

**DIPARTIMENTO DI INGEGNERIA
CORSO DI DOTTORATO IN INGEGNERIA INDUSTRIALE E
DELL'INFORMAZIONE -
PHD COURSE IN INDUSTRIAL AND INFORMATION ENGINEERING -
35TH CYCLE**

Title of the research activity:	<p>Advanced radiation sensors VLSI design in CMOS technology</p> <p>Research Field: Sensors and Electronics for High Energy Physics, Medical and Space applications.</p> <p>International and National Collaborations: CERN (European Organization for Nuclear Research, Switzerland); Jiangsu CAS-IGBT Technology Co., Ltd. (sede Avezzano, Italy), INFN (Istituto Nazionale di Fisica Nucleare, Italy).</p>
State of the Art:	<p>Monolithic CMOS sensors embed in the same substrate the sensor and its read-out electronics. They are fabricated in commercial, microelectronics-grade foundries. CMOS sensors offer an attractive alternative to standard hybrid pixel and micro-strip detectors to build systems with better performance, higher reliability, and lower cost.</p> <p>The main limitations of the state-of-the art radiation detectors are the resistance to very high fluences irradiation and power dissipation over relatively large sensing areas [Terzo-2017], [Wang-2017].</p>
Short description and objectives of the research activity:	<p>The purpose of the present research is to develop innovative CMOS monolithic pixel detectors that can replace standard hybrid pixel and silicon strip detectors in a wide range of applications such as High Energy Physics experiments, Medical applications as well as Space applications.</p> <p>The proposed development relies on three key elements:</p> <ul style="list-style-type: none"> — a sensor fabrication technology that, starting from the experience gained in the previous research activity within national and international collaborations and projects, will improve in such a way to be suitable for a wide range of applications. — a set of smaller-size test structures to investigate relevant issues that can be addressed without full-size prototypes (e.g. radiation resistance, monitoring of the substrate properties, influence of different pixels architectures on charge collection efficiency). — a versatile and scalable front-end electronics and architectures, capable to effectively support the development of sensors with realistic size and performances. <p>The CMOS electronics will be common to the different sensor options, that will be explored by changing only the substrate material and/or some step of the production process.</p> <p>All the design improvements and modifications introduced in the process flow will be validated with the help of Technology Computer-Aided Design (TCAD) simulations, relying on process data provided by the foundry. A proper TCAD modeling of the bulk and surface radiation damage effect should also be devised and validated for the selected technology [Moscatelli-2016], thus fostering its application for the comparison of different layout/doping profiles aiming at optimizing the radiation resistance of the device in terms of SNR and breakdown effects.</p> <p>Aiming at low power design, alternative pixel front-end architectures will be investigated [Placidi-2016]. In particular, a so-called Weak Inversion Pixel Sensor (WIPS), shown in Fig. 1, exploits a dedicated, yet simple circuitry, based on a pre-charge/evaluation scheme, which</p>

allows for "sparse" access mode and thus for speeding-up the read-out phase [Passeri-2004].

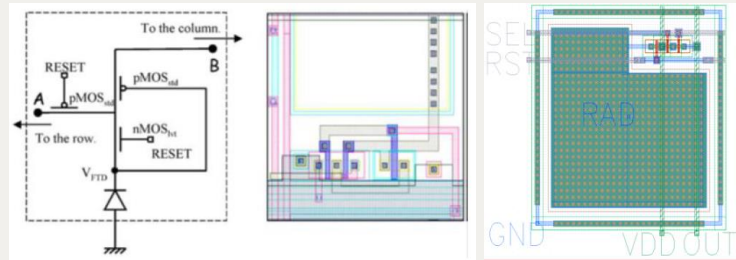


Fig. 1: CMOS WIPS scheme: equivalent circuit (left-hand side), corresponding layout (right-hand side)

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 [Passeri-2004] D. Passeri, P. Placidi, M. Petasecca, P. Ciampolini, G. Matrella, A. Marras, A. Papi, G.M.Bilei, "Design, Fabrication, and Test of CMOS Active-Pixel Radiation Sensors", IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 51, NO. 3, JUNE 2004.
 [Placidi-2016] E. Conti, S. Marconi, T. Hemperek, J. Christiansen and P. Placidi, "Performance evaluation of digital pixel readout chip architecture operating at very high rate through a reusable UVM simulation framework", Proc. of NSS (2016).
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