Abstract

This thesis focuses on the development of X-ray sensors for medical applications using CMOS technology. Specifically, the ARCADIA technology was used, which allows for the development of monolithic active pixels with fully depleted silicon substrate. This approach leads to CMOS sensors with a thicker sensing layer and thus a better X-ray detection efficiency.

Two prototypes were developed using this process. The first, named COBRA, allows for the detection of the X-ray dose delivered to a tumor using brachytherapy. This is possible because COBRA is small enough to be inserted into the patient and effectively detect the absorbed dose. COBRA is the first application of its kind and is currently undergoing the patent process.

The second project is an X-RAY counter composed of a matrix of pixels in ARCADIA technology. It takes charge sharing into account primarily digitally, unlike other solutions on the market. This is possible thanks to a specially developed analog front-end and the ARCADIA technology that allows for the implementation of full CMOS circuitry directly in the pixel. Each pixel is also equipped with 4 registers capable of storing information on the energy of the incident X-ray. The pixel has a pitch of 110 μm.

The thesis is structured as follows: The first chapter provides a comprehensive overview of the current technologies available for developing monolithic radiation sensors. The ARCADIA technology, which was used to develop all the prototypes presented in this thesis, is also described. The second chapter describes the problem of measuring the absorbed dose of the prostate tumor with brachytherapy. This introduces COBRA, which aims to address this problem. The first version of COBRA is also described.

In the third chapter, a second version of COBRA is described in which we reduced the number of PADs to 3 so that the insertion of the probe is as non-invasive

as possible. The final configuration and layout are then described. In addition, the asynchronous serial communication system with a dedicated protocol developed for this application is also described. In fact, having only one PAD for both the analog channel and the digital channel necessary for configuring the internal DACs, we had to develop a custom system.

Finally, in the last chapter, the entire X-ray counter is described. This includes electrical diagrams of the analog front-end and digital logic, the logical and physical organization of pixels and the complex interconnection system between them useful for managing charge sharing.