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Semiconductor neutron detectors

Solid-state neutron detectors have many applications in different fields, such as security, medical imaging, cultural heritage, forensics, and high energy and nuclear physics. The shortage and the consequent increasing cost of 3He gas, on which most neutron detector systems were based for decades, has played an important role in boosting the development of silicon based devices featuring high aspect-ratio cavities filled with neutron converter materials (typically based on 10B or 6Li). In order to achieve good performance, both in term of neutron detection efficiency and suppression of gamma-ray sensitivity, the key aspects are the optimization of the size of the cavities and of the gap regions in between them. Moreover, the deposition techniques of converter materials should be optimized to ensure conformal filling of small cavities and good stability. Very good results have so far been obtained by different research groups in Europe (e.g., Delft University, University of Prague, CNM Barcelona) but most of all in the USA (e.g., University of Kansas, Lawrence Livermore National Laboratory, Rensselaer Polytechnic Institute), with efficiency values up to ˜50% using only a single detector layer. The state of the art in semiconductor neutron detectors will be reviewed, with emphasis on silicon based devices. Moreover, the R&D activity carried out in the framework of the INFN HYDE (HYbrid DEtector for neutrons) Project will be reported, covering design and technological aspects, simulations, and selected experimental results. In particular, a new sensor structure, aimed at high detection efficiency while minimizing the process complexity will be introduced.

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