Exploring Image Sensor Applications

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AGENDA

Part 1: Motivation & Basics

- Motivation
- Description of image sensors and their operation.

Part 2: Existing Applications

- Electron Microscopy Detectors
- Radiation Detectors

Part 3: Future Applications Analysis

- Finding new application areas: Technological Competence Leveraging
- Conclusion and Open Discussion

EXPLORING NEW IMAGE SENSOR APPLICATIONS

How do we see the invisible?

Expanding the field-of-use of image sensor applications.

- Presenting the fundamentals of image sensors and some existing applications.
- Exploration of possible future applications.

HOW IMAGE SENSORS WORK

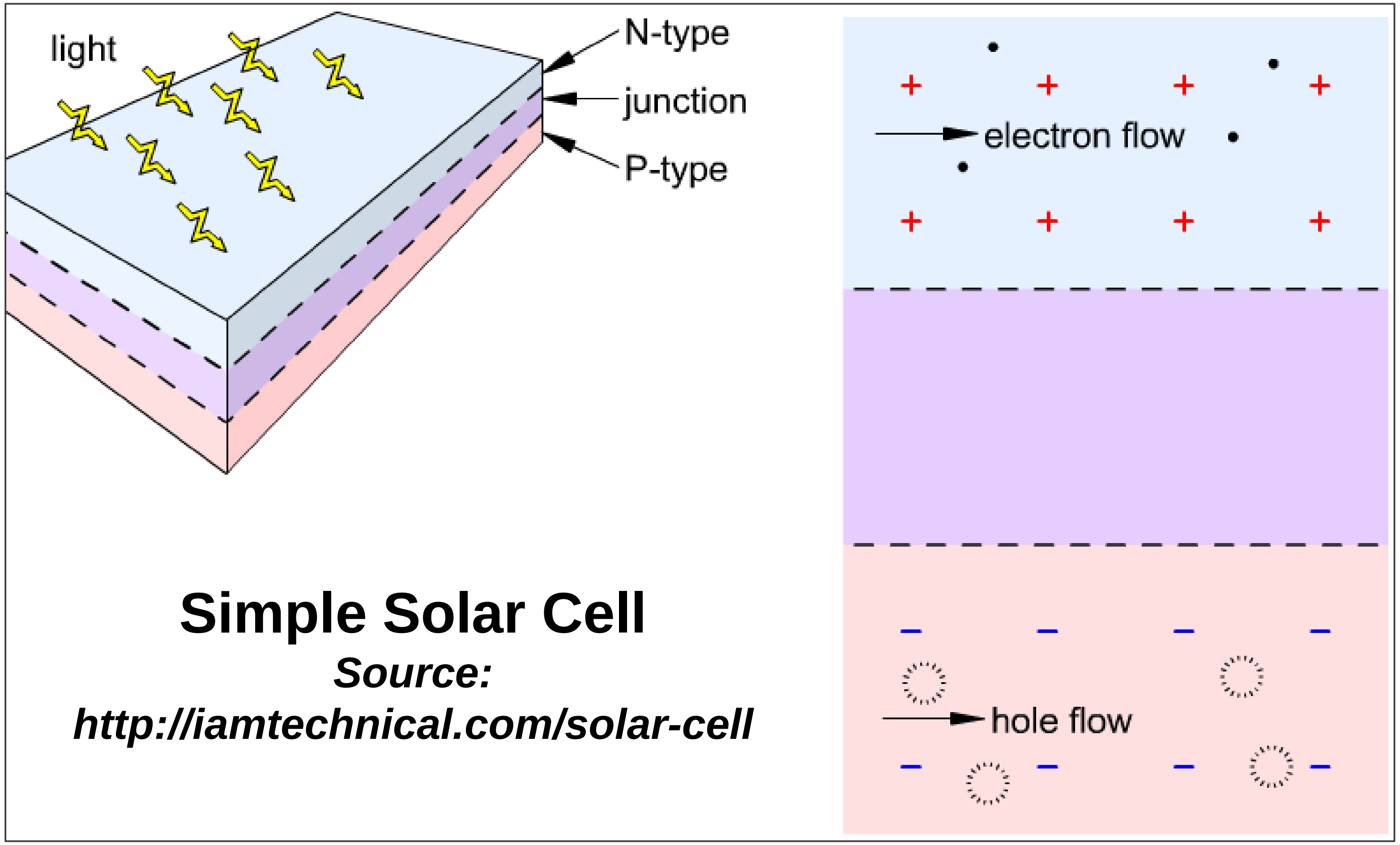
Photodetector basics:

