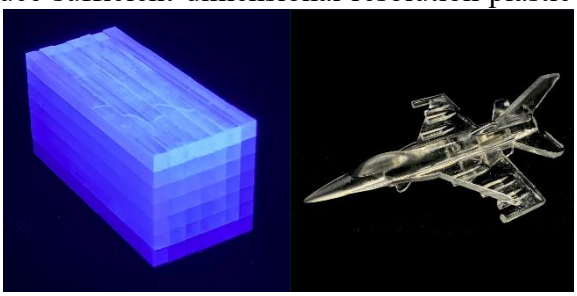
Rapid Photocured Plastic Scintillators for Radiation Detection and Additive Manufacturing Applications

Chandler Moore[1], Juan Manfredi[1], Michael Febbraro[1,2], Daniel Rutstrom[1], Andrew Decker[1,3], Ryan Kemnitz[1], Thomas Ruland[2], Brennan Hackett[2], Paul Hausladen[2]

[1]*Air Force Institute of Technology, Wright-Patterson AFB, 45433, OH, U.S.A.*
[2]*Oak Ridge National Laboratory, Oak Ridge, 37830, TN, U.S.A.*
[3]*Defense Threat Reduction Agency Nuclear Science and Engineering Research Center, West Point, 10996, NY, U.S.A.*
Corresponding Author Email: Chandler.Moore.3@us.af.mil

Fast neutron imaging offers an attractive alternative to thermal neutron imaging due to the portable nature of DD and DT neutron generators and the ability to penetrate materials that thermal neutrons are unable to. The current technology for fast neutron detection for imaging is limited in achieving high spatial resolution, strong neutron discrimination, and practical ability to make complex geometry. Traditional fast neutron detector fabrication methods require days to weeks of thermal polymerization and significant additional labor to produce sufficient dimensional resolution plastic scintillator arrays. The present work helps to reduce this limitation by developing additive manufacturing techniques to faster construct detectors with similar performance in dual particle applications.



Complete and polished 7x7 2D pixel array illuminated by 405 nm light and measured at 21 x 21 x 50 mm with pixels 3 x 3 mm (left) and F-16 complex geometry printed with novel formula scintillator resin (right).

In this work custom designed rapid light-curing resins and scintillation filaments produced with commercial manufacturing machinery have shown feature resolution at or below the mm scale while maintaining a geometric production speed on par with standard additive manufacturing techniques and light output comparable to industry standard scintillators. The developed automated assembly machine designed around a set of programmable robot arms is shown to be capable of dual alternating layering of individual light-cured resin layers and optical segmentation with a self-bonded enhanced specular reflector. This allows the production of high precision two-dimensional scintillator arrays in short fabrication times.

Results include design of the additive manufacturing setup, prototype automated assembly, and characterization of the produced geometry. Analysis will be included on the rapid-curing resin formulation and its component absorption/emission spectra, repeatability of the finalized array and geometry procedure, and scintillation response to incident neutron and gamma radiation. A preliminary study of produced two-dimensional scintillator arrays for shadow mask imaging utilizing a DT neutron generator will also be included.