Descsription and Impact of US patent No.: 9,613,993 B2 , granted Apr. 4, 2017

“Segmented AC-coupled readout from continuous collection electrodes in semiconductor sensors”

Hartmut Sadrozinski, Abraham Seiden (UC Santa Cruz)

Nicolo Cartiglia (INFN Torino)

Semiconductor sensors, and especially Silicon detectors, are 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 harness and speed. An example is the Ultra-fast Silicon Detector (UFSD) developed at UC Santa Cruz, which improve the timing capability of the silicon detectors by a factor 1000, 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 segmantation.

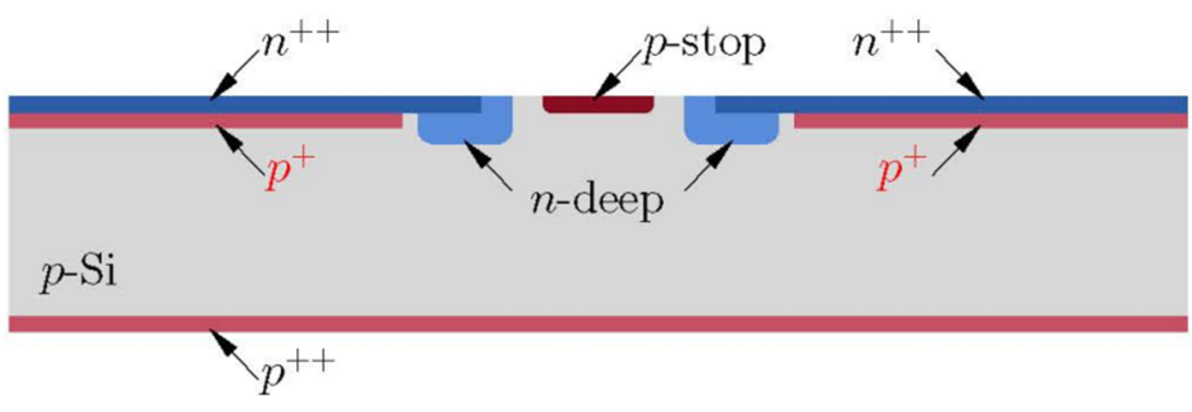

Figure 1 Cross section of a conventional Ultra-fast Silicon Detector. Note the many different section on the top surface of the sensor, ensuring the segmentation, requiring high accuracy in design and production.

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 signal and send them to separate amplifier channels.

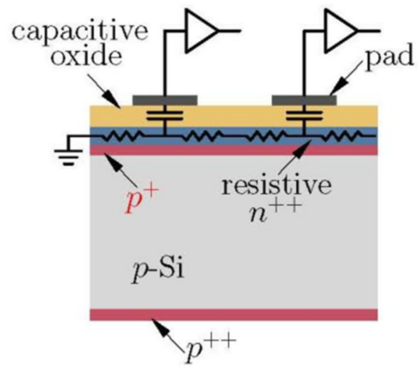

Figure 2 Cross section of a radically simplified Ultra-fast Silicon Detector covered by the patent. All the silicon layers and the oxide of the coupling capacitor are in uniform sheets, and only the metal pad for the readout is segmented.

The first proof-of-principle prototypes of the AC-coupled UFSD have been fabricated by CNM, a Spanish collaborative 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. 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.