

# Femtosecond Single-Mode Diode-Pumped Cr:LiSAF Laser Mode-Locked with Single-Walled Carbon Nanotubes

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## Summary

We present a low threshold and low pump-power Cr:LiSAF laser, excited with an inexpensive single mode laser diode emitting 120 mW. This laser is passively mode-locked with new Saturable Absorber Mirrors (SAMs) based on carbon nanotubes.

## Introduction

Femtosecond laser sources are very attractive devices for many applications such as seeding of high power amplifiers, non-linear optics, pumping of optical parametric oscillators or performing ultrafast spectroscopic investigations. Laser materials with large gain bandwidth are needed for ultrashort pulse generation. The widest bandwidths are obtained with vibronic lasers: among them Cr:LiSAF is a particularly interesting medium since it can be directly diode-pumped [1]. Saturable absorbers are most effective to induce self-starting passive mode-locking allowing simpler and more reliable ultrafast sources. The state-of-the-art solution is represented by Semiconductor Saturable Absorber Mirrors (SESAMs), but recently new carbon nanotube saturable absorbers have been extensively investigated in solid state lasers. They benefit from a much simpler fabrication process that allows lower costs. Moreover, compared to SESAMs they have favorable properties such as larger bandwidths, faster recovery times and smaller saturation fluence. Currently it is reported their use with Ti:Sapphire lasers [2], Cr:Forsterite or Cr:YAG lasers, or other sources such as Nd-, Yb-, Tm- doped bulk lasers [3]. In this work we present for the first time, to the best of our knowledge, the use of Single Walled Carbon Nanotube Saturable Absorber Mirrors (SWCNT-SAMs) to operate a Cr:LiSAF laser in femtosecond soliton mode-locking regime.

## Setup and results

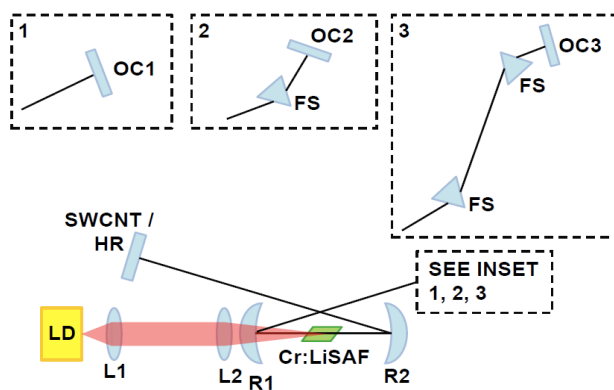


Fig 1. Cavity layout. LD: pump laser diode; L1: aspheric lens (f=6 mm); L2: spherical lens (f=50mm); R1 and R2: curved mirrors HR @800-900 nm AR @670 nm (R1=50 mm, R2=100 mm); FS: fused silica prism; OC1: output coupler for CW experiments (T=0.5%, 1%, 2%, 5%); OC2=OC3: output couplers for central wavelength tuning and ML operation, T=1%, 30° wedge.

The pump source of the X-folded resonator is a single mode laser diode emitting 120 mW at 660 nm. The active media is a 3%-doped, 4-mm-long, Brewster-cut,

Cr:LiSAF crystal. Different output couplers have been tested in CW experiments (see Fig 1 Inset 1). The optimum output coupling transmission turns out to be 2%, with a slope efficiency exceeding 32% and an absorbed pump power at threshold of 27 mW. A very low 16.5 mW absorbed pump power at threshold was measured with the 1% output coupler employed in the CW mode-locking experiments. We also measured the laser tunability using a dispersive Fused Silica (FS) prism in the cavity (see Fig 1, Inset 2). The tuning range extended from 800 to 935 nm, covering almost the entire gain bandwidth, mainly limited by the mirrors optical coatings. In the mode-locking cavity (see Fig 1, Inset 3) a second FS prism separated by 43 cm from the first one is used for intracavity dispersion compensation. The best result obtained was a 122-fs-pulse train with a bandwidth of 7.5 nm (fwhm), centered at 875 nm, as shown in Fig 2. The time-bandwidth product was close to the Fourier limit and the average output power was about 16 mW. Even larger bandwidths have been obtained with larger time-bandwidth products, turning out in slightly longer pulses. Mode-locking threshold was relatively low, occurring at an absorbed pump power of about 73 mW and output power of 4.7 mW. The central output wavelength tunability in mode-locking operation was relatively narrow, in fact continuous tuning was possible only within 14 nm, from 868 nm up to 882 nm (Fig 3).

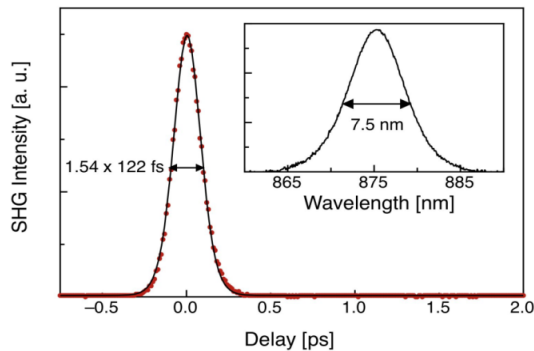


Fig 2. Pulse autocorrelation trace and spectrum

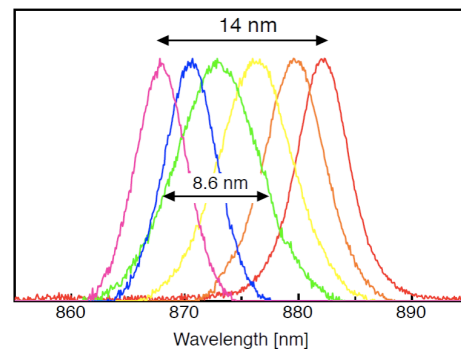


Fig 3. Mode-locking tunability range

## Conclusions

In this work we demonstrated that a Cr:LiSAF laser can be mode-locked with SWCNT-SAMs. The best results we obtained are 122-fs pulses with an average output power of 16 mW and a central output wavelength tuning range of 14 nm. Our results suggest that increasing the pump power can be beneficial both for reducing pulse durations and extending the tuning range.

## References

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