Direct Spectra Detection of Fast Neutrons by Wide-bandgap Organic Single Crystalline Semiconductors

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Compact fast neutron detectors are significant for high-resolution neutron imaging and beam flux monitoring, which cannot be achieved directly by inorganic semiconductors. The direct detection method for fast neutrons is demonstrated based on very few organic semiconductor detectors, however, neither the high detection efficiency nor the energy discrimination ability has not been achieved [1, 2]. A current challenge is the lack of suitable organic single crystalline semiconductors (OSCS) with desired dimension and properties [3, 4].

Here, centimeter sized Methyl 4-hydroxybenzoate ($C_8H_8O_3$, 4MHB) OSCS with the wide bandgap of 4.10 eV are obtained by a solvent evaporation method. The detector based on as-grown high-quality 4MHB OSCS has a high hydrogen density of 4.20×10^{22} n·cm^{-3}, a high bulk resistivity of $(6.95\pm0.17)\times10^{12}$ Ω·cm, and excellent charge mobility of 15.62 ± 0.31 cm^2·s^{-1}·V^{-1}. Thanks to the excellent hydrogen density and charge carrier transport, the 4MHB detector firstly achieves direct spectra detection for ^{241}Am-Be neutron source with detection efficiency of 78.50 % cm^{-3}, detection time down to 0.50 μs, and the energy discrimination for incident neutrons. In addition, the 4MHB detector possesses good charge carrier transport even after irradiated by 10^{13} n·cm^{-2} neutron (energy: 1 MeV), benefiting from the three-dimensional π-π bonds in 4MHB OSCS that are less damaged by incident neutrons.

This work [5] demonstrates that wide-bandgap 4MHB OSCS show great potential as direct fast neutron detectors, having highly-localized and tissue-equivalent properties that benefit neutron imaging and cancer therapy applications.

References

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