Super resolution microscopy based on photo-excited nonlinear reflectivity (Ramot)

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A new, **label free**, far field super resolution scheme, aimed towards material science, which is based on ultrafast, nonlinear excitation of materials to non-equilibrium state. In a pump-probe scheme, we optically excite a spatial temperature profile throughout the diffraction limited spot, and probe the material with an overlapping beam. Due to nonlinearities in thermal properties, we demonstrate enhancement of at least x2 better than the diffraction limit including enhanced sectioning in Z plane.

The Need

Nanoscopy in semiconductors research and industry is a developing field with growing demand as device size decrease each year. Optical methods offering high resolution inspection are needed for post fabrication validation as well as process control. Current Super resolution techniques, based on luminescence, are inadequate for material imaging.

Potential Application

Our method can address issues such as: optical defects validation, optical process control and thermal imaging of active devices with unprecedented 3D spatial resolution. The technology can be integrated in existing inspection machines for high resolution imaging in research and various stage of R&D and manufacturing. The proposed physical mechanism can adapt any additional algorithmic method for further enhancing the resolution.

Stage of Development

The concept for SR imaging by utilizing the nonlinear response of TR was demonstrated. Using an air objective, resolution of 105 nm was achieved, well beyond the diffraction limit for the pump and probe beams. We have shown the applicability of the method to silicon, Au and VO2 nanostructures. We have also developed a simplified version of the super resolution optical setup. Further improvement in the absolute resolution can be expected. The data acquisition rate is inherently high due to the fast response of TR and its large cross section.

Patents

O. Tzang, O. Cheshnovsky. “METHOD AND SYSTEM FOR MICROSCOPY”. U.S. Patent 62/044,458, Sep 2 2014.

Supporting Publications:

1. O. Tzang, A. Pevzner, R. E. Marvel, R. F. Haglund, and O. Cheshnovsky, “Super-Resolution in Label-Free Photomodulated Reflectivity,” Nano Lett., vol. 15, pp. 1362–1367, 2015.

2. O. Tzang, Doron Azury, O. Cheshnovsky. “Super resolution methodology based on temperature dependent Raman scattering”. Optics Express Vol. 23 pp. 17929-17940, 2015.

3. O. Tzang, O. Cheshnovsky. “New modes in Label-Free super resolution based on photo-modulated reflectivity”, Optics Express Vol. 23, pp. 20926-20932, 2015.

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