Electrochemical growth of copper-halide scintillators

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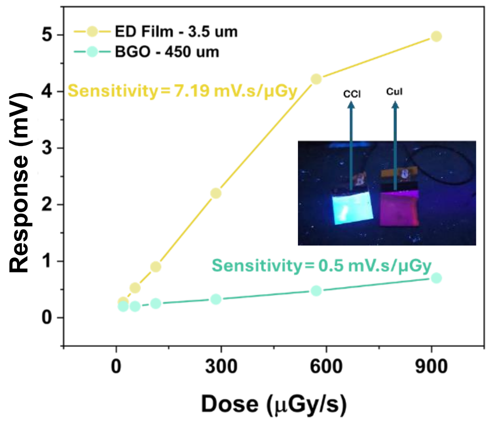
Scintillators are widely used radiation detectors because they can be fabricated over large areas with thicknesses sufficient to efficiently attenuate high-energy X-rays. Conventional fabrication relies on high-temperature single-crystal growth or solution-processed composite films in polymer matrices, which can reduce optical coupling, effective attenuation, and increase light scattering. Direct growth of scintillator films on substrates enables dense, binder-free layers composed of the active material, but currently they rely on techniques such as chemical vapor deposition and physical vapor deposition, which often require high vacuum and temperatures, together with complex instrumentation, limiting scalability and increasing cost [1].



Response calibration curve for a scintillator film coupled with a photodiode circuit. In the inset, a picture of the copper iodide (CuI) film before conversion to $Cs_3Cu_2I_5$ (CCI).

Electrochemical deposition offers a low-cost, scalable, and solution-based alternative with precise control over film thickness and morphology via simple tuning of deposition parameters. Here, we introduce a novel two-step electrochemical synthesis of copper-halide scintillator films with high effective atomic number, high density, and large photoluminescence quantum yields [2].

The resulting films exhibit photoluminescence quantum yields of up to ~87% for $Cs_3Cu_2I_5$-rich films (CCI) and ~33% for $CsCu_2I_3$-rich films. Time-resolved photoluminescence at ~450 nm shows a dominant sub-nanosecond decay component, enabling operation under high-repetition-rate X-ray pulsed excitation up to ~200 MHz. A thick mixed-phase film demonstrated a calculated light yield of ~3.0×10^4 photons/MeV, surpassing a thicker bismuth germanate (BGO) reference in dose-rate sensitivity tests under identical conditions. Due to its low-temperature, substrate-compatible nature, this electrochemical approach provides a cost-effective and scalable route to large-area scintillation screens, integrated radiation imaging layers, fast-timing scintillators, flexible detector geometries, and optoelectronic devices such as UV photodetectors and white-light down-conversion layers.

1. Oke et. al., "Atomic layer deposition and other thin film deposition techniques: from principles to film properties," *Journal of Materials Research and Technology*, **21**, 2481-2514 (2022).

2. Yang et. al., "Large-Area Perovskite-Related Copper Halide Film for High-Resolution Flexible X-ray Imaging Scintillation Screens" *ACS Energy Letters*, **7(2)**, 844-846 (2022).