1. Photons can **free electrons**.

1. Electrons (-ve) and holes (+ve) drift in **opposite directions** in presence of electric field.

1. They collect at electrodes to generate a **voltage signal**.

1. Combining pixel signals together provides a 2D image.



Simple Solar Cell

Source: http://iamtechnical.com/solar-cell

TYPES OF IMAGE SENSORS

The most common devices are Charge Coupled Device (CCD) and CMOS:

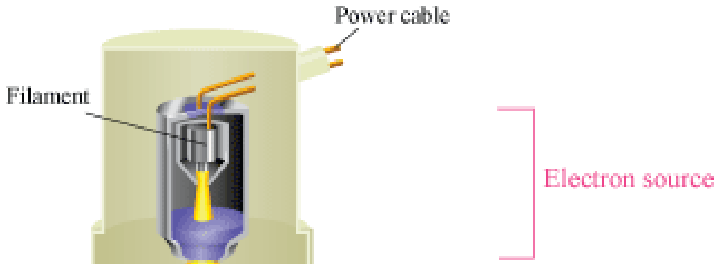
CMOS:

- Faster acquisition.
- Higher sensitivity - better contrast and detectability.

CCD:

- Higher dynamic range.
- Longer exposure required.

ELECTRON MICROSCOPY



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Operation in a glance:

- Electron emitters generate electron beam
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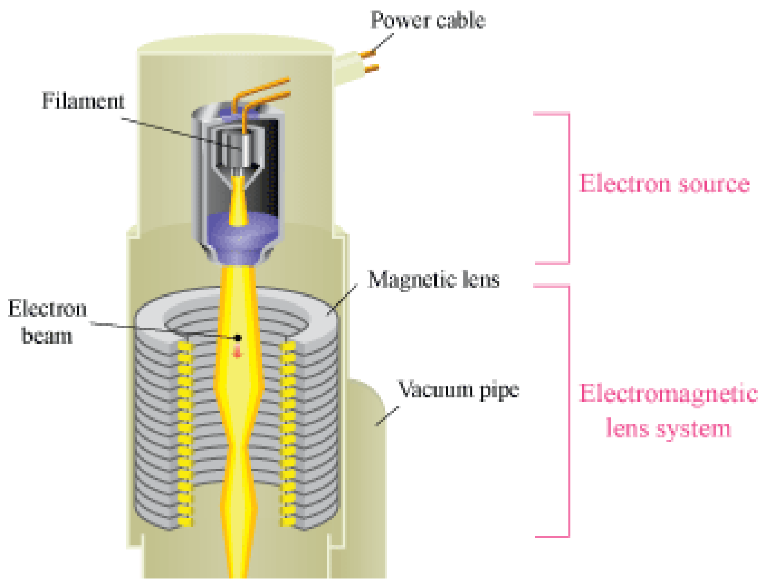

