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# PEAR - Plasmonic Electronically Addressable super-Resolution: Accelerating the in-depth understanding of biomedical processes at the nanoscale via a novel real-time, optical limit-breaking imaging technology

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## Abstract

PEAR offers an innovative solution for the next generation of microscopy. The method achieves imaging beyond the far-field diffraction limit via addressable plasmonic elements, which act similar to sensor pixels, potentially offering below 25 nm spatial resolution while providing faster than video rate imaging.

Furthermore, the technology has the following advantages:

- spatial resolutions far beyond the diffraction limit,
- deterministic,
- label-free,
- in-vitro capabilities, fully biocompatible,
- easy integration into existing microscopes: retrofittable,
- parallel read-out instead of scanning enables fast (video rate or higher) imaging,
- exchangeable Optical Chip: prevents deterioration of method.

## Methodology

The photonic chip contains an electronically addressable array of nanoscale elements, acting as quasi-pixels:

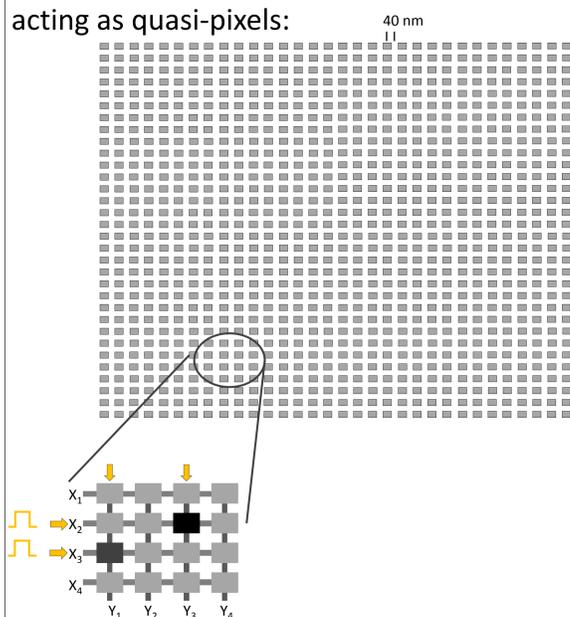


Fig. 1: Pixel array which forms the essential part of the optical chip facilitating PEAR.

These pixels can be switched from "on-resonance" to "off-resonance" via a modulated current. This modulation results in appreciable changes of the electric near-field strength above the pixels, which can be detected via optical heterodyne detection:

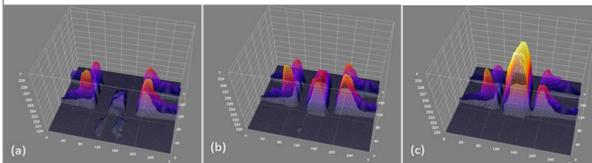


Fig. 2: From left to right: Experimental data of the modulation of a single pixel derived with a scanning nearfield microscope for three different currents (a) 0 nA, (b) 250 nA, (c) 960 nA.

The ability to rapidly address these active plasmonic elements and to encode information in the way the pixels are addressed enables retrieval of spatial information in the far-field, leading to sub-diffraction-limit imaging. Because of the known, nanolocalized addressability of the modulation, a dedicated computer algorithm is capable of extracting the contained information. A second benefit of the pixel-addressing is the resulting capability to read-out all the spatial information in parallel, which leads to unprecedented speed of image acquisition and enables real-time video rate investigations of mechanisms.

## Validation

In the following we are presenting tests to validate the high spatial resolution of PEAR and compare it against state-of-the-art microscopy resolutions:

Test of spatial resolution:

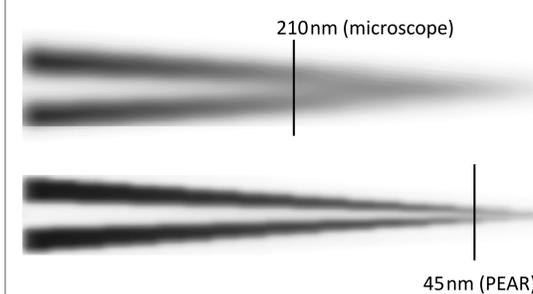


Fig. 3. Resolving power of a high NA microscope compared to PEAR.

Clearly, PEAR is providing a substantially higher spatial resolution, close to the physical size of its pixels.

This solution is bio-compatible and can be easily retrofitted into existing commercially available microscopes, and will provide a greatly improved in-depth understanding of subcellular mechanisms and even macromolecular reactions in real-time.

As an example we present a PEAR imaged biologically relevant sample, namely the eightfold symmetry of gp210 proteins around the nuclear pore complex fully resolving the central channel in comparison to a high NA microscope image which fails to resolve this central channel (below):

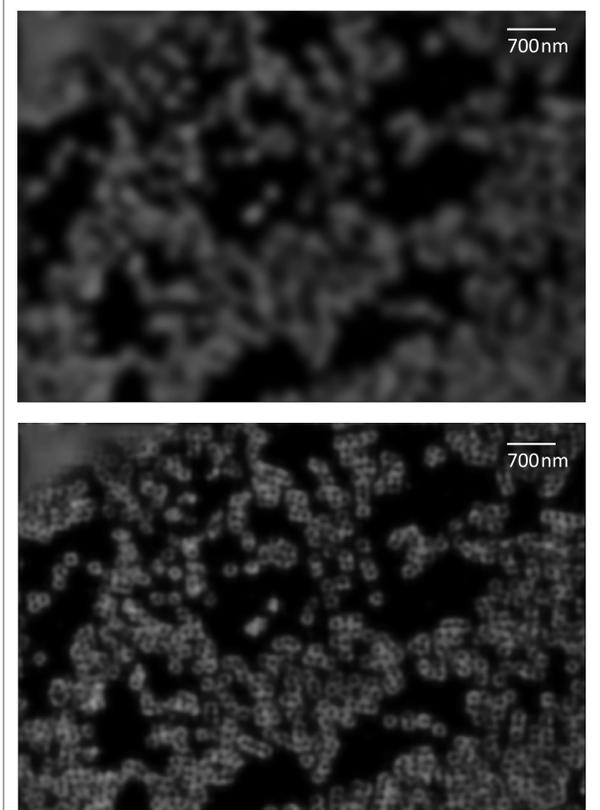


Fig. 4  
above: microscope image with NA=1.45,  
below: PEAR image with 40 nm pixel size.

## References

- [1] D. Zerulla, Patent Dec. 2017, PCT 2018  
[2] E. McClean, D. Zerulla, "Nanoscale Tailored Plasmonic Material", *Advanced Optical Materials*, 4(3), 339–486 (3/2016).

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