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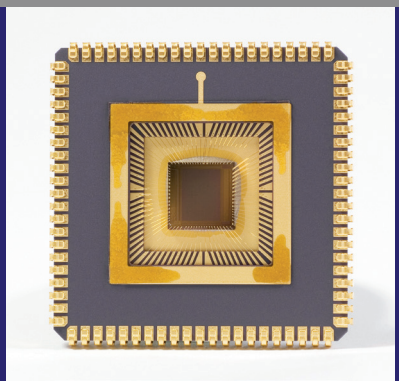


1 *TCAD Simulation of the ToF-LDPD-structure.*
2 *ToF-sensor based on LDPD.*

LATERAL DRIFT-FIELD PHOTO-DETECTOR FOR TOF-IMAGING

Fraunhofer Institute for Microelectronic Circuits and Systems IMS

Finkenstr. 61
D - 47057 Duisburg
phone +49 203 37 83-0
fax +49 203 37 83-266
www.ims.fraunhofer.de

contact
Michael Bollerott
phone +49 203 37 83-227
vertrieb@ims.fraunhofer.de

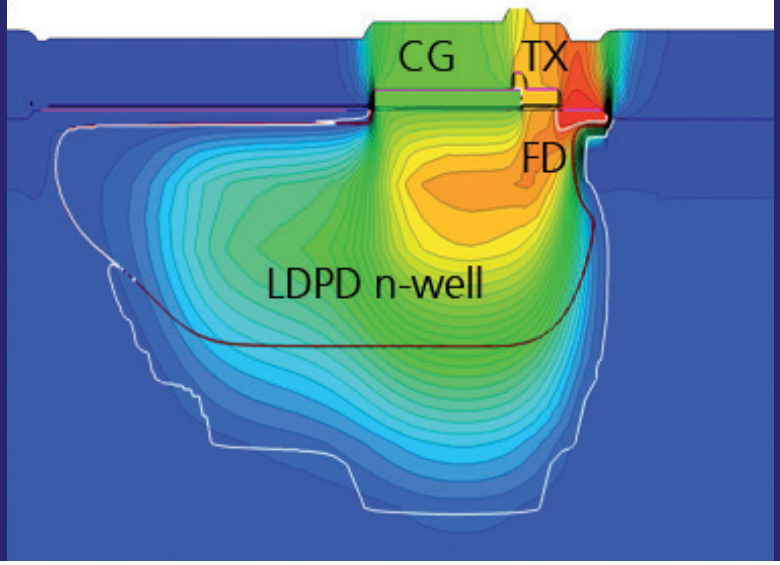
Time-of-Flight-Imaging using the Lateral Drift-Field Photodetector

Nowadays, nearly every digital camera or mobile phone uses the pinned photodiode (PPD) as light sensitive detector fabricated in a low cost CMOS process. Driven by reaching higher and higher counts of megapixels (MP) this PPD is shrinked down to pixel sizes of 1µm and below to provide two dimensional colour imaging. However, these pixel structures do not match the performance requirements - such as high dynamic range, responsivity, and high internal charge transfer speed - needed for special imaging applications (i.e. 3D imaging or low light imaging).

For this reason the Fraunhofer IMS has developed the so called Lateral Drift-Field Photodetector (LDPD) using its 0.35µm CMOS technology with a special non-uniform lateral doping profile to provide a drastically increased internal charge transfer speed compared to a conventional pinned photodiode. Inside this structure an internal electrical drift field enables transfer speeds of photogenerated charges in the nanosecond scale for a pixel size of 40µm.

Based on this LDPD pixel structure Fraunhofer IMS has developed and fabricated a 3D Time-of-Flight (ToF) sensor with 128 x 96 pixels.

This ToF-sensor reaches frame rates of up to 100fps and performs distance ranging up to 10 metres with a resolution of a few centimetres.



