

# NANOPARTICLE SCINTILLATORS FOR GAMMA, X-RAY, AND NEUTRON DETECTION

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**Background:** We are developing a nanoparticle scintillation detector platform that is sensitive to gamma, X-ray, and neutron radiation. This is patterned on a glass substrate containing charge conversion nanoparticles doped into a fast electron scintillating resin. Doping the resin with tailored nanoparticles allows for the discrimination between gamma and neutron radiation since the nanoparticles convert the radiation into fast electrons (beta radiation). These fast electrons scintillate the resin creating different intensities of optical pulses depending on the species of radiation. The created light pulse exits the resin since the nanoparticles are appreciable smaller than the scattering threshold of light. The optical pulse is then measured with an off the shelf Photo-Multiplier (PM) tube.

**Homeland Security:** Nuclear weapons emit gamma and neutron radiation which are difficult to shield so the ability to detect these types of radiation is crucial for homeland security applications. Geiger counters are typically the choice of field detectors, but these devices are large, usually shoe box sized. Although the construction of a workable prototype of a MicroGeiger has been reported, a flaw in this device is that it only detects easily shielded beta radiation [1]. A popular material used in radiation detection is scintillators which convert radiation to optical pulses; however, these scintillators do not measure neutrons and are limited in gamma detection [2]. By doping a beta scintillating resin with charge conversion nanoparticles, these scintillators are able to detect more species of radiation.

**Detectors:** The types of nanoparticles used for the detection of gamma and neutron radiation are  $Pb_3O_4$  and  $Gd_2O_3$  respectively. Mixing the  $Pb_3O_4$  particles into the scintillating resin converts the gamma radiation into several fast electrons by photoelectron conversion (Fig. 1a). The fast electrons scintillate the resin creating a characteristic optical pulse which exits the detector since the nanoparticles are smaller than the wavelength of light (Fig. 1b). For the neutron detector,  $Gd_2O_3$  particles are mixed into the scintillating resin. The neutrons are converted to a fast electron through an on-chip fusion reaction creating a light pulse measured by a PM tube and displayed on an oscilloscope (Fig. 2). A representative micromachined scintillator made with  $Gd_2O_3$  is shown in Fig. 3.

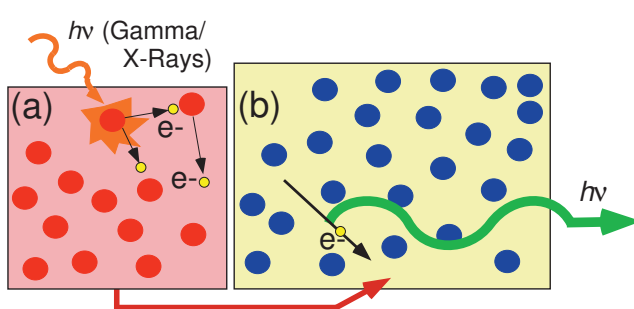


Fig. 1: Lead oxide nanoparticles convert impinging gammas/X-rays into photoelectrons (a-left). These fast electrons travel through the transparent doped beta scintillating resin. The resin converts the electrons into characteristic light pulses that leaves the detector since the scattering threshold of light is larger than the diameter of the nanoparticles (b-right).

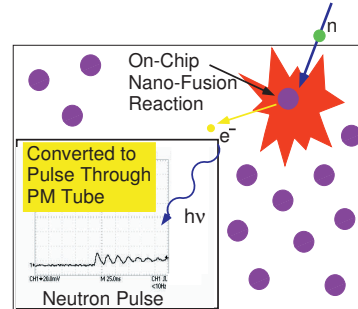


Fig. 2:  $Gd_2O_3$  nanoparticles offer outstanding neutron-to-electron conversion, with a cross-section of 255,000 barns at thermal energies. Imbedded into the scintillator, they allow neutron detection when used with a photo multiplier tube.

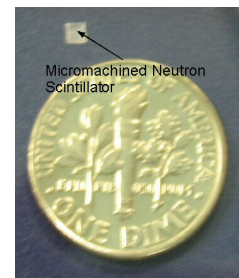


Fig. 3: The doped polymer resin with  $Gd_2O_3$  can be spun into thin films or microcasted into small dies. Thin films can either be  $O_2$  etched or micromachined into sub-mm dimensions.

**References:** [1] C. Wilson, C. Eun, Y. Gianchandani, "D-MicroGeiger: A Microfabricated Beta-Particle Detector with Dual Cavities for Energy Spectroscopy", *IEEE MEMS 2005*, Jan. 2005, pp. 622-625 [2] G.F. Knoll, *Radiation Detection and Measurement*, J. Wiley, 2000

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