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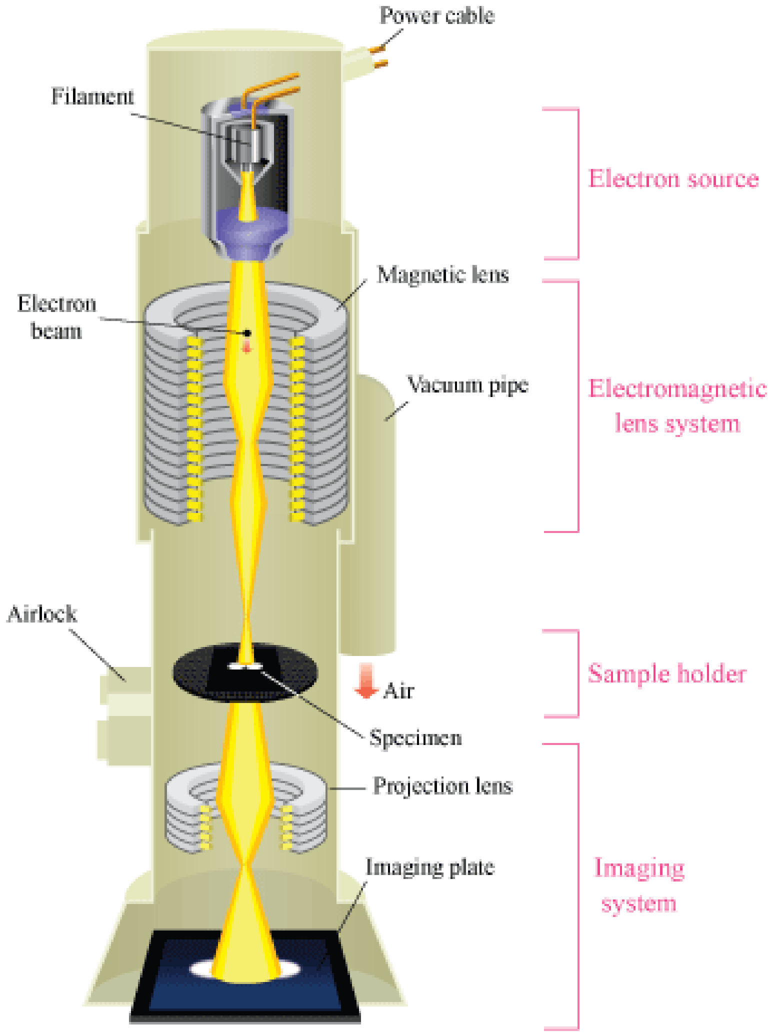
Particle-Sample Interaction: electrons may scatter in different directions

- Scanning EM (SEM) exploits back-scatter
- Transmission EM (TEM) exploits front-scatter

TEMs are currently the leading device for achieved resolution.



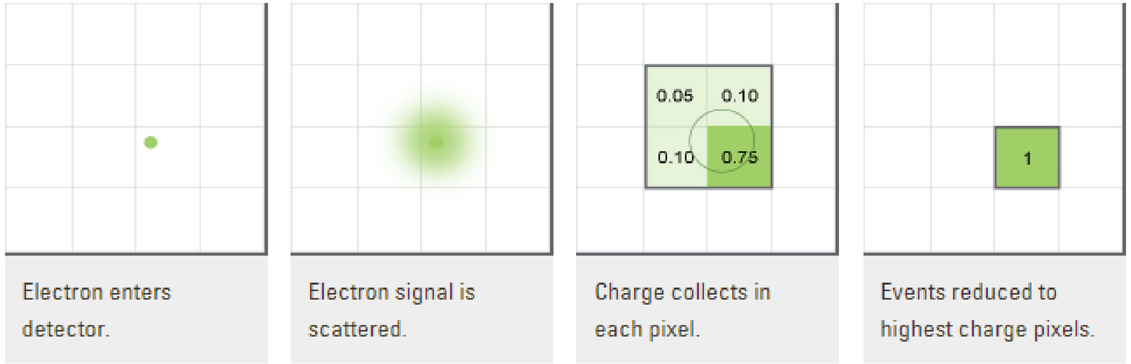
ELECTRON MICROSCOPY FIELDS/TECHNIQUES

TEM Modes: CTEM / STEM / Diffraction

Different application fields: Life Science, Materials Science, Semiconductor Analysis..

Major latest EM outbreaks:

- Electron counting technique enabled last resolution revolution - as opposing to normal charge integration mode.

