A CMOS Line Sensor Targeting Time-Resolved Spectroscopy For Detecting Bacteria In The Lung In Vivo

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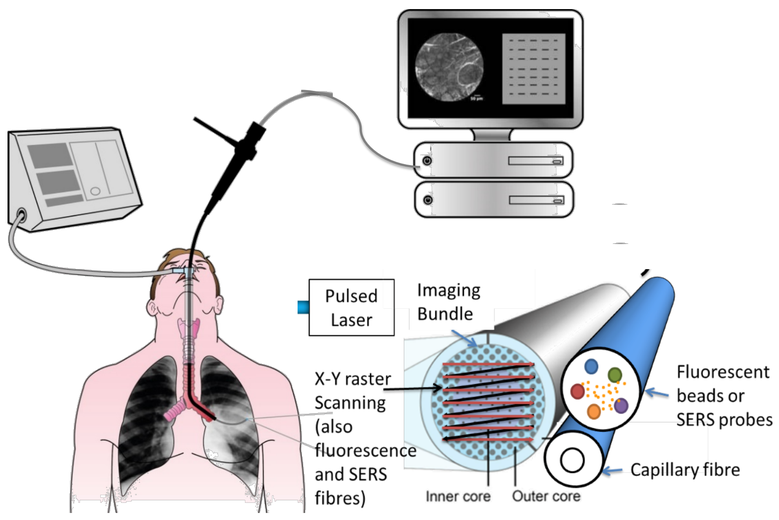


INTRODUCTION

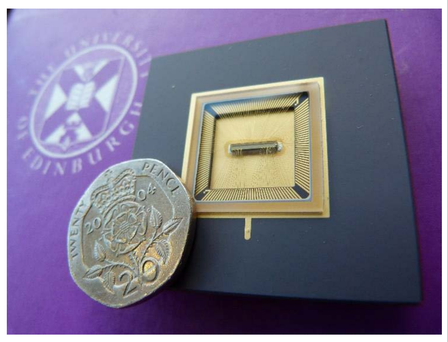
The Proteus project aims to improve medical diagnosis in the distal lung of critically ill patients through an optical fibre based sensing and imaging platform. As such several biomedical detection techniques are being designed that exploit the spectrally and time resolved detection of light [1]. We have developed a broadly configurable CMOS Single-Photon-Avalanche-Diode (SPAD) based line sensor named Ra1. The sensor allows the time correlated detection of low light intensities on several parallel timing channels [2] to facilitate such diagnostic device.

AIMS

- Optimized firmware for controlling the sensor and providing high throughput of data
- Characterization of the chip
- Applying line sensor in spectrograph setup and demonstrate performance in recording spectrally and time-resolved data of fast chemical reactions
- Improved time-gating for better noise reduction and higher resolution
- Investigate the application of sensor in other biomedical techniques

RA1 LINE SENSOR

- 2 × 256 pixels targeting different wavelengths (RED and BLUE pixels)
- 4 SPADs of 23.78 µm pitch per pixel, 43.7 % fill-factor
- 256 independent timing channels
- 3 different modes: single photon counting (SPC), time-correlated single photon counting (TCSPC), centre-of-mass (CMM)
- Time-gating can be applied in each mode



