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A latchup topology to investigate novel particle detectors

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Here is described a novel approach to detect particles by means of a solid-state device susceptible to latchup-like effects. The stimulated ignition of latchup effects caused by external radiation has so far proven to be a hidden hazard. Here this is proposed as a powerful means of achieving the precise detection and positioning of a broad range of ionising particles. The cell can be constructed using state-of-the-art CMOS technologies. Thus, whenever this structure ignites upon charge detection, whatever its origin, a latchup condition is stated and this is a starting point for future pixel device designs.

Summary

The paper describes an innovative idea for an ionizing particle detector. This is an alternative topology for a solid-state pixel detector. It is based on latchup effect, which is usually exploited as a dangerous hazard in solid-state electronic devices and is common in to-date CMOS technologies working in a radiation environment. Review of the latch up effect, description of the circuit topologies under investigation to assess the operating principle and initial experimental results will be presented. In principle the detector can operate at room temperature, does not require a high voltage power supply and is intrinsically more tolerant to radiation effects than the common solid-state detectors based upon reverse-biased junctions. In fact, a latchup-based detector can be easily constructed using state-of-the-art CMOS technologies. A prototype made up of discrete components is described and its rough sensitivity is exploited. Tests with daylight, electrons, via a current pulse generator and with a laser beam have proved that charge sensitivity of the order of 1 pC can be easily achieved. This seems to be very promising for future applications in particle detectors or signal readout systems, being the threshold already very precise (low noise) using commercial components. All in all, the whole power consumption of the cell is also very low, of the order of 1mW, when it is not ignited. This can be easily understood since the number of components inserted, basically two transistors, one reset switch and some resistors, is much smaller than that of the modern pixel circuits. Hence, it is reasonable to expect even better numbers and results for integrated versions of the latchup circuit. New ideas, circuit topologies and technologies will be presented. Possible applications range from heavy-ion discriminator to beam monitor provided they deposit an over-threshold charge in the cell. Applications in particle and radiation detection will be suggested. Other types of latchup detector studies oriented to low-power applications are ongoing by the authors.

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