The thesis deals with a novel approach of developing an indigenous printed circuit board (PCB) technology based on nanodosimeter that consists of a three-dimensional (3D) positive-ion detector. It works under the principle of ion-induced impact ionization. The signal collected from the nanodosimeter was confirmed satisfactorily. During the process of improving the performance of the detector, it was confirmed that the cathode of the detector and the thickness of the detector played a major role in enhancing the efficiency of the detector. When the insulating property of the material used in the cathode is increased, the amplitude and efficiency of the detector get enhanced. When the conductivity of the cathode is increased, the performance of the detector is improved due to enhancement in the number of positive ions that are focused into the detector cells. As the thickness of the detector is increased, the detector efficiency is also increased due to the enhancement in ion-induced ionization inside the detector cells. Likewise, the upgraded 3D positive-ion detector of thickness 3.483 mm using gold as strip material, tungsten (87%)-coated copper (13%) as the core wire, and gold-coated ceramic as cathode using a Co-60 source showed a maximum efficiency of 12.3% under propane medium. Further, it is reported that the efficiency of the present detector is approximately four times higher than the reported one under nitrogen medium using an Am-241 source.

Further, the scope of the 3D positive-ion detector to be used in the field of (i) radiation protection, (ii) gamma-spectrometry, (iii) as gas sensor, and (iv) oncology was confirmed as given below.

- In the field of radiation protection, the detector can be used to detect alpha-, beta-, and gamma-radiation as well as to measure the radiation dose and hence may help to predict radiation-induced cancer risk since the response of the detector is varied depending on the type of incident radiation.
- For gamma-spectrometry, the fabricated detector can be used to detect various gamma-emitting sources since the detector output is increased quantitatively when the energy of incident gamma-radiation is increased.

In oncology, the present 3D positive-ion detector can be used to detect breast and lung malignancy at an early stage and also to distinguish them. This was possible because of variation in the output pulse of the 3D positive-ion detector in terms of the pulse amplitude, rise time, fall time, frequency, full width half maximum, ionization cluster size, and ion drift time caused by the variable emission of volatile organic compounds from the normal and malignant breast and lung tissue of all stages obtained from the biopsy samples. Based on these, the indigenously fabricated PCB technology-based 3D positive-ion detector would be established as an electronic nose (E-nose) to detect and diagnose lung, breast, and colorectal malignancies of all stages from exhaled breath samples.

This detector technology may be extended toward radiation dosimetry either to replace the conventional dosimetric quantity like absorbed dose by nanodosimetric quantity like ionization cluster size distribution or to include an additional quantity to quantify radiation at DNA level. It can also be extended toward radiation biology to predict different types of DNA damages induced by all ionizing radiations such as photons, neutrons, and charged particles and hence to optimize the biological treatment plans in radiation therapy.

The thesis makes a significant contribution in the field of radiation protection for the estimation of early cancer risk, in gamma-spectroscopy to discriminate various gamma-emitting sources, in the study of the response of the detector in gas medium, and in establishing such detector as E-nose to detect and diagnose certain malignancies.

This research work may establish this detector as a good tool in the field of cancer management.
