Technology Offer

Fast Photodetector with Intrinsic Amplification: Avalanche Photodiode Array

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The invention relates to a new monolithic Avalanche Photodiode array with a novel inter pixel isolation structure. The technology allows the design of sensitive photodetectors with remarkable spatial resolution at very fast imaging capabilities for various applications.

Although Avalanche Photodiodes are a convenient tool due to their intrinsic amplification, their use in photodetectors with high pixel densities is challenging due to insufficient isolation of the pixels. Hence their use in imaging is limited.

The problem was solved by a new design concept for APD arrays that uses an amplification region which is spatially homogenous over the entire sensitive area, especially at the pixel edges as well. A complete signal detection combined with remarkably small pixel sizes was achieved and significantly broadens the scope of application for APDs.

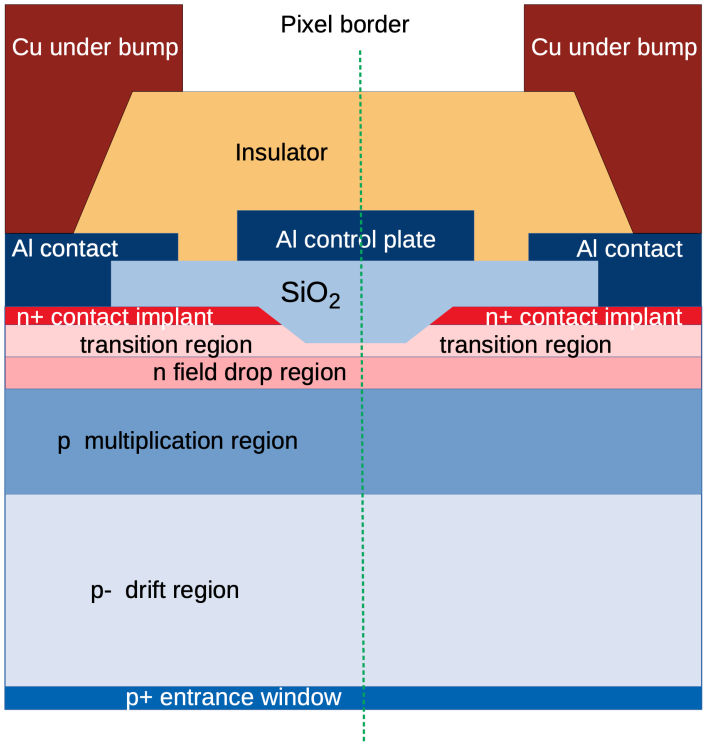

Fig. 1: The cross section of a possible implementation of the invention shows the large drift regions in which a homogenous electric field ensures high sensitivity at the pixel edge as well. An n-doped field drop region prevents the multiplying electric field from reaching the contact implants. For the inter pixel isolation various shapes and compositions are possible

Advantages

- Fast readout and processing
- Internal amplification of low intensity radiation
- Small pixel size possible
- High and homogenous sensitivity

Applications

- Fast spatially resolved detection of low-intensity soft X-Rays
- Fast imaging of visible photons
- Real time precision spectroscopy
- Particle tracking in high energy physics experiments

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Background

Avalanche Photodiodes (APD) are well proven components for amplified photon detection that are used in fast responding detectors at low photon flux. However, the possibilities of constructing an array of APD detectors are limited due to the necessary protective structures to avoid edge breakdowns. The latter are caused by high electric fields due to the doping profile. State of the art APD arrays avoid edge breakdowns by reducing the electric field towards the edge, which consequently limits the sensitivity. Therefore, they fail to meet the requirements of sufficient isolation between pixels, the suppression of edge breakdowns and a homogenous amplification over the entire detector.

Technology

A new monolithic Avalanche Photodiode array has been developed to overcome the aforementioned shortcomings and to further expand the application possibilities of APDs.
According to the invention and its novel approach, the distribution of the electric field and hence the amplification is constant over the entire array and does not change at the pixel edges. The cross-section of a possible implementation of this concept is shown in figure 1. The radiation enters the detector through the p-doped entrance window and is absorbed in the *multiplication region 1*. As the generated charge carriers follow the electric field towards the anode, they are further multiplied via impact ionization in the highly p-doped *multiplication region 2*. In the subsequent region, the *field drop region*, the electric field strength is reduced below the critical value for charge multiplication. In order to ensure inter pixel isolation with minimal amplification field disturbances, the *contact implants* of each pixel as well as their isolation are located in the region of reduced electric field. Different isolation arrangements have been tested successfully.
As no decrease of the electric field at the pixel edge is needed, the sensitivity is almost constant over the entire pixel surface. Hence pixel sizes can be chosen very low without restricting the detection performance.

Patent Information

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