Ph.D. proposal

Research Lab: Institut Fresnel

Ph.D. director: Frank WAGNER
Email: frank.wagner@fresnel.fr
Address: Institut Fresnel, Domaine Universitaire de Saint Jérôme, 13397 Marseille
Phone: 0413945554

Co-director: Jean-Yves NATOLI

Title: **Study of light-matter interaction in optical materials under high intensity ultraviolet nanosecond multipulse irradiation**

Description:

The resistance of optical materials to intense nanosecond single pulse irradiation has been studied in detail during the last years. These studies were mostly driven by the large 'inertial confinement fusion lasers' projects like the Laser Mégajoule in France and the NIF in the US. Another challenge appearing today is to produce optical components that resist to a high number of slightly less intense nanosecond pulses. The aimed pulse numbers are typically 10^9 for space applications [1] but also for laser machining in standard applications.
Many materials show in fact the so-called fatigue effect: a decrease of the laser damage threshold with increasing pulse number. In the UV, this effect is often induced by cumulative material modifications.
Today's laser systems have very limited life time when emitting at 266 nm. These problems at 266 nm are a serious bottle neck for the development of reliable and powerful lasers at this interesting wavelength whether we speak about pulsed lasers or continuous wave lasers.
The ILM team of the Institut Fresnel has already carried out a number of studies on laser-induced aging at UV wavelengths [2,3]. We lately showed that it is possible to follow the evolution of fused silica during 266 nm irradiation using laser induced fluorescence up to the damage event [4]. Measurements of the linear and non-linear refractive index can also be realized to evaluate the laser induced modifications.
During this Ph.D. thesis we propose de carry out a systematic study of the fatigue effect varying the critical parameters of the irradiation: beam size, pulse number, pulse repetition rate and others. A model describing well-known and new data will be developed in order to describe the physical mechanisms of the laser induced modifications leading to laser damage.
The optical materials to investigate are the ones dedicated to high power multipulse applications such as fused silica which can also serve as reference sample for the applied metrology. The interesting nonlinear optical crystals are LBO and CLBO that are investigated in collaboration with Crystal Laser (Nancy, France)
The experimental setup including a nanosecond Nd:YAG laser at a pulse repetition rate of 100 Hz has been developed and was optimized for destructive measurements and fluorescence measurements.

Bibliography:

[1] D. Wernham et al. ‘Verification for robustness to laser-induced damage for the Aladin instrument on the ADM-Aeolus satellite’ Proc. SPIE 10014, Laser-Induced Damage in Optical Materials, 1001408 (Dec 6, 2016)
[2] C. Gouldieff et al,” Nanosecond UV laser-induced fatigue effects in the bulk of synthetic fused silica: a multi-parameter study”, Opt Express, Vol. 23, Issue 3, 2962-2972 (2015)
[3] F. R. Wagner et al. "Contrasted material responses to nanosecond multiple-pulse laser damage: from statistical behavior to material modification", Opt. Lett 38, 1869-1871 (2013)
[4] A. Beaudier et al., “Using NBOHC fluorescence to predict multi-pulse laser-induced damage in fused silica”, Optics Comm. 402, 535-539 (2017)