Abstract

This study introduces a new approach for achieving ultrafast imaging with high repetition rates while ensuring that the images are free from speckle artifacts. This work is based on previous results within an AFOSR funded project in the working groups of Prof. Vogel and Dr. Linz at the Institute of Biomedical Optics. In the previous work, a ps (picosecond) laser was used to pump a dye cell and it was shown that the emission of the dye cell can be used for speckle-free imaging at high temporal and spatial resolution. However, the ps laser system had a repetition rate of 0.5 Hz and the novel light source allows for stroboscopic imaging only. In the project, high speed imaging with repetition rates up to kHz and MHz is desired and thus, in the present thesis, a fs (Femtosecond) laser with a repetition rate up to 1 MHz will be investigated for pumping the dye cell and higher repetition rates. Hence, the present method involves using an ultrafast laser (femtosecond laser) directed onto a cuvette containing a solution of rhodamine 6G dye. Three different cuvette setups were utilized in the project: a standard cuvette, followed by a standard cuvette equipped with a magnetic stirrer that stirs the solution continually and finally, a customized cuvette featuring a pump with a high continuous flow of solution. In the three setups, the concentration of rhodamine 6G is 0.1 g/l dissolved in 98% ethanol was used. The emission of the fs pumped dye cell was characterized in dependence on pump pulse energy and repetition rate for each setup. The emission of the dye cell at maximum pulse energy was finally used as an illumination source for a US Air Force (USAF) target and the resulting images were captured using a high-speed camera. The quality assessment of the images with contrast-to-noise ratio (CNR) and contrast value (K value) were calculated for each image.

The focus of the investigation is on reducing coherent artifacts like speckles in ultrafast imaging at higher repetition rates in ultrafast imaging, with the goal of improving image quality and spatio-temporal resolution. The methodology involves the design of innovative configurations for the dye cuvette to establish a light source, which helps to address the challenges associated with speckle formation during ultrafast imaging.