Al-Mustaqbal University
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Medical Techniques
Radiological Techniques
Department

Eighth Lecture 14/11/2023

Radiation Protection Course

Lecturer

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Chapter Seven
Radiation Detection and Measurement
Scintillation and Semiconductor detector

Scintillation detectors

1. **Organic Scintillators**
2. **Inorganic Scintillators**
3. **Semiconductor Detectors**
4. **Instrument Calibration**
5.

Introduction: A scintillation counter is a scientific instrument designed to detect and measure ionizing radiation. It is widely used in fields such as nuclear physics, medicine, environmental monitoring, and homeland security. The basic principle behind a scintillation counter involves the detection of scintillation, which is the flash of light produced when ionizing radiation interacts with certain materials called scintillators.

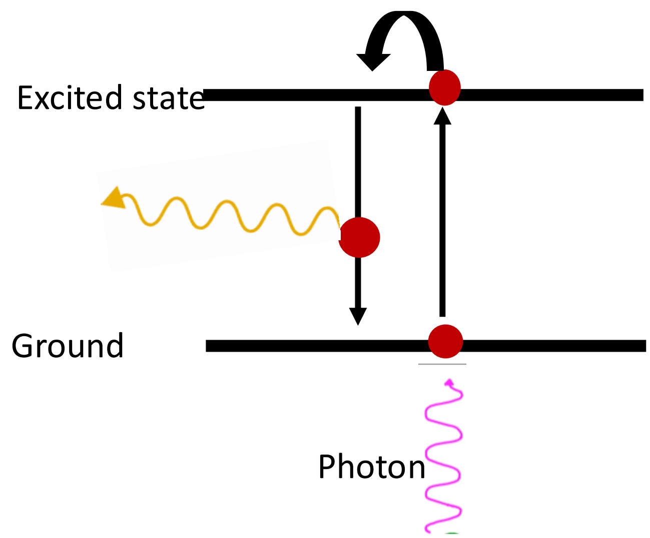
Organic Scintillators:

An organic scintillation counter is a type of radiation detector that uses organic materials as scintillators to detect ionizing radiation. Scintillators are substances that emit light when they interact with ionizing radiation, such as alpha, beta, or gamma particles.

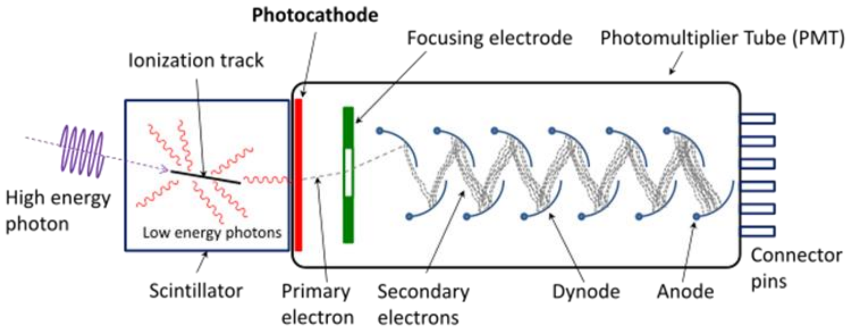
Organic scintillation counters are widely used in various fields, including nuclear physics, medical imaging, and environmental monitoring. Here is a detailed overview of the components and working principles of an organic scintillation counter:

Working of Organic Scintillation Detectors:

1. **Scintillator Material**: In organic scintillation counters, the scintillator material is typically an organic compound containing carbon, hydrogen, and sometimes nitrogen. Organic scintillators can be liquid or solid.
2. **Interaction with Radiation**: When ionizing radiation, such as gamma rays or alpha/beta particles, interacts with the scintillating material (commonly a crystal or organic compound), it transfers energy to the atoms in the material.
3. **Creation of Excited States**: The energy transferred to the atoms excites them to a higher energy state. This excited state is not stable, and the atoms tend to return to their ground state.
4. **Emission of Photons**: As the excited atoms return to the ground state, they release the excess energy in the form of photons (light) in the visible or ultraviolet range. This emitted light is characteristic of the scintillating material.
5. **Light Collection**: The emitted photons travel through the scintillating material and are collected by a photomultiplier tube (PMT) or another light-sensitive detector. The PMT is often used because of its high sensitivity to low levels of light.
6. **Conversion to Electrical Signal**: The collected light strikes the photocathode of the PMT, causing the emission of electrons through the photoelectric effect. These electrons are then accelerated and multiplied through a series of dynodes in the PMT, resulting in a significant amplification of the signal.