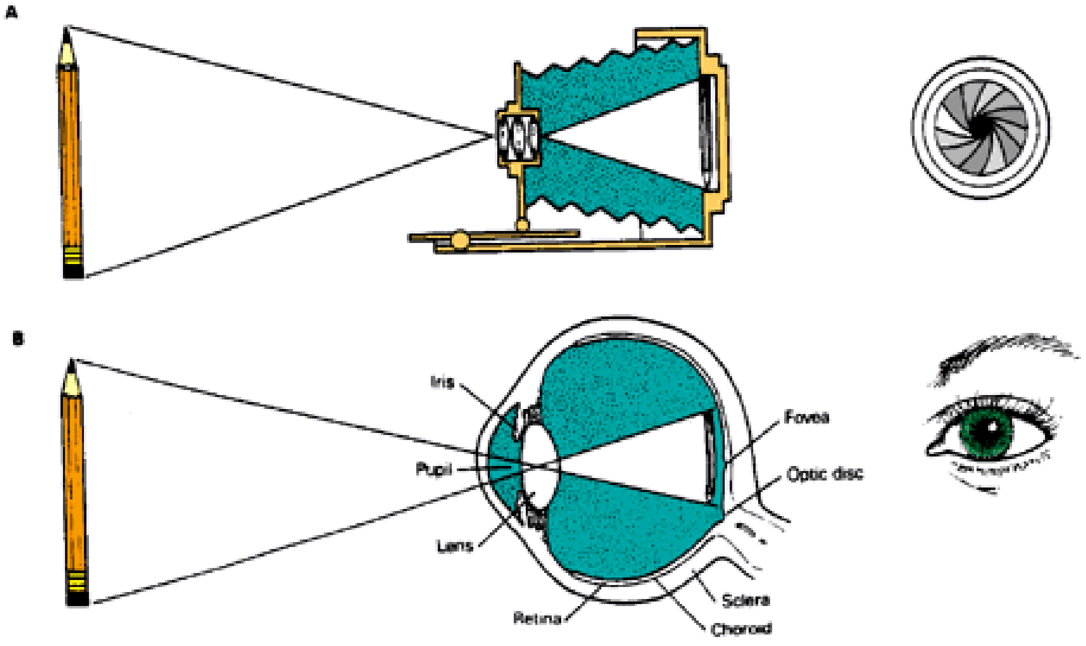


- Cryo-EM used to reduce Biological sample damage - it enabled 2017 chemical Nobel prize winning

DETECTORS FOR ELECTRON MICROSCOPY

Detectors play a major role in this dramatic atomic resolution improvement.

Optical analogy to human eye: detectors are sensitive to particles as human eye is to light, transforming incident particles into electric signals.



Detection history in EM:

1. FILM: no live analysis
2. CCD: low frame-rate
3. CMOS: rolling shutter

Different characteristics needed:

- Diffraction -> high dynamic range
- Life Science -> low noise, high sensitivity
- Material Science -> radiation hardness

ENVIRONMENTAL RADIATION DETECTION

Why?

- Vital for health and safety.

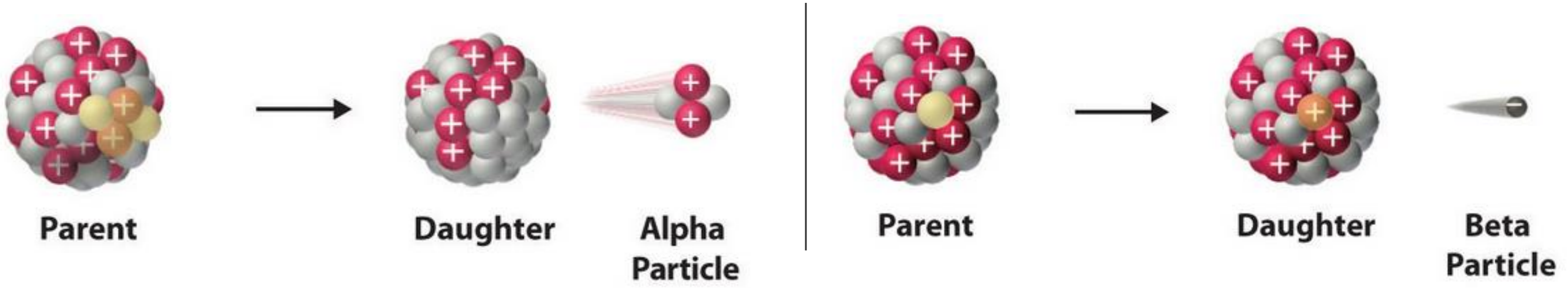
Areas:

