DIGITAL-HOLOGRAPHIC ANALYSIS OF MATERIAL MANIPULATION CAUSED BY SINGLE PULSE FS-LASER APPLICATION

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1. INTRODUCTION
Digital-holographic microscopy (DHM) is the appropriate mean to measure changes in optical path length by quantitative phase contrast for better understanding of the laser-material interaction around the focal volume. We use DHM for refractive index measurement of femtosecond (fs)-laser manipulated Hydroxy-ethylmethacrylat (HEMA), which is a well-established contact lens material and moreover serves as phantom for transparent soft tissue.

2. SETUP, RESULTS, DISCUSSION AND REFERENCES
A single 350 fs pulse with 210 nJ energy was focused with an objective NA0.6 inside the copolymer HEMA. The laser pulse energy was 10 times above the damage threshold for HEMA of ca. 20 nJ. After laser treatment, quantitative DHM phase contrast [1] was used to measure the optical phase delay, caused by the irreversible laser-manipulation. Using the phase delay, φ(x) and thickness, d(x) of the affected region one can obtain values for the absolute refractive index, n(x). Averaging for 31 similar affected regions we obtained a refractive index change of 0.005 ± 0.003 in the focal point. The intended size of laser manipulation (focal spot size) was in the range of 3 µm laterally. The affected regions however, showed an axial distribution of 10 µm. Measuring the refractive index profile of fs-laser single pulses is essential for a better understanding of the interaction of multiple laser pulses for applications like cell and tissue manipulation, ophthalmology or waveguide writing. Consequences of refractive index changes are e.g. beam deviation caused by the forego laser pulse. The results presented here can be used as a basis for simulations of laser tissue (material) interaction and prediction of laser pulse displacement by refractive index change. To our knowledge, this is the first refractive index measurement of a single applied fs-laser pulse in HEMA. We present refractive index profiles of single and multiple pulses to show feasible interaction processes which take place at fs-laser treatment of transparent soft tissue.