576 pixels.

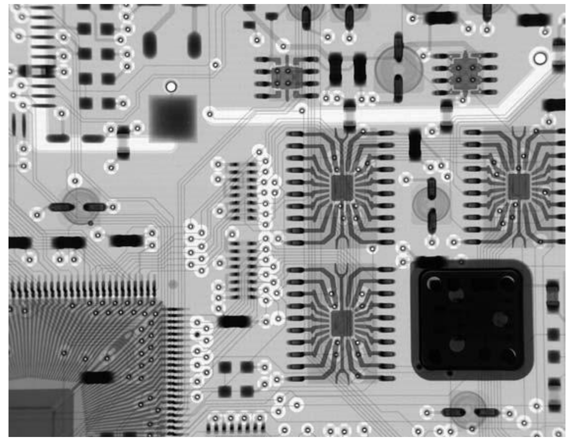
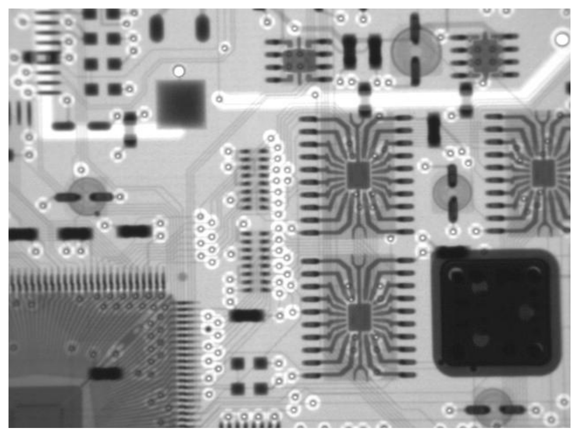


Figure 1. Top: Digital x-ray radiography image Bottom: Analog x-ray radiography image.



Conversely, a digital detection system encompasses the sensor, amplifier, and analog-to-digital conversions within the camera. In fact, the sensor and conversion can be incorporated into a single package.

A number of different formats are available in digital detection systems.

[Continued on Page 2]

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Some common sensors for digital detectors for x-ray inspection include:

- Image intensifier using a digital CCD camera, or a digital image intensifier
- CMOS flat panel detector
- Amorphous silicon imaging panel
- Amorphous carbon with scintillator panel
- Fibre-optic plate with x-ray scintillator (FOS)
- FOS coupled to a CCD camera

The table at the bottom of the page shows some of the important features and differences between digital and analog sensors. A CMOS sensor would be classified as a digital sensor.

While analog intensifiers are fast, their resolution is limited in both pixel size and gray scale. Both CMOS sensors and digital intensifiers use the cesium iodide phosphor, but can resolve the phosphor image with higher resolution or more line pairs per centimeter.

Digital intensifiers are faster than CMOS sensors. While a CMOS sensor can output images at a rate of up to 4 images per second, the digital intensifier can do rates up to 25 images per second, providing better real-time imaging. In order for a CMOS sensor to provide real-time imaging, the array must be sub-divided into a checkerboard pattern. This reduces the resolution, making the images lower quality.

However, some systems use CMOS sensors because they are cheaper than digital intensifiers. One should be aware of this issue when performing x-ray imaging.