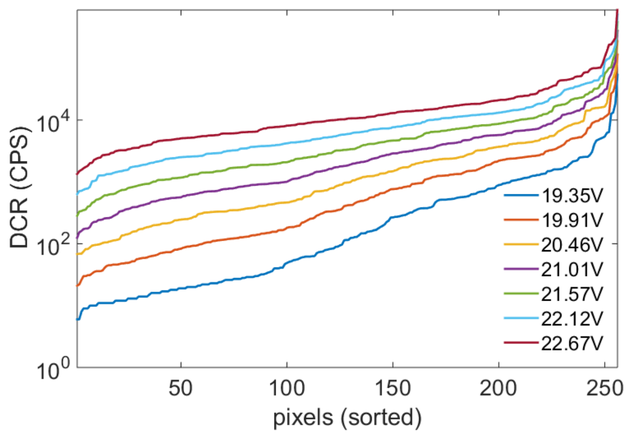


Fig. 2. Dark count rate (DCR) of RED pixels at different bias levels

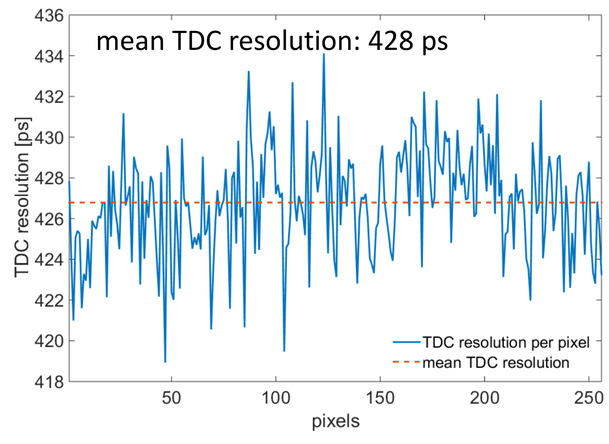


Fig. 3. Time-to-digital converter (TDC) resolution

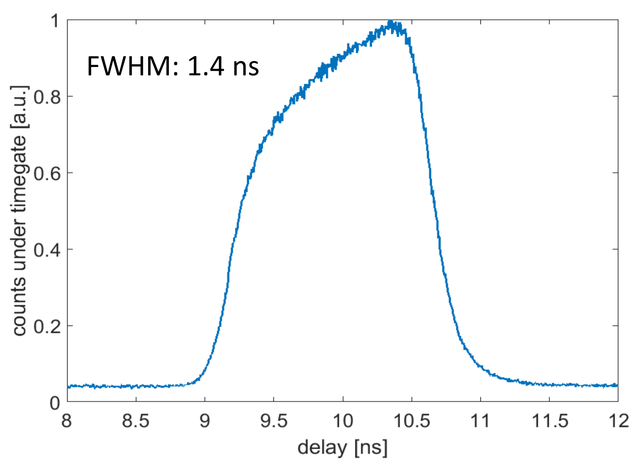


Fig. 4. Time-gating in SPC mode

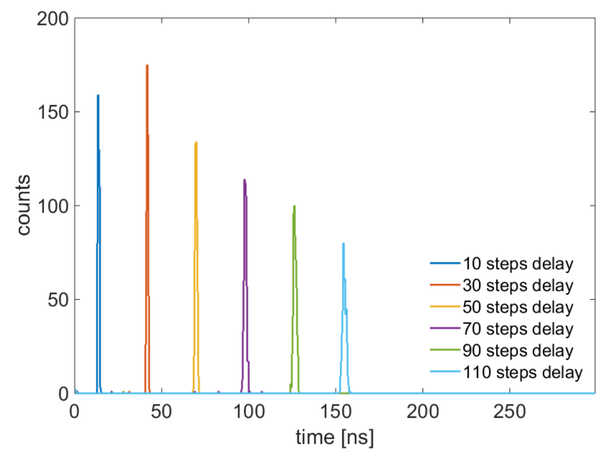


Fig. 5. Time-gating in TCSPC mode

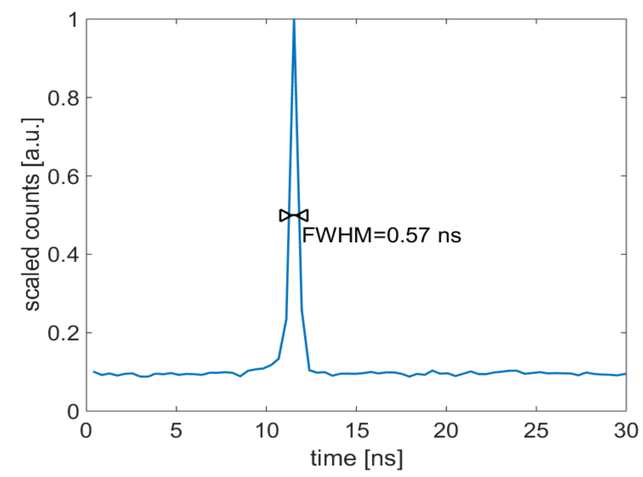


Fig. 6. Instrument response function on a BLUE pixel, 600 nm excitation

- Firmware optimized to get 19.000 lines/s
- Custom, Python based software written for communication
- Improved line sensor is under development
- Existing endoscopic fluorescence detection system is to be expanded with time-resolved detection

REFERENCES

[1] W. Becker, Advanced Time-Correlated Single Photon Counting Applications (Springer, 2015)
[2] N. Krstajić, et al., 256 × 2 SPAD line sensor for time resolved fluorescence spectroscopy, Optics Express, vol. 23, pp. 5653-5669, (2015).

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