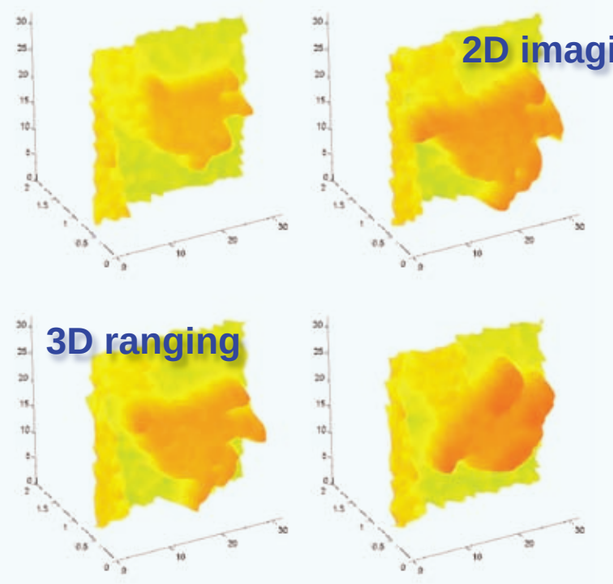
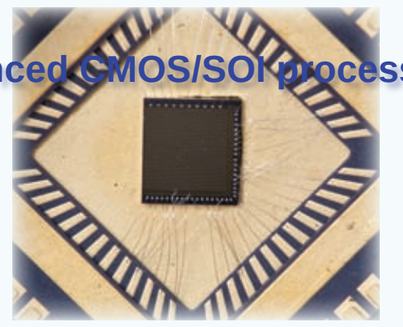
Microelectronic Single-Photon 3D Imaging Arrays for low-light high-speed Safety and Security Applications

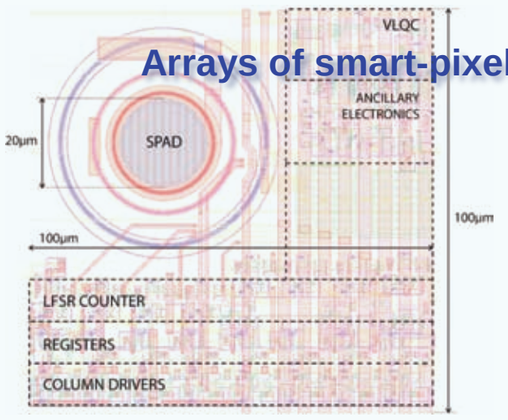
www.mispia.eu

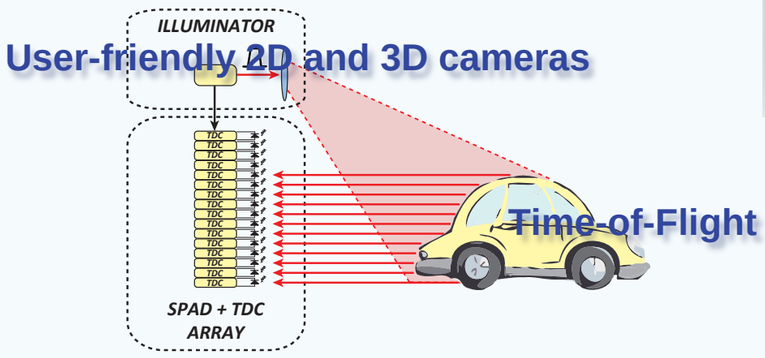
MiSPiA will develop beyond state-of-the-art photonics technology for array imagers of smart-pixels able to detect single photons. Intelligent in-pixel pre-processing will simultaneously provide ultra high sensitivity (single-photon level), very high frame-rate (up to 200,000fps) and advanced multi-spectral (300-900nm) three-dimensional (3D) distance ranging and two-dimensional (2D) imaging of fast moving objects. MiSPIA detectors will be used in two key applications: long-range (200-1,000m) 2D and 3D active identification in low light level surveillance operations; and very fast (over 200fps) short-range (10-50m) 3D monitoring in automotive pre-crash safety systems. Instead of (slow and noisy) CCDs and CMOS active pixels (with poor sensitivity and noisy electronics), MiSPIA will exploit the ultimate performances of truly-single photon detectors: the Single-Photon Avalanche Diodes (SPAD). MiSPIA imagers will be based on four different SPAD smart-pixels: “photon-counting” pixels for 2D imaging; LIDAR pixels for 3D direct “time-of-flight” (dTOF); two different phase-sensitive pixels for 3D indirect time-of-flight (iTOF) depth acquisitions. Full-size imager chips will be manufactured, characterized and eventually integrated into two 3D ranging cameras deployed into the two end-users applications for validation. MiSPIA technologies will be both highly-advanced and cost-effective: a high-voltage 0.35µm CMOS processing for front-side illuminated imagers; and a new flipped-chip Silicon-on-Insulator (SOI) CMOS technology for back-side illuminated imagers. Both will prove beyond state-of-the art co-integration of photonic SPAD detectors and CMOS microelectronics for intelligent and dense 2D imaging and 3D ranging high-performance cameras. Such cameras will provide imaging at the quantum limit and on-chip pre-processing at the most effective speed and a drastic reduction of manufacturing costs, down to 5€ per imager chip.