High speed charge transfer in the pixel achieved by

- increasing doping concentration in readout direction
- using a charge collection (CG) electrode building up an intrinsic lateral drift field

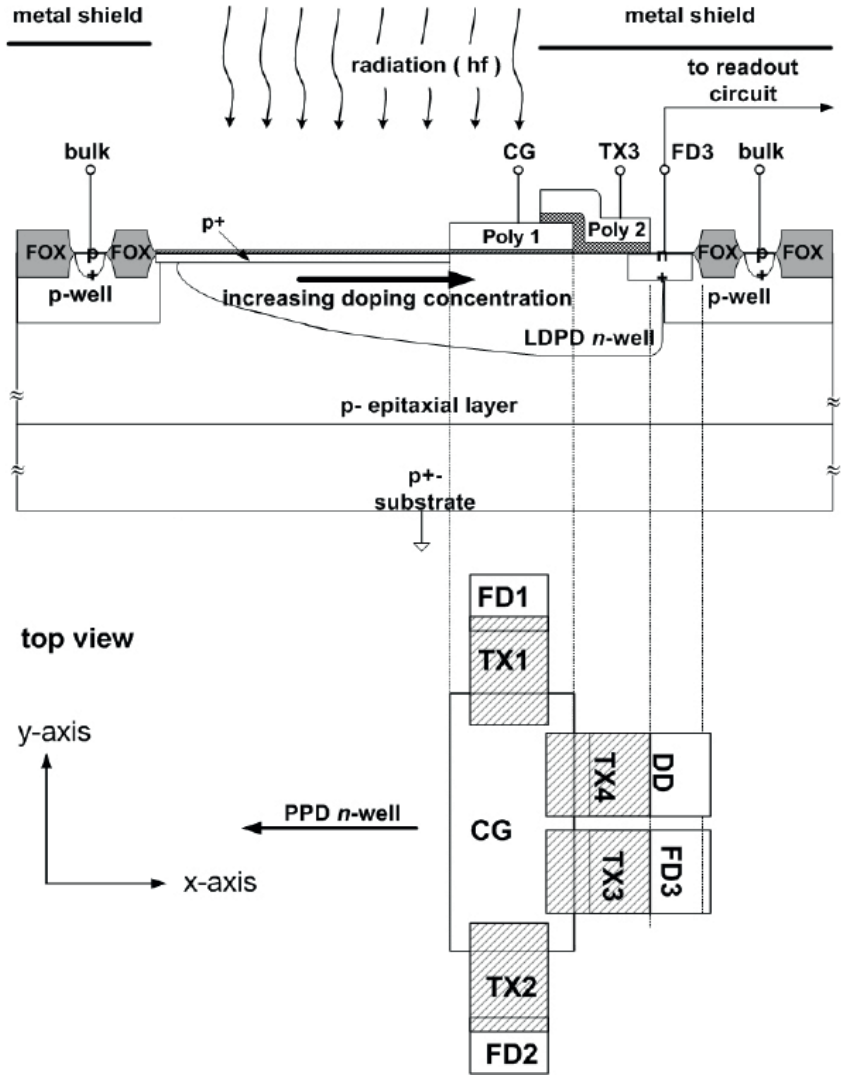
In-pixel accumulation functionality

- 4 readout taps (floating diffusions, FD)
- low noise and non-destructive readout
- adjustable dynamic range
- Robust and efficient background light suppression
- High responsivity in NIR

128x96 Time-of-Flight Sensor Based on the Lateral Drift-Field Photodiode

- 128x96 pixel array (SQCIF)
- Chip area: 6.45 x 6.45 mm²
- 0.35µm 2P4M CMOS process with modified n-well and high voltage option
- 4T pixel architecture with Lateral Drift-Field Photodiode
- Pixel pitch: 40 µm
- Pixel fill factor: 38 %
- On-chip Correlated Double Sampling (CDS)
- 2 analog output channels (CDS mode)
- 3 analog output channels (direct output without CDS)
- Pulsed laser illumination (NIR)
- Laser pulse width: typ. 30 ns
- Robust background light suppression
- Distance measurements up to 10 m
- Depth resolution < 1 cm

cross sectional view



3 *Simulation of electrostatic potential.*

4 *LDPD pixel structure.*