Diamond detector

Diamond is an insulating material with a very large band gap, 5.5 eV. It can be operated like other semiconductors of the IV group, such as Si and Ge, by applying electrical contacts to opposite faces of the crystal.
Diamond detectors can be used in extreme conditions where other detectors cannot: they can be operated at high temperatures (250-300 °C) and in environment where the radiation level is very high (for example the CMS experiment at LHC).
Crossing the diamond, a charged particle or photon with energy above the band gap produces electron/hole pairs ($E_{e\text{-}h}$=13 eV) which are separated by the electric field between the electrodes and then collected (Figure 1).
With the CVD technique, diamond detectors can be produced with good energy resolution (<1%) and 100% charge collection efficiency.

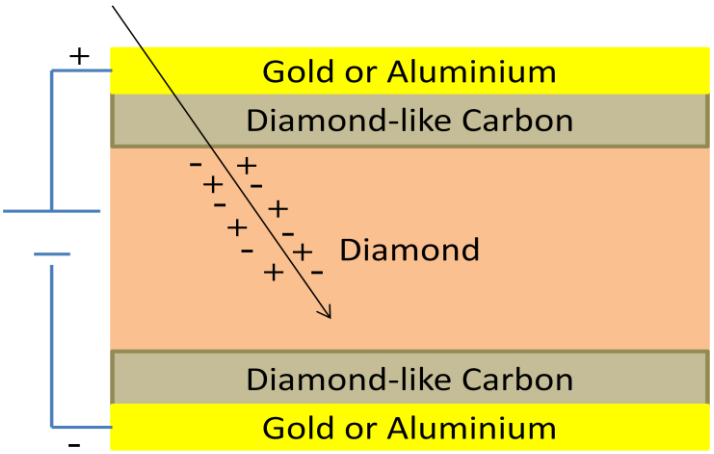

Figure 1 Diamond detector.

Neutron detection using diamonds is based on the collection of the electrons/ holes pairs produced by charged particles generated by neutron reactions with carbon. The most important reactions producing charge particles are:

- the elastic channel, in which a neutron hits a carbon atom. The carbon atom recoils with an energy equal to $E^{max}_{R} = 0.28\ (\cos^2\theta)E_n$, where θ is the recoiling angle and A=12.
- the $^{12}C(n, \alpha)^{9}Be$ reaction (*n- alpha reaction*), in which a neutron breaks the carbon nucleus into an alpha particle and a ^{9}Be atom. The energy threshold for this reaction is 6.17 MeV, the Q-value being negative and equal to -5.7 MeV.
- the $^{12}C(n,n')3\alpha$ reaction (*n- 3alpha reaction)* in which the carbon nuclei break up into three alpha particles. The energy threshold for this reaction is 7.9 MeV, the Q-value is -7.3 MeV.

The elastic cross section is the most important in the neutron energy range 1-6 MeV, where the *n-alpha* and *n- 3alpha* reactions cannot take place. These channels are the most efficient in the neutron energy range above 10 MeV because the energy released in diamond is higher than the energy released by carbon elastic recoil.

Experiment description

The experiment consists in the measurement of the pulse height spectrum of an alpha source coupled to a diamond detector.

Figure 2: Picture of the diamond detector to be used in the measurement.

The aim is to measure the alpha spectrum at different bias voltage values. The position of the peak, its full width half maximum (FWHM) and its area have to be calculated. The measurements have to be performed using a bias voltage from 50 V up to 450 V (every 50 V, 9 points). 5 minutes per point (estimated time 1hour).

The second (optional) part of the experiment consists in the measurement of the ^{241}Am peak position and FWHM moving the alpha source away from the detector. 5 points have to be taken (4 mm from the detector up to 20 mm). The bias voltage to be used is 400 V.

The electronic chain consists in:

- Diamond detector + alpha source (^{214}Am, Ea = 5.48 MeV);
- Preamplifier 142 A;
- Amplifier;
- ADC;
- Maestro acquisition system.