Pulse propagation studied en route by near-field microscopy

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Demands on speed and capacity for telecommunication and computer applications are increasing exponentially, while simultaneously the dimensions of the components have to decrease to the micro- or even the nanometer scale. In the optical domain, development of truly integrated optical devices, and especially microcavities, are key in order to meet these challenges.

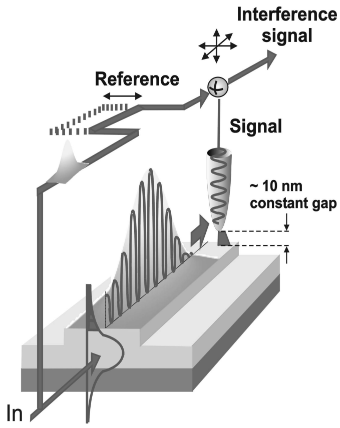

Figure 1 : Schematic representation of the pulse tracking experiment.

As the development of photonic devices advances, so too will the need to monitor the transient behavior of optical pulses as they propagate through such devices. However, peeking inside a photonic structure is far from trivial as conventional optical microscopy is limited by the diffraction limit. What occurs inside the device therefore remains mostly hidden. Recently we demonstrated [1,2] a non-invasive technique based on an optical photon scanning tunneling microscope (PSTM) that can be used to “visualize” pulses as they propagate through an optical device with both temporal and spatial resolution (see fig 1).

As we make use of a heterodyne detection scheme both the amplitude and the phase information [3] on the pulses is retrieved at the same time. At a reference time given by the position of an optical delay the position of a pulse is pinpointed. With this technique we have recently been able to observed time-resolved “ballistic” motion of ultrashort optical wave packets within a cylindrical microresonator. Figure 2 shows a measurement at a fixed reference time in which a 120 femtosecond pulse has just passed a ring-resonator. It is clearly visible that part of the pulse is coupled to two different modes in the resonator. By repeating this measurement for different reference times the motion of the pulse in the cavity is followed in time. This “*example*” of the direct visualization of the time evolution of light pulses in a complex photonic device shows how new insights into their behavior can be obtained.

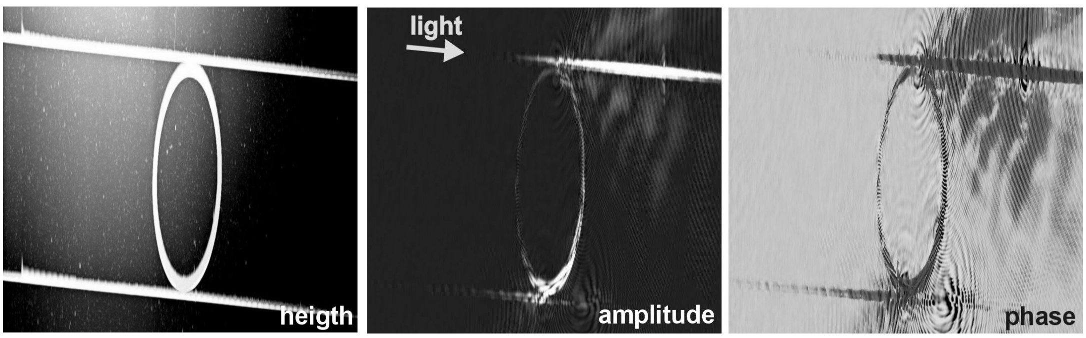

Figure 2 : Visualization of the time resolved motion of a femtosecond pulse (120 fs, λ = 1300 nm) through a cylindrical ring-resonator (radius 25 μm) measured by PSTM. From left to right the simultaneously measured topography of the structure (~250 x 70 μm), optical amplitude and phase of the pulses are shown. The optical amplitude clearly shows that part of the pulse which passes the resonator is coupled into the resonator. Two different modes can be distinguished.

References

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