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New Generation of UV, IR and γ - ray sensors with Carbon NanoTubes (CNT)

Many types of Ultra Violet (UV) and Infrared Radiation (IR) detectors are used up to now, based on a variety of materials depending on the wavelength being detected. UV spectrum is of particular interest not only in particle physics where scintillators emit in this region but also in other fields like agriculture where the maturity of a fruit can be detected in UV("so called bee eye"). Concerning Chemical, Biomedical applications the use of Medium Wavelength Infrared (MWIR) spectrum in the range 3-5 μm is significant for gas identification and skin tumor identification but these cameras require cooling for good resolution. On the other hand γ-ray detectors are gas filled or solid state sensors like scintillators, silicon based strip or pixel detectors or even CdTe and Diamond sensors.

The main idea of this proposal is to build low cost and low operating voltage UV, IR and γ- ray sensors based on arrays of well-aligned Carbon Nano Tubes (CNT) in the form of Single Wall CNT (SWNT) or Multi Wall CNT (MWNT).
For the UV, IR sensor the plan is to develop a CNT layer on a Silicon substrate and to use the hetero-junction created when CNT are grown on Si as a
photo-detecting sensor. The Silicon substrate will be already preprocessed with lithographic techniques to build pixels. The periphery of each pixel will be used as electrodes to bias the pixel and get the signal out.
The advantages are: i) they can operate at Room Temperature in a wide range of UV spectrum (200nm -400nm) and IR spectrum (from 0.8 μm to almost 5μm), because the layer of MWNT's covers a wide range of diameters ii) there is no need for HV power supply since a low voltage of the order of 20V between the electrodes of the CNT pixel is enough to operate iii) matrix arrays of CNTs can be easily grafted on a surface in a variety of scales (from mm down to nm) by lithographically patterning a precursor and v) they are very cheap in production. A CNT layer width of a few tenths of microns is good enough for a UV or IR detector.
On the other hand in the case of a γ-ray detector with radiation source localization capabilities (i.e. Compton Camera) the width of the CNT layer required should be much bigger. This is because the main absorption mechanism for 200KeV to 2MeV γ rays (typical range of most of the radioactive sources) in Carbon is Compton scattering. To improve the radiation source localization resolution it is important
to trace the recoil electron path coming from the Compton scattering in order to shrink the compton cone and estimate the source of the γ rays. Calculation show that
scattered electrons of about 1MeV are expected to travel about 2mm in Carbon and thus this is a good detector dimension to have full charge collection. Thus the γ-ray detector will be a pixel CNT detector based on the same topology presented above for the UV, IR sensor of about 2mm depth and 500μm x 500μm pixel size or even less to have enough hits to reconstruct the electron path.
TRL level: This is quite a new area of CNT application and thus the starting will be the study of the essential characteristics and behaviours of the CNT-Si

system followed by the development of the simulation tools (TRL1,2). Preliminary work has shown that such kind of detectors in the UV and IR part of the spectrum are possible. The parameters involved are the thickness of the CNT layer, the use of a tunneling layer, the conductance of the substrate and the use of a capping layer. Then the construction of a prototyping will follow (TRL 3,4) and with the help of a company the extensive test of the prototype in realistic conditions could be performed (TRL 5,6).

Summary

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Authors: Dr KYRIAKIS, Aristotelis (NCSR ”DEMOKRITOS”); Dr GLEZOS, Nikolaos (NCSR ”DEMOKRITOS”)

Presenters: Dr KYRIAKIS, Aristotelis (NCSR ”DEMOKRITOS”); Dr GLEZOS, Nikolaos (NCSR ”DEMOKRITOS”)