Enabling Low-Cost Radiation Detectors Through Organic Electronic Device Design, Fabrication, and Integration

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Abstract:

The first part of our presentation focuses on device innovations performed by our group at Georgia Tech. Our group has developed stretchable organic photodiodes with performance adequate for low-light level detection. The stretchability matches the mechanical properties of human skin, appropriate for wearable electronics and detectors with deformable form factors. The devices show low electronic noise currents in the range of tens of femtoamperes, noise equivalent power (NEP) in tens of picowatts at 60% strain, response time of 142 µs, and a high strain at break of 189% [1]. This was achieved using a blend of an elastomeric material SEBS, with P3HT and ICBA donor/acceptor materials. We also show progress in 3D-printable plastic scintillators utilizing Bi-containing compounds and organic dyes exhibiting delayed fluorescence for enhanced capture cross-section and light yield.

The second part of our presentation discusses our collaborative work with the Electronic Detector Group at Brookhaven National Laboratory. Our collaboration has entered the prototype phase to study large volume kton water-based liquid scintillators (WbLS), useful for high-energy particle physics experiments, and potentially remote-monitoring and sensing of nuclear fuel cycles for nonproliferation. There is an operational 1-ton prototype detector, consisting of a tank capable of testing variants of WbLS. Work is ongoing in DAQ system, data analysis, and simulations, with a focus on separating Cherenkov and scintillation light from charged particles and high energy gamma rays. Future work will focus on quantifying probability of detection, and spectral discrimination of gamma rays and neutrons by incorporation of low-cost metal photocathodes, organic electronic surface modifiers, and optical filters.