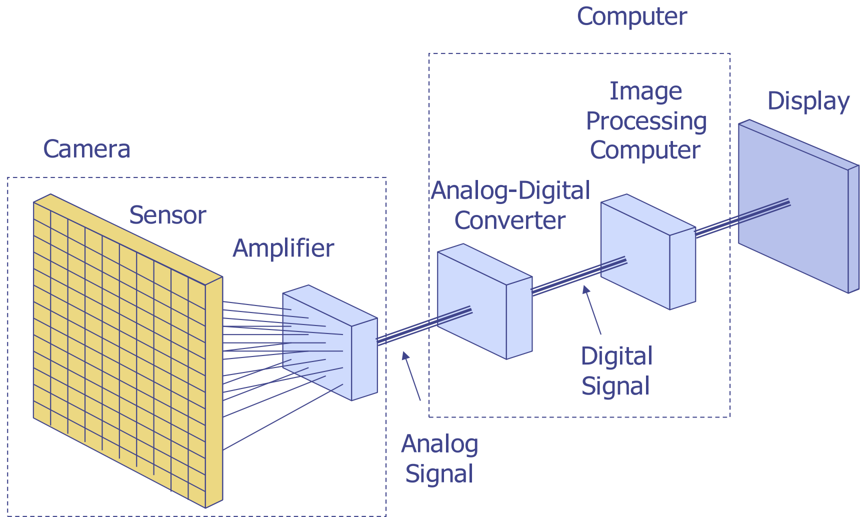
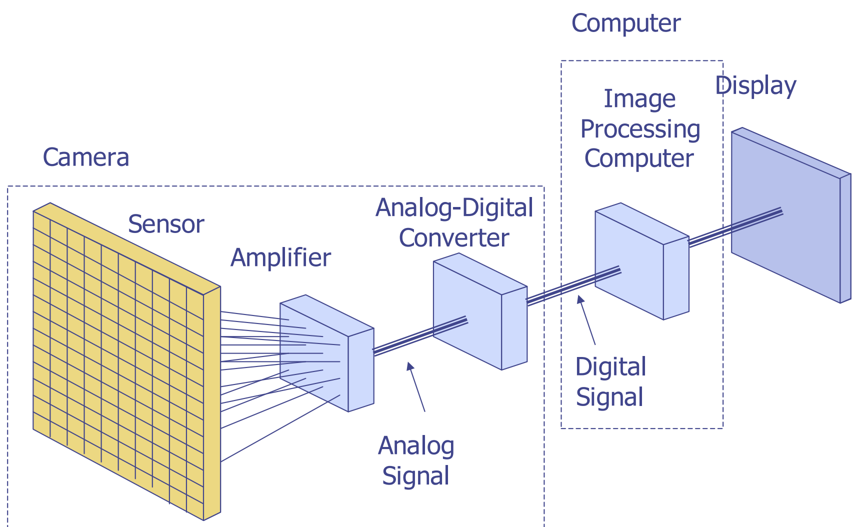


Figure 2. The picture on the top shows an analog x-ray radiography system, with the analog-digital converter separate from the camera. In a digital system like the figure on the bottom, the analog-digital converter is part of the camera.



Comparison of Features of CMOS Flat Panel Detector with Digital and Analog Image Intensifiers

Feature	Analog Intensifier	Digital Intensifier	CMOS Sensor
Pixel Size of Detector	640 x 480	1280 x 1024	1024 x 1024
Resolution (line pairs/cm)	50	72	80
Gray Scale Resolution	8-bit	16-bit	12-14-bit
Frame Rate (frames/sec)	25	25	4

Elementary Particle Classes: More than Meets the Eye

[Technical Tidbit]

A fermion is any particle that has an odd half-integer (like 1/2, 3/2, and so forth) spin. Quarks and leptons, as well as most composite particles, like protons and neutrons, are fermions. Most important to our discussion is that electrons are fermions.

For reasons we do not fully understand, a consequence of the odd half-integer spin is that fermions obey the Pauli Exclusion Principle and therefore cannot co-exist in the same state at the same location at the same time.

Bosons are those particles which have an integer spin (0, 1, 2...). All the force carrier particles are bosons, as are those composite particles with an even number of fermion particles (like mesons).

When considering solar cells, it's most important to note that photons are bosons.