- Radioactive pollutants in **water** (drinking water, waste treatment, sea), **underground** (mining, drilling), **agriculture** (soil, across food-chain).

WHAT WE WANT TO DETECT

- Alpha-particles and beta-particles.
- Electromagnetic radiation (gamma rays, x-rays, ultraviolet, near-infrared).

Alpha and Beta Decay
Source: chem.libretexts.org, Introductory Chemistry (Tro).



Electromagnetic Radiation Spectrum

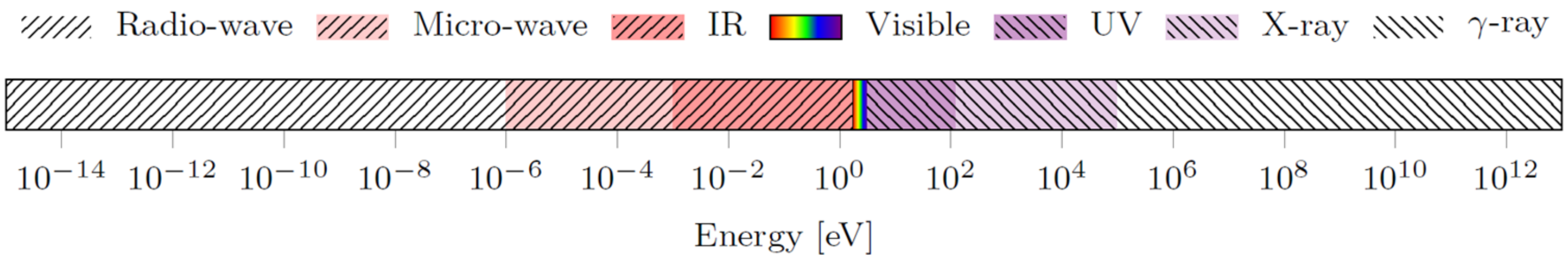


IMAGE SENSORS FOR RADIATION DETECTORS

Geiger-Müller: Gas-filled chamber with electrodes - **no image sensor**.
✗ Can only find count rate.

Scintillator: Plastic/Crystal that absorbs radiation and emits light .
✓ Signal scales with energy of radiation.
✗ Multiple components - photomultiplier tube for detection.

Solid-State (Image Sensor):
✓ Signal also scales with energy.
✓ Higher energy resolution than scintillator.
✓ Fewer components.

