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BioQantSense

Quantum Ghost Imaging using 2-D SPAD array

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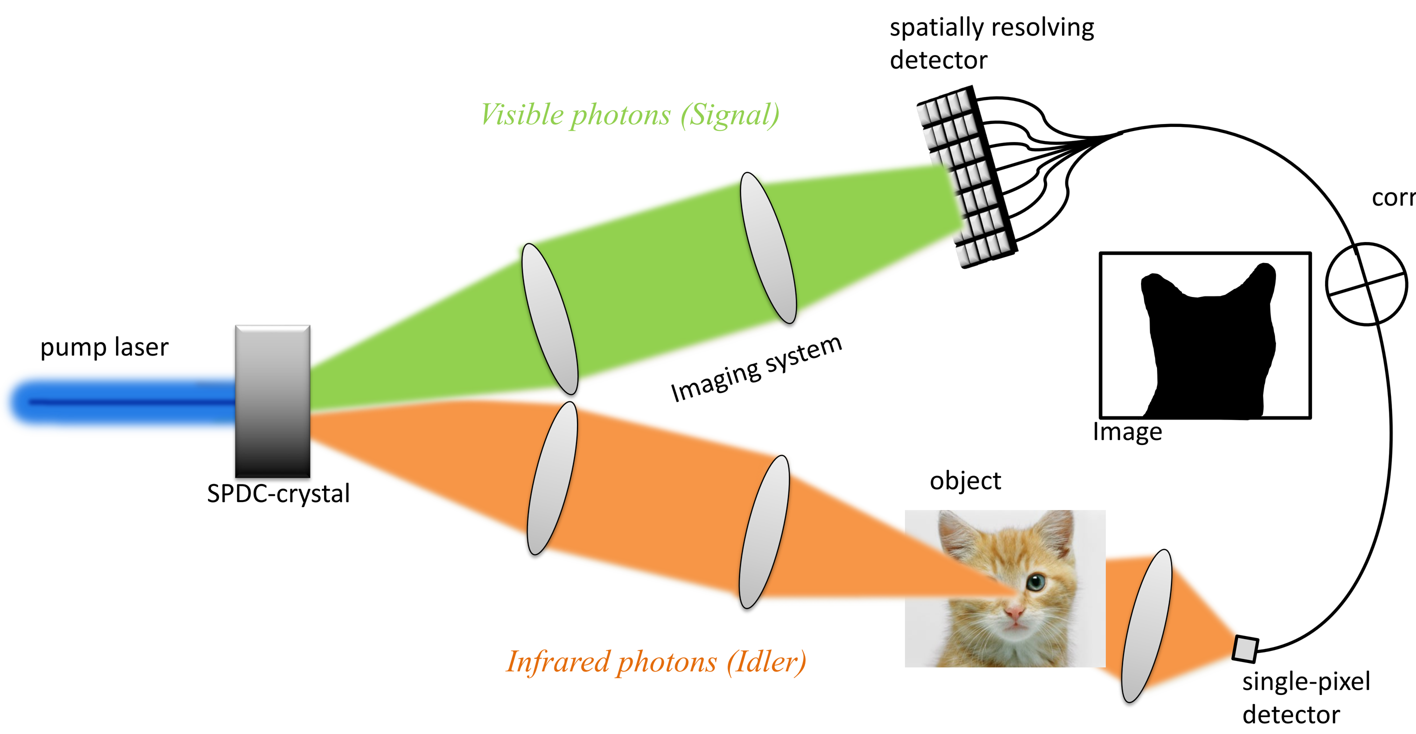
Abstract: Quantum Ghost Imaging (QGI) is a powerful imaging technique that takes advantage of the spatial correlations of photon pairs generated using Spontaneous Parametric Down conversion (SPDC). We present a QGI scheme that utilizes a 2D Single-Photon Avalanche Diode (SPAD) array in the spatially resolving arm while allowing investigation of the object with near-infrared photons. This innovative approach enables us to capture images across the field of view in under a minute, without scanning, while removing the need for cumbersome image-preserving delay lines inherent to QGI with Intensified Charge-Coupled Device (ICCD) cameras.

