Development of a High Power Femtosecond Laser

Pieter H Neethling[1], Erich G Rohwer[1], Heinrich Schwoerer[1], Lourens Botha[1,2]
[1] *Laser Research Institute, University of Stellenbosch, Stellenbosch, South Africa*
[2]*National Laser Centre, CSIR, Pretoria, South Africa*
Author e-mail address: PieterN@sun.ac.za

Abstract: The Laser Research Institute and the CSIR National Laser Centre are developing a high power femtosecond laser system in a joint project with a phased approach. The laser system consists of an fs oscillator and a regenerative amplifier. An OPCPA amplifier and a multi-pass amplifier are under development.

1. Introduction and Current Status

The development of a high power femtosecond laser has been proposed as a possible project under the umbrella of the Photonics Initiative of South Africa PISA. This follows a joint program on ultrafast and intense laser science between the Laser Research Institute (LRI), University of Stellenbosch and the CSIR National Laser Centre (NLC), which was developed in the years 2004 and 2005, where a phased approach was proposed. This program with its final goal of a PetaWatt laser facility is designed in four to five successive technological phases, each of them having a particular scientific value, and particular educational and technological challenges.

Both the LRI and the NLC have started the first phase several years ago and have gained a relevant expertise in femtosecond laser science and applications. Whereas the NLC focuses on spatial and temporal pulse shaping, coherent control of molecular dynamics and micro machining, the LRI's focus lies in ultrafast molecular spectroscopy and ultrafast electron diffraction of solids. All these methods complement each other and all are requirements and necessary ingredients for the progress of the overall program. Hence, essentially the first phase of the proposed project has been successfully completed. For a first phase in amplification a regenerative amplifier has been built up in order amplify pulses from a Coherent Mira fs laser oscillator. In this work the design and characteristics of this amplifier system will be presented.

2. Current Status and Next Phase of Development

The second phase of the project is currently being implemented. The teams focus on strengthening their specific niche areas for the benefit of the whole program: the NLC contributes pulse shaping in space and time as a prerequisite of all high power lasers, the concepts of coherent control and its expertise in diode pumped solid state lasers, whereas the LRI builds two successive amplifications stages based on parametric amplification and stimulated emission to reach the 1 TW level.

The proposed concept is a dual amplifier based on optically pumped chirped pulse amplification OPCPA as first stage, providing excellent mode quality, broad amplification bandwidth and efficient energy gain, and as second stage a conventional multi-pass Ti:sapphire amplifier as power amplifier. These amplifiers will be used to amplify the pulses from the Coherent Mira/BMI amplified femtosecond laser at the LRI. Ideally the OPCPA stage should be pumped by a 100 – 300 ps laser with tens of mJ pulse energy, matching the stretched pulse duration. This laser will be developed by the CSIR/NLC. The Ti:sapphire multi-pass amplifier will be pumped by an existing Nd:YAG laser. This approach is followed in most of today's high intensity laser systems. It requires a careful monitoring and shaping of temporal and spatial profile of the laser beam, which is the expertise of the NLC.

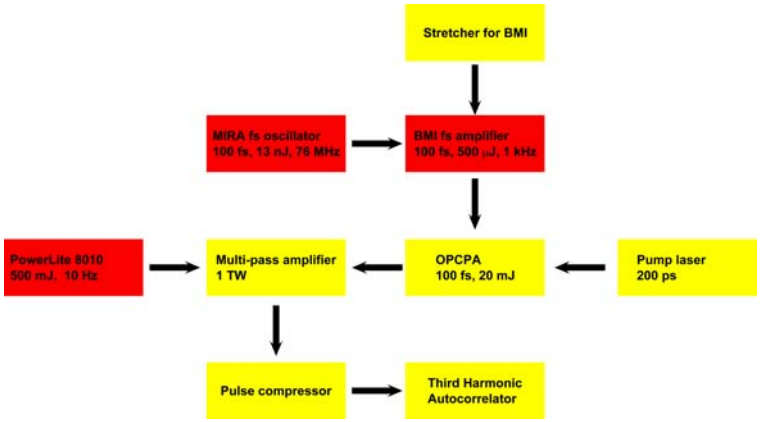

Fig 1: Schematic of the components required for Phase 2 of the high power femtosecond initiative. Elements in red are existing infrastructure while elements in yellow will need to be developed.