quantum states have been presented in Refs. [1, 2, 3]. We have proposed a more precise measurement using a pixel detector with an image magnification system [4]. Another pixel detectors for UCN have been developed recently, such as that reported in Ref. [5]. In this article we present the development of a pixel detector based on a commercial charge coupled device (CCD) covered with a neutron converter. By comparing ^{10}B and ^{6}Li as converter materials, we find that a ^{6}Li converter produces energetic tritons which penetrate deep into the CCD in various directions, degrading the spatial resolution. Hence we conclude that ^{10}B is an appropriate material for a neutron converter.

2. Detector design

The developed detector consists essentially of a CCD covered by a neutron converter. Charged particles produced via nuclear reaction in the converter are detected with the CCD. The choices of converter material and CCD are key for this detector.

2.1. Neutron converter

^{10}B and ^{6}Li are chosen as test materials for the neutron converter, because of their large cross-sections with neutrons. The neutron absorption cross-sections for ^{10}B and ^{6}Li are 4.01×10^3 and 0.95×10^3 barn, respectively, for thermal neutrons (v = 2,224 m/s).

Neutrons react with ^{10}B and ^{6}Li in the following processes:

$$\begin{aligned} \mathrm{n} + {}^{10}\mathrm{B} &\rightarrow \alpha\ (1.47\ \mathrm{MeV}) + {}^{7}\mathrm{Li}\ (0.84\ \mathrm{MeV}) + \gamma\ (0.48\ \mathrm{MeV}) \quad 93.9\% \quad (1) \\ &\rightarrow \alpha\ (1.78\ \mathrm{MeV}) + {}^{7}\mathrm{Li}\ (1.01\ \mathrm{MeV}) \quad 6.1\% \\ \mathrm{n} + {}^{6}\mathrm{Li} &\rightarrow \alpha\ (2.05\ \mathrm{MeV}) + {}^{3}\mathrm{H}\ (2.73\ \mathrm{MeV}) \quad 100\% \quad (2) \end{aligned}$$