MiSPIA idea is to develop advanced microelectronic SPAD array chips able not only to count single photons (“single-photon counting”), but also to accurately tag them with their arrival time (“single-photon timing”) and so provide a full image (“single-photon imaging”) of the object under investigation. Therefore, MiSPIA aims to conceive, develop and fabricate photonic and microelectronic technologies for cost-effective manufacturing of very fast, highly sensitive, two-dimensional (2D) and three-dimensional (3D) SPAD cameras running at higher speed than standard video-rate.









Project objectives

MiSPIA aims at two clearly identified 3D applications: high frame-rate, short-range (10-50m) 3D ranging systems for automotive prompt intervention for front- and back- pre-crash safety systems; and multi-spectral long-range (200-1,000m) 3D ranging systems for security surveillance. In the automotive field, moving or standing objects/obstacles to detect are vehicles, bicycle, pedestrian, small objects (trees, poles, etc.). Possible preventive or protective actions will be pre-crash warning (e.g. an acoustic warning signal), collision mitigation, pre-tensioning of safety belts, pre-setting of air bags.

- Single Photon Avalanche Diode smart-pixels with “in-pixel intelligence”
- Front-side illuminated array chips (FrontSPAD)
- 3D ranging modules based on FrontSPAD arrays
- Back-side illuminated array chips (BackSPAD)
- Assembly and test of the BackSPAD imager
- Integration of the 3D camera into short-range high speed Safety applications
- Integration of the 3D multi-spectral camera into long-range Security application

MiSPiA Consortium

Project Parterns

Politecnico di Milano, IT

Fraunhofer-Gesellschaft zur Foerderung der angewandten Forschung e.V, DE

Heriot-Watt University, UK

Micro Photon Devices s.r.l., IT

Centro Ricerche FIAT scpa, IT

EMZA Visual Sense LTD, IL

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MiSPIA consortium consists of 7 partners, who are among the leading European research groups in the fields of SPAD arrays and single-photon instrumentation (Politecnico di Milano, Italy), CMOS sensors fabrication and advanced SOI processes (Fraunhofer-Gesellschaft zur Foerderung der angewandten Forschung e.V, Germany), design and fabrication of microlens arrays (Heriot-Watt University, United Kingdom), development of time-correlated single-photon counting detection modules and cameras (Micro Photon Devices s.r.l., Italy), safety applications in automotive field (Centro Ricerche Fiat scpa, Italy), then a leader in the security surveillance monitoring (EMZA Visual Sense Ltd, Israel) and finally CF consulting srl (Italy) with vast experience in the management and dissemination of European projects.

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