E-newsletter

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"MiSPiA" FP7 PROJECT

Milan, 10th December 2010 – "**MiSPiA**" (***Microelectronic Single-Photon 3D Imaging Arrays for low-light high-speed Safety and Security Applications***) is a new Collaborative research project funded by the European Commission in its Seventh Framework Programme for research, technological development and demonstration activities (2007-2013), which was launched in June 2010 under the coordination of the Politecnico di Milano, Dipartimento di Elettronica e Informazione. According to the Grant Agreement number 257646, the MiSPiA project will be funded for € 2,632,854 for performing activities for 36 months in the field of photonics.

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 and 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. Instead Rear Pre-Crash is finalised to the rear impact detection and the automatic release of protective actions. Relevant objects/obstacles are any vehicles approaching with danger of crashing from behind.

Many social needs require the acquisition of images at low light levels (possibly with no artificial illumination), at video or even higher frame rates (possibly thousands of frames per second, fps), and also with distance-resolution (possibly millimeter precision). Nowadays the imager market offers a broad portfolio of either commercial- or scientific-grade cameras, ranging from consumer CMOS Active Pixel Sensor cameras up to high-end CCD imagers. None of them simultaneously offer high speed and ultra high sensitivity: CCDs reach sensitivity at close to single-photon level, but necessarily require cooling and long integration times (i.e. very low frame rates); APS imagers provide video-rates but with relatively limited detection efficiency, thus requiring bright illumination scenes. The MiSPiA concept is to provide simultaneously both high frame-rates and single photon sensitivity chips with monolithic integration of **Single-Photon Avalanche Diode** (**SPAD**) pixels and sophisticated in-pixel intelligence able to process at the pixel-level intensity-data and depth-ranging information, enabling 3D mapping of rapidly changing scenes in light starved environments.

MiSPIA's 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.

MiSPIA proposes to exploit both standard CMOS technology, for cost-effective 2D imaging and 3D ranging cameras, and highly innovative beyond the state-of-the-art SOI/CMOS processing, for advanced imager performance.

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.

The MiSPIA Project will have major impacts on technological fields, application environments and end-user needs, because MiSPIA technology for SPAD arrays, 2D imaging and 3D ranging chips will define a new paradigm in the fields of silicon photonics and microelectronics integration and of advanced ultra-sensitive time-resolved and spectrally-resolved imaging. Not only Safety and Security scenarios will benefit by MiSPIA cameras, but also completely different fields. The European Union will become more and more competitive against USA, Japan and Canada and will acquire a renowned leadership in conceiving, manufacturing and deploying ultra high sensitive and fast camera sensor chips and systems.

In the first months of the MiSPiA projects, the partners defined the requirements, constraints and specifications for both the short-range 3D SPAD ranging system in the automotive safety applications and for the long-range 2D imaging and 3D ranging SPAD system in security applications.

Then the partners evaluated in depth the two different manufacturing technologies to be exploited for the fabrication of the SPAD imagers at the Fraunhofer IMS institute. The former technology is aimed at providing a cost-effective solution and will be based on a 0.35µm CMOS process to be used for fabrication of both 2D and 3D planar front-side illuminated SPAD arrays. The latter manufacturing technology is based on both, advanced Silicon-On-Insulator (SOI) based SPAD arrays and CMOS integrated processing electronics to be monolithically integrated to lead to advanced back-side illuminated SPAD arrays.

Eventually in November 2010, after just 6 months from the kick-off meeting, the first fabrication test batch came out from the foundry. The test chips contained various devices of the first prototypal SPAD detectors, with different layout and cross-sections. Now these devices are being tested and fully characterized in the laboratories of Politecnico di Milano for assessing their electrical and optical performance. In the meantime a new fabrication test batch was submitted to the foundry, with first microelectronic circuits for driving the individual SPAD devices and sensing their ignition at each photon arrival. In January 2011 such preliminary pixels (with SPAD and in-pixel electronics) will be characterized and the design of novel array architectures will start, based on the best performing combination of SPAD device and in-pixel processing electronics.