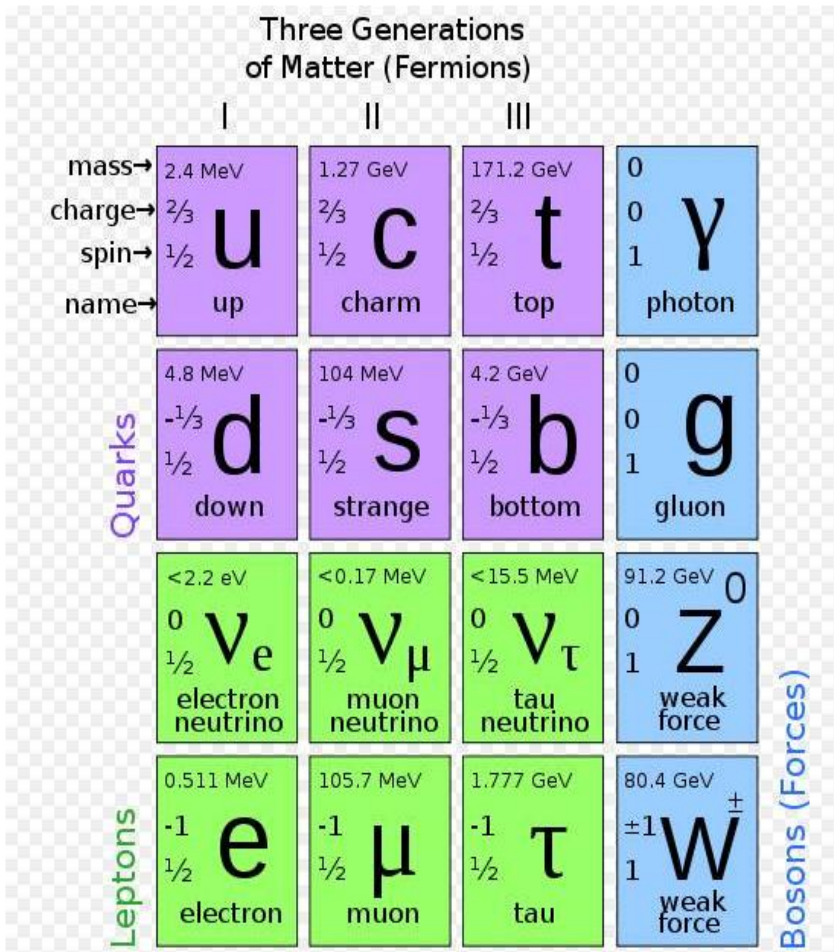


Figure 3. Chart showing subatomic particles.

Ask the Experts

Q: For conductive die epoxy, is it possible for the epoxy to become non-conductive? Is the epoxy conductive to X,Y Z direction while grain size of silver is connected in specific direction? I believe the epoxy is a silver small grain size in liquid form. The liquid is non-conductive.

Is this correct? If so, how does the epoxy become conductive?

A: Conductive epoxy adhesives usually set up their conductivity in a planar manner. Silver additive is normally in a flake format and forms a set of platelets that provide that planar structure. Cure shrinkage of the base epoxy resin compresses the silver particles to make mechanical contact with each other.

Losing conductivity could result from (1) thermomechanical delamination, (2) poor or no initial curing, or (3) separation of silver through either (a) initial resin bleed or (b) incomplete pre-mixing.

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To submit questions to the Q&A section, inquire about an article, or suggest a topic you would like to see covered in the December newsletter, please contact Alicia Constant by email at alicia.constant@semitracks.com.

We are always looking for ways to enhance our courses and educational materials.

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Announcements

2010 International Reliability Physics Symposium

May 2-6, 2010 • Anaheim, CA

For nearly 50 years, IRPS has been the premiere conference for engineers and scientists to present new and original work in the area of microelectronics reliability. Find out more.

Semiconductor Reliability

[Course Spotlight]

A semiconductor device is only as good as its reliability: the probability that it will perform its function under specified conditions for a set time. Today's ICs possess shorter lifetimes and reduced reliability margins, and rapid developments have led to the use of materials that are not well characterized. While reliability levels are at an all-time high level in the industry, rapid changes may lead to unintentional failures and the inability to predict when devices might fail.

Your company needs competent engineers and scientists to solve reliability problems. Semitracks' 3-day course on Semiconductor Reliability offers detailed instruction on how to determine what failure mechanisms might occur, test for them, develop models for them, and eliminate them from the product.

The course covers four main topics.

1. **Overview of Reliability and Statistics.** Participants learn the fundamentals of statistics, sample sizes, distributions, and their parameters.
2. **Failure Mechanisms.** Participants learn the nature and manifestation of a variety of failure mechanisms that can occur at both the die and package levels. These include time-dependent dielectric breakdown, hot carrier degradation, electromigration, stress-induced voiding, moisture, corrosion, contamination, thermomechanical effects, etc.
3. **Test Structures.** Participants learn how test structures can be designed to test for a particular failure mechanism.
4. **Test Strategies.** Participants learn the basics of testing test structures, conducting design screening tests, and performing burn-in testing effectively.

This course is designed for every manager, engineer, and technician concerned with reliability in the semiconductor field, using semiconductor components, or supplying tools to the industry.

What makes ours different?

Our courses are dynamic. We use a combination of instruction by lecture, problem solving, and question/answer sessions to give you the tools you need to excel in the failure analysis process. From the very first moments of the seminar until the last sentence of the training, the driving instructional factor is application. The course notes offer hundreds of pages of reference material that the participants can apply during their daily activities.

Our instructors are internationally recognized experts. Our instructors have years of current and relevant experience in their fields. They're focused on answering your questions and teaching you what you need to know.

Our analysis instructional videos help you visualize the process. Semiconductor reliability analysis is a visual discipline. The ability to identify nuances and subtleties in images is critical to locating and understanding defects. Many tools output video images that must be interpreted by analysts. Our videos allow you to directly compare material you'll learn with your actual analysis work.

Find out more information by visiting our website, www.semitracks.com. There you can view a course outline, sample slides, and dates of a course near you.