Introduction

Investigation of biological samples using Infrared wavelengths remains a challenge due to the unavailability of suitable detectors. Quantum Ghost Imaging (QGI) offers an ingenious solution to this problem as it does not require spatial resolution at the illuminating wavelength [1], [2].



Schematics of Quantum Ghost Imaging

> QGI with Infrared Illumination

- Object illumination with *Idler photons,* detected by a single-pixel detector.
- *Signal photons* detected by a suitable camera.
- Image reconstructed by correlating Signal and *Idler* [3].

Method

The Signal and *Idler* photons are generated at 1.4 µm and 600 nm respectively using a BBO crystal (Type I SPDC). A 32x32 Single-Photon Avalanche Diode (SPAD) array in the spatially resolving arm detects the Signal photons. The sample is investigated with *Idler* photons (near-infrared) and transmitted photons are detected by a single pixel InGaAs detector (*ID 230, ID Quantique*) [4].

> Features of 2D SPAD array

- 32x32 pixel (1.69 x 1.88 µm) SPAD array with a 19.5% Fill Factor allowing images across the field of view, without scanning.
- In-pixel Time-to-digital converter allows pixel-by-pixel correlations.
- No need for cumbersome image-preserving delay lines inherent to QGI with Intensified Charge-Coupled Device (ICCD) cameras [5].

Results

> Resolution Target

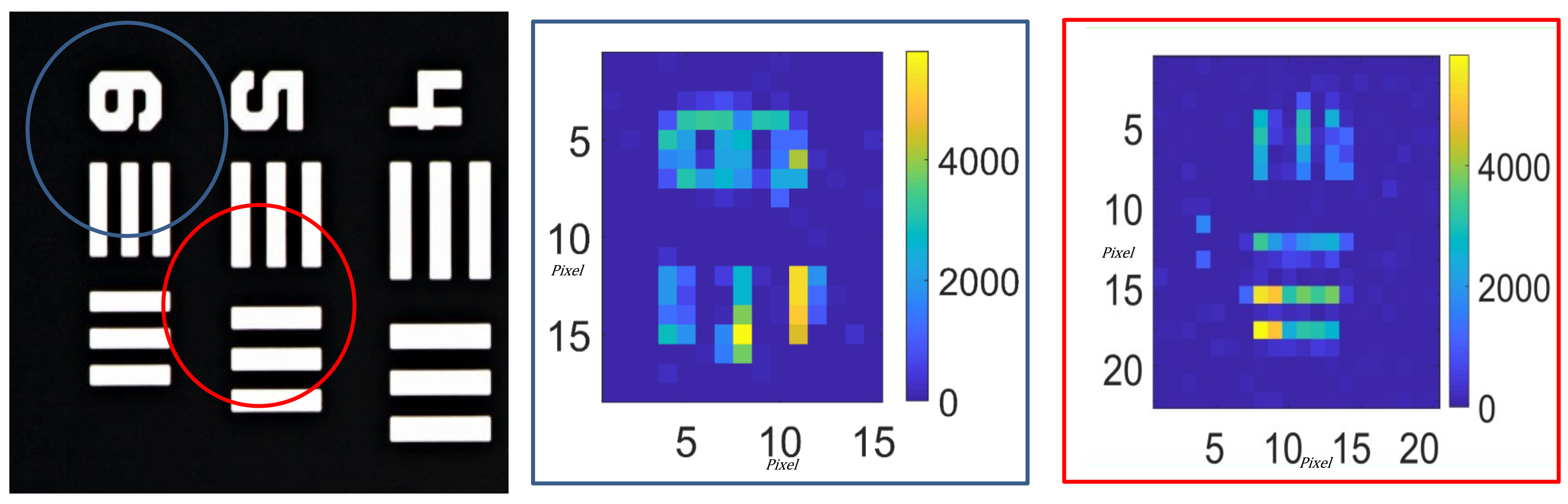


Fig 1: Ghost images of resolution target using the presented scheme. USAF resolution target with highlighted zones (Left: Element 6 (Blue) and Element 5 (Red) of Group 2 corresponding to 1.12 mm, and 1.26 mm) and corresponding ghost images (Right). Accumulation time ~ 20 min.

