POINT-SCANNING MICROSCOPY WITH SINGLE-PHOTON-AVALANCHE-DIODE ARRAY

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ABSTRACT:

The performances of any optical microscope are strictly connected to its photodetector. Indeed, the temporal and spatial resolution/range of a microscope and the different information provided by the microscope depend also on the spatial, temporal, and spectral characteristics of the detector used. Point-scanning microscopy, such as confocal laser scanning microscopy (CLSM) and nonlinear microscopy, typically involves single-point detectors - digital or analog - with exquisite temporal and spectral characteristics, but without any spatial ability: on the contrary to cameras, the photons collected by single-point detectors are integrated across the whole sensitive area, thus discarding the important information encoded in their relative positions on the image plane. Single-photon avalanche photodiode (SPAD) array detectors have everything in favor to fill this gap and to open to a new - or revised - class of microscopy techniques.

We describe in detail the spatial, temporal and spectral characteristics of a novel SPAD array optimized to cover many different point-scanning microscopy and spectroscopy techniques. As an example of application, we show how we easily integrated the SPAD array into a conventional CLSM to implement image scanning microscopy (ISM), improving its optical spatial resolution of a factor $\sqrt{2}$ without compromising the other functionalities of the confocal microscope [1].

We discuss how the information decoded from imaging with a detector array can be used in the context of image processing, adaptive optics, and molecular dynamics study. We finally provide a perspective of further important developments on the detector.

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