Descsription and Impact of

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“Segmented AC-coupled readout from continuous collection electrodes

in semiconductor sensors”

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Semiconductor sensors, and especially Silicon detectors, have an ubiquitous and necessary presence in many Science applications where the location of a particle has to be determined with high precision. They have been developed in the last 40 years making use of the progress in semiconductor technology we usually associate with Silicon Valley. Silicon detectors are at the heart of very large particle detectors at the Large Hadron Collider in Geneva, Switzerland, which recently found the Higgs particle, and to which the SCIPP group has contributed with their know-how. But Silicon detectors are also the integral part of smaller instruments e.g. in medical applications like the proton CT scanner developed at UC Santa Cruz.

Over the years, silicon detectors have undergone technical improvements of increased sophistication, which contributed to an advance in performance in terms of radiation hardness and speed. An example is the Ultra-fast Silicon Detector (UFSD) developed at UC Santa Cruz, which improves the timing capability of the silicon detectors by a factor 1000 down to 10 pico-seconds, extending their application to new fields. This sophistication comes with the price of increased complications, and naturally production cost. This is shown in Figure 1, which shows a cross section of one of the UFSD and makes clear that the details of the process are quite complicated, requiring many masks to achieve the required segmentation. The many interfaces can also lead to reduced performance.

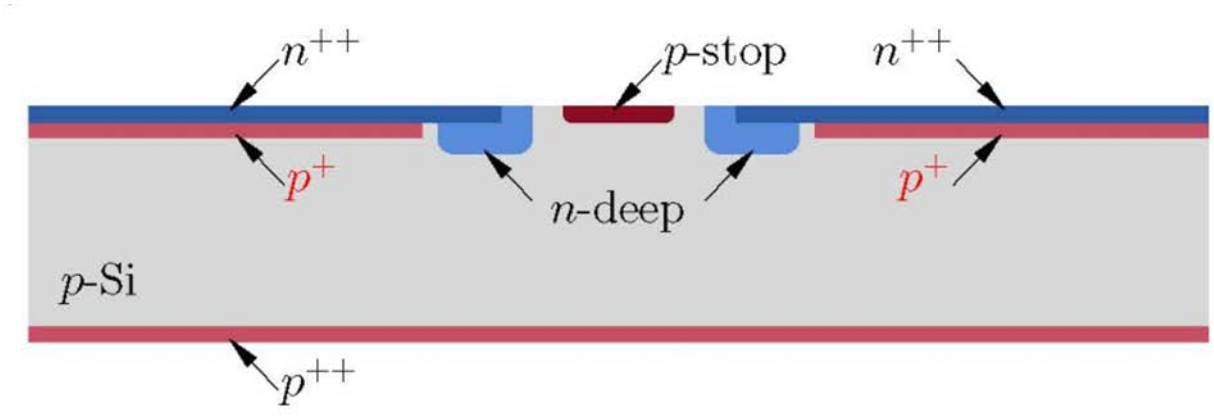

Figure 1 Cross section of a conventional Ultra-fast Silicon Detector. Note the many different sections on the top surface of the sensor required for the segmentation, complicating design and production.

The patent aims at a radical simplification of the design, leading to improved performance and drastically reduced cost. A cross section of the patented design in Figure 2 makes this evident: instead of segmenting the top surface with many different section of Fig.1, the surface consists of large uniform sheets of implanted silicon and oxide, which are easy to fabricate. The only segmentation is in the metal pads which are used to pick off the signals and couple them into individual amplifier channels.

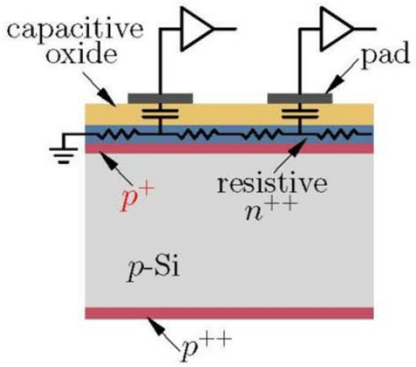

Figure 2 Cross section of a radically simplified Ultra-fast Silicon Detector covered by the patent. All the silicon layers and the oxide of the coupling capacitor are in uniform sheets, and only the metal layer is segmented into readout pads.

The first proof-of-principle prototypes of the AC-coupled UFSD have been fabricated by CNM Barcelona, a Spanish collaborating institute, and are being tested in the SCIPP labs with an IR laser by UCSC undergraduates. The demonstrated simplification will permit a wider application of UFSD. In collaboration with our Torino colleagues work has begun to tailor the designs for application of the new sensors in particle physics detectors at the Large Hadron Collider and in hospitals which employ proton beams to fight cancer.