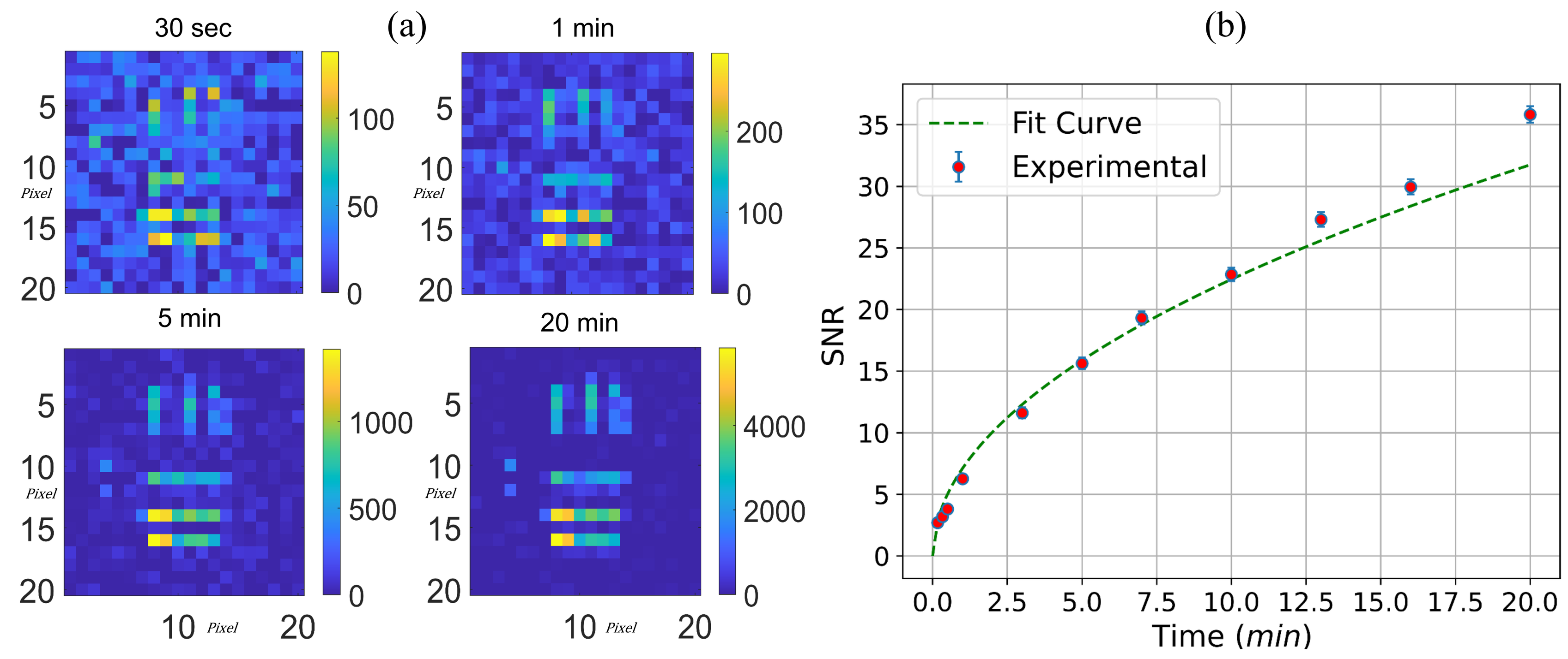


Fig 2: (a) Subset of Ghost images of the highlighted zone shown in Red in Fig 1 for different accumulation times and (b) SNR curve as a function of integration time.

