Implemented Pixeled Phosphor Detector (PPD) for laser coupled FEL beam diagnosis

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Introduction

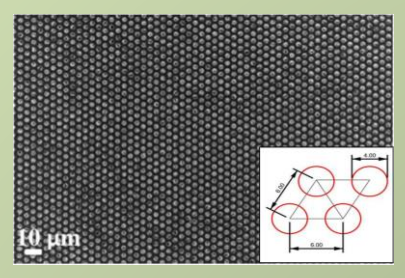
The diagnosis of the Free-Electron Laser (FEL) beam quality is an essential prerequisite in the field of pulsed high-power vacuum ultraviolet (VUV) and soft X-ray (SXR) sources [1]. The measure of femtosecond event requires the *pump-and-probe* technique and a precise control of spatial and temporal alignment of pump and probe sources is fundamental.

The Idea

Spatial and temporal alignment of FEL beam and the initial seed signal on a single device.

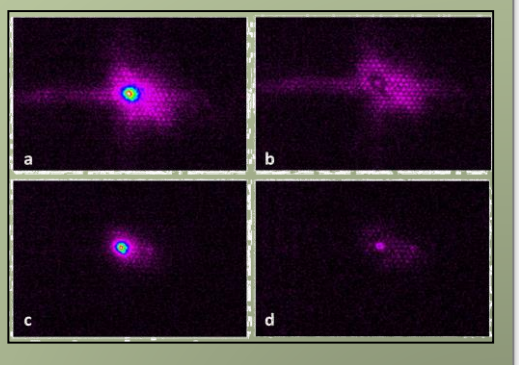
Spatial alignment

The Pixeled Phosphor Detector (PPD) [2] consists of micrometric holes in a silicon substrate arranged in a hexagonal lattice filled with suitable phosphors. The direct observation of the light emitted by the illuminated pixels allows the size of the central spot to be estimated due to the fundamental harmonic.



PPD with **P46** phosphors.

- Pulse energy: 7 µJ
- Wavelenght: 30.5 nm (40.7 eV)



a) after 1 s of integration (10 FEL shots);

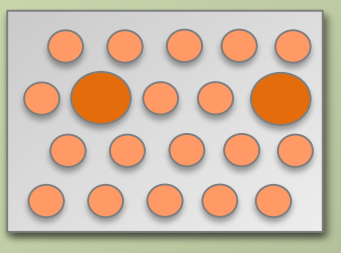
b) after ~10 s of exposure to the FEL beam;

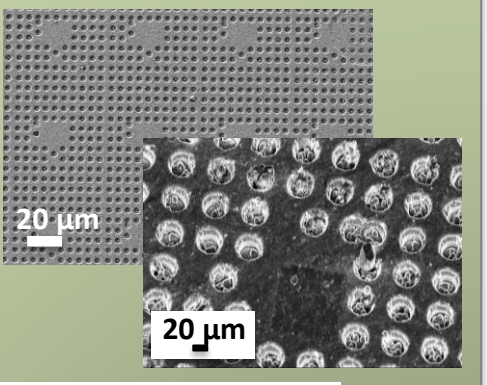
c) ITO coating (100 nm) after integration of 10 FEL shots;

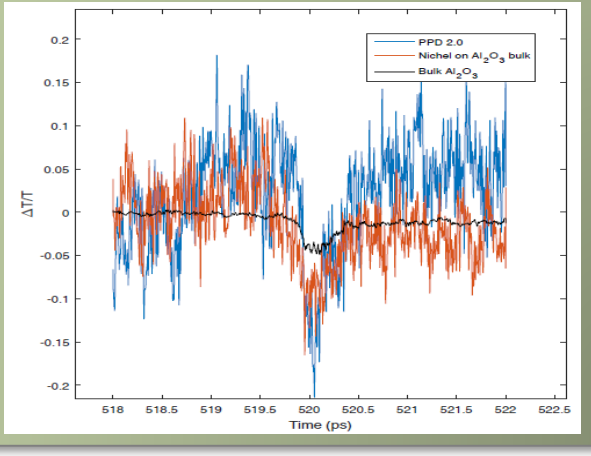
d) ITO coating after ~10 s of exposure to the FEL beam.

Temporal alignment

A seed signal, which is a pulsed laser (λ=260 nm) at the electron bunches repetition frequency, is temporally synchronized to overlap FEL beam. The use of Al_2O_3, which change trasmittance at specific wavelenght, allows to temporally align the FEL beam and the seed signal just observing the trasmittance of the material.







Potential Impact

The proposed device allows in-situ characterization and spatial alignment of FEL beam and the initial seed laser with an unprecedented resolution not achievable using classical phosphor screens. Furthermore, thanks to the change in the trasmittance when exposed to the FEL beam, the use of a layer of Al_2O_3 provides the temporal alignment of FEL beam and seed laser, avoiding several days actually needed to temporal tuning, by using only a couple of hours and enabling a real time control of pump and probe experiments.

[1] Chalupský, J. et al., Nucl. Instr. Meth. Phys. Res (2011), A 631 130–133. **[2]** Matruglio, A. et al., J. Synchrotron Radiat. (2016), 23, pp. 29-34.