Technology Offer

SNOM: New Sensitive Detection Method for Small Periodic Signals
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The invention relates to a new detection method for small periodic signals in Scanning Near Field Optical Microscopy (s-SNOM). Solving the problem of the rapid sampling rates necessary for lock-in amplification, the method is a powerful new readout system for various other applications as well.

Lock-in detection is a widespread technique, which enables the detection of very small periodic signals. However, it imposes constraints between the lock-in modulation frequency and the sampling rate, which makes it problematic when measuring very high frequency signals.

The problem was solved by a method based on the analysis of a phase-shifted, analogous copy of the modulation signal, which can be read out at rates significantly below the modulation frequency. This makes the signal real-time evaluation of high frequency signals with low amplitudes significantly easier and cheaper. The system has proven high performance in Scanning Near Field Optical Microscopy but can be used in other applications as well.

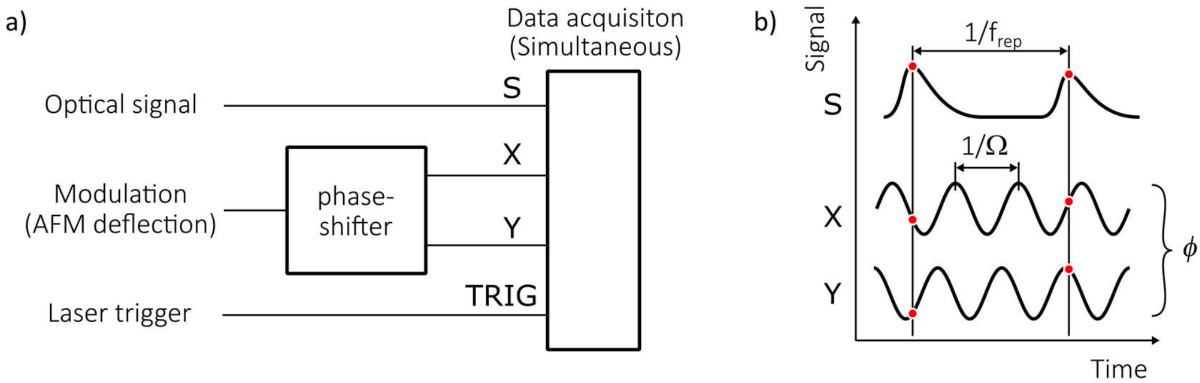

Fig. 1: Brief overview of the signal processing method. **a)** Besides the optical signal from the microscope tip *S* and a laser trigger (*TRIG*), the modulation signal is copied and phase shifted to form the pair (*X*, *Y*). **b)** The signals *X* and *Y* are sampled at the laser repetition rate entered by a trigger. From *X* and *Y* a phase relation can be obtained instantaneously for every sample.

Advantages

- Low computational overhead
- Real-time data acquesition
- High sensitivity
- Compatible for all components
- Cheap and easy to integrate into existing systems
- Adaptable for various applications

Applications

- Detection of small amplitude signals following a known reference frequency
- Limited compatibility of detection electronics due to frequency constraints
- Low SNR signals
- Limited sampling rates

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Background

In scattering-type Scanning Near Field Optical Microscopy (s-SNOM) the modulation signal for lock-in amplification is represented by the tapping frequency of the microscope tip. Short pulse lasers are often used to illuminate the tip. As each laser pulse contains only one datapoint of information, the laser repetition rate must be at least twice the tapping frequency, which relates to a strict relation between the two frequencies in the case of lock-in amplification. Current solutions to this problem are often just a compromise between the tapping frequency and the laser pulse rate, which limits the versatility of components.

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The invention solves the aforementioned limitations by converting the continuous sampling necessary for lock-in detection into a discrete sampling process where each laser pulse is recorded independently with a single sample. As visualized in figure 1 this conversion is achieved using analog electronics to create two narrow band copies (X,Y) of the modulation signal at frequency Ω that have a fixed phase shift relative to each other, which is in the optimal case $\pi/2$.

The two components X and Y are sampled simultaneously at each laser pulse according to the laser trigger input (*TRIG*). Therefore, the required sampling rate f_{rep} is significantly lower than that needed for other techniques, thereby reducing cost and greatly increasing versatility.

The components X and Y are used to obtain a unique value of the modulation phase ϕ for every laser pulse. The resulting dataset can be analyzed using fast and efficient algorithms. Low computational requirements enable real-time processing and facilitate operation of the entire device. The method is easily extended to multiple signals and multiple modulation schemes.

Patent Information

(Application Filed)

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