7. **Output Signal**: The final output is an electrical signal that corresponds to the intensity of the original ionizing radiation. This signal can be further processed and analyzed to determine the energy and type of radiation that interacted with the scintillating material.



Inorganic Scintillation Counter:

Working: the same principle as organic scintillation counter

Organic Scintillation Vs. Inorganic Scintillation Detectors

Feature	Organic Scintillation	Inorganic scintillation
Scintillating Material	Organic compounds, hydrocarbons (Carbon, hydrogen)	Inorganic crystals or compounds (e.g., NaI(Tl), CsI(Tl),
Energy Resolution	Generally lower energy resolution	Higher energy resolution
Hygroscopicity (التاثر بالرطوبة)	less sensitive to moisture	need protection from moisture
Cost	less expensive compared to inorganic scintillators	Generally more expensive
Applications	Nuclear Medicine(PET scan), environmental monitoring, routine laboratory measurements	spectroscopy, nuclear physics research, Nuclear medicine كاميرات جاما للتصوير الطبي لرؤية الهياكل والأعضاء الداخلية من خلال الكشف عن أشعة جاما المنبعثة من المستحضرات الصيدلانية الإشعاعية

Applications of scintillation counter:

Scintillation counters are widely used in medicine for various applications due to their ability to detect and measure ionizing radiation. Here are some key applications of scintillation counters in the field of medicine:

Radioimmunoassay (RIA):

تلعب عدادات التلألؤ دورًا حاسمًا في تقنيةRIA وهي تقنية تستخدم لقياس تركيزات المواد المختلفة في العينات البيولوجية. في هذه الطريقة، يتم استخدام مادة مشعة كمتتبع، ويتم الكشف عن الإشعاع المنبعث بواسطة عداد وميض. وهذا يسمح بتقدير كمي حساس للغاية ومحدد للمواد مثل الهرمونات والأدوية والبروتينات الموجودة في السوائل البيولوجية.

Positron Emission Tomography (PET):

التصوير المقطعي بالإصدار البوزيتروني :هي تقنية تصوير طبي تستخدم أجهزة التتبع الإشعاعية التي ينبعث منها البوزيترون لتصور وقياس العمليات الفسيولوجية في الجسم. غالبًا ما تُستخدم بلورات التلألؤ جنبًا إلى جنب مع أنابيب المضاعف الضوئي للكشف عن أشعة جاما المنبعثة أثناء إبادة البوزيترونات في عمليات مسح .PET يتيح ذلك إنشاء صور مفصلة ثلاثية الأبعاد للعمليات الأيضية والكيميائية الحيوية داخل الأنسجة.

Semiconductor Detectors:

Semiconductor detectors are devices used to detect and measure ionizing radiation, such as alpha and beta particles, gamma rays, and X-rays. They are based on the principle that when ionizing radiation interacts with a semiconductor material such as (Ge) or (Si), and it creates electron-hole pairs, leading to a measurable electrical signal.

Working:

Ionization Process: Incident radiation, such as X-rays or gamma rays, interacts with the semiconductor material. The energy from the radiation is transferred to electrons in the atoms of the semiconductor, causing them to move to higher energy levels or be completely ejected from the atoms.

Generation of Electron-Hole Pairs:

The ionization process creates electron-hole pairs. Electrons are freed from their atomic orbits, leaving behind positively charged holes.

Drift of Charge Carriers:

An electric field is applied across the semiconductor material, typically using electrodes. The electron-hole pairs created by the radiation move in response to this electric field.

Collection of Charge:

The electrons and holes drift towards the positively and negatively biased electrodes, respectively. As they move, they generate an electrical signal that can be measured.

Application of semiconductor detector in medicine:

Positron Emission Tomography (PET)

Single Photon Emission Computed Tomography (SPECT)

X-ray Imaging Radiation

Therapy Dosimetry: Semiconductor detectors are utilized in radiation therapy for dosimetry, which involves measuring and monitoring the radiation dose delivered to a patient during cancer treatment.

Gamma Camera Imaging

Instrument Calibration

Instrument calibration is the process of adjusting and verifying the accuracy and precision of a measuring instrument or device. This ensures that the instrument provides reliable and accurate measurements over time. Calibration involves comparing the output of the instrument to a known standard or reference to identify and correct any deviations.

The goal of calibration is to minimize or eliminate any systematic errors or inaccuracies in the instrument's readings. Calibration is essential in various fields and industries where accurate measurements are critical, such as manufacturing, healthcare, scientific research, and environmental monitoring.