> Si-Au Sample

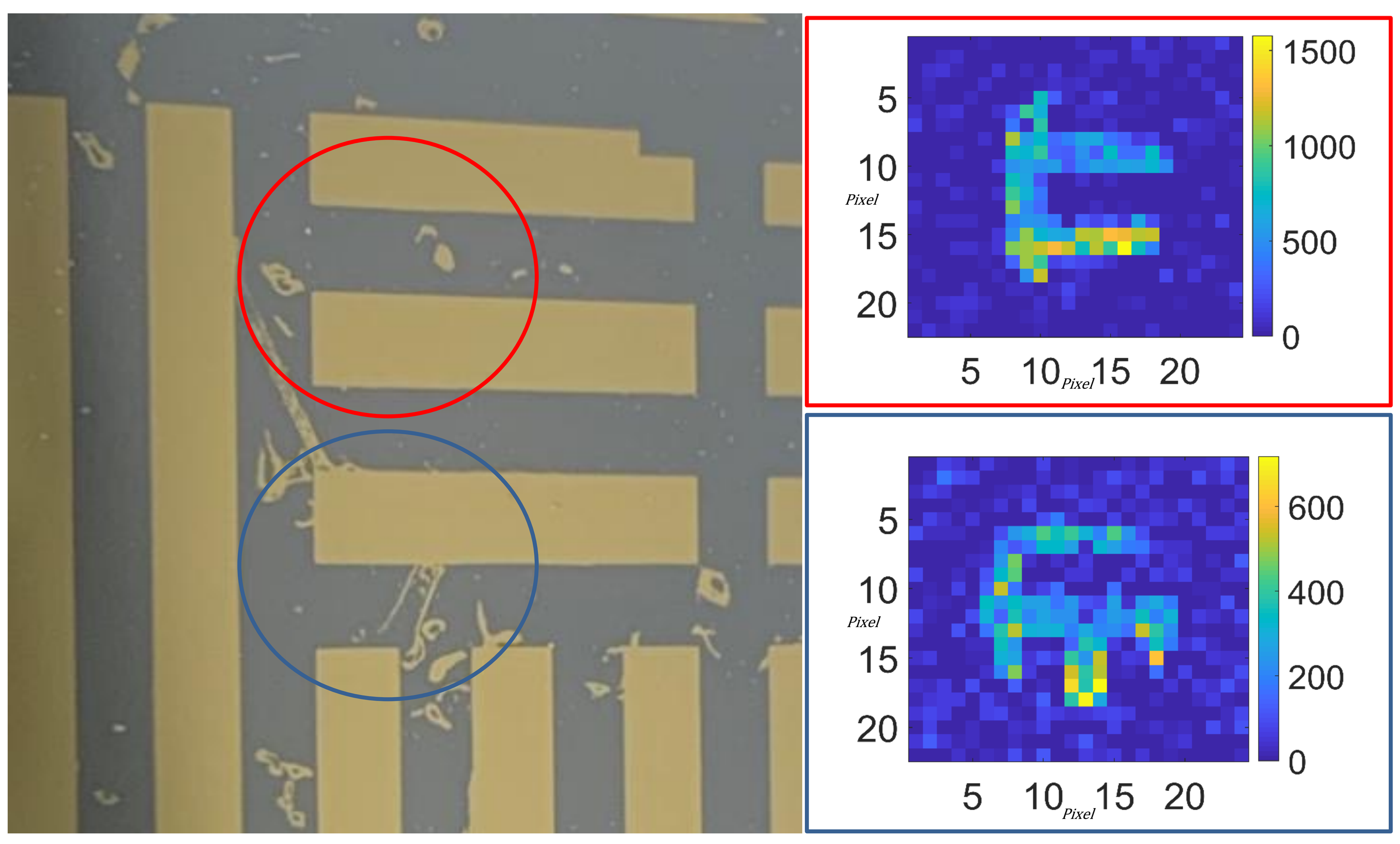


Fig 3: Ghost images of a doubly polished Si - Au Sample* with 2 mm Au slits on Si substrate with highlighted zones (Left) and corresponding ghost images (Right). Accumulation times ~ 5 min (Red Frame) and ~ 2 min (Blue Frame).

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Conclusion

Our results demonstrate the potential of this scheme to advance the field by providing faster and more efficient imaging capabilities with the possibility of investigating samples at wavelengths rendered inaccessible due to the unavailability of suitable cameras.

References:
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