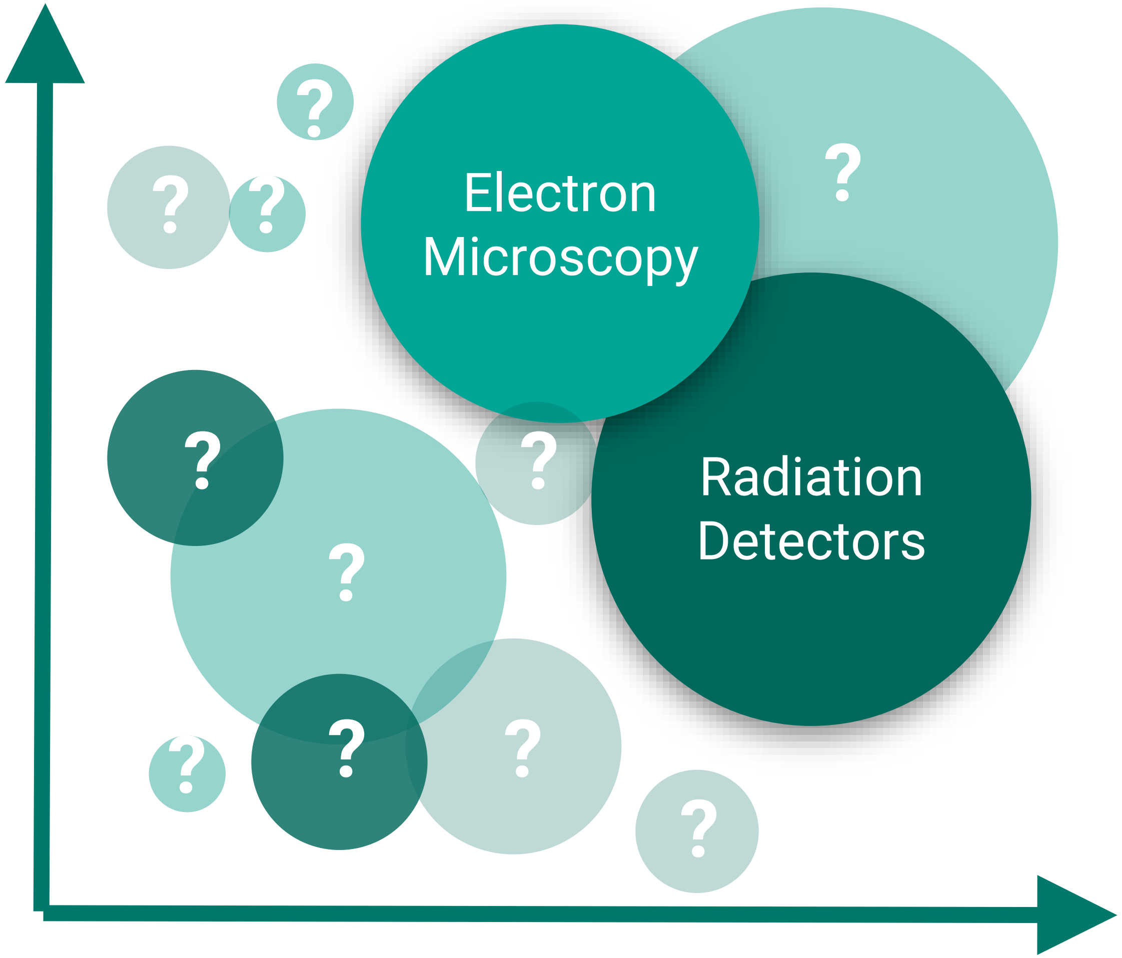
USING CMOS

Many different technologies are already used for image sensors.

Why use CMOS technology?

- Radiation hard, monolithic sensors, smart sensor arrays.
- Mass produced, commercial process - high availability.

ELECTRON MICROSCOPY & RADIATION DETECTORS - WHAT ELSE?



SEARCH FOR NEW APPLICATION FIELDS TO IMAGE SENSORS

1 Identification of technology benefits

Analyzing the technology from the user's perspective with a focus on: **problem solved** and **benefits derived**.

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Rough assessment of the technology according to strategic fit and benefit relevance; further in-depth analysis of **market and competitors**.

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4 Design of a business model

Business model should answer the question: "*how exactly should the company enter the market within a specific application area?*"

SOME USEFUL QUESTIONS TO ASSESS A MARKET ATTRACTIVITY OF AN APPLICATION FIELD

- ? How many benefits offered by the technology are relevant for this application field?
- ? How relevant is/will be the problem solved by the technology in this application area?
- ? Can this new market be served with existing resources of the company?
- ? Is it possible and reasonable to enter the market in the near future?
- ? Is it strategic important for the company to enter this market?
- ? Is the business model scalable?
- ? How the company will differ from the competitors (unique value proposition)?

CONCLUSION:

- Image sensors are in rapid expansion, especially CMOS devices.
- They play a fundamental role in many modern applications.

CAN WE EXPLOIT THEM EVEN MORE?

Time for questions and open discussion.