OPTIMIZATION OF THE 2PEF PROCESS

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Abstract

The present work reports the study of the optimization of the two-photons excited fluorescence (2PEF) in fluorescein and Meh-PPV solutions through ultrafast pulse shaping and genetic algorithm.

Samples

The fluorescein and MEH-PPV solutions concentrations are 0.36 mg/ml and 0.19 mg/ml respectively. The absorption spectra in the UV-Vis region, obtained with a Cary 17 spectrophotometer, are presented in Fig.2. These two chromophores present strong 2PEF when excited above linear absorption wavelength at nonresonant region with strong laser pulse.

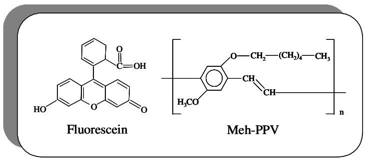

Figure 1: Molecular structures of the compounds investigated.

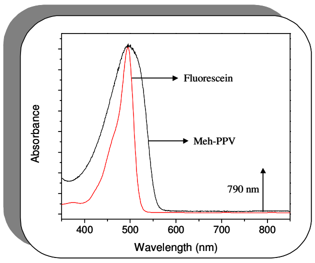

Figure 2: Absorbance spectra for the fluorescein and Meh-PPV dissolved in methanol and in chloroform, respectively.

Experimental setup

In this experiment were used laser pulses at about 790 nm with approximately 15 fs, delivered by a commercial Ti:sapphire Kerr-lens modelocked (KLM) laser from K&M company, operating at around 80 MHz repetition rate to indice the 2PEF in our solutions. The typical average power of the laser was 400 mW (~5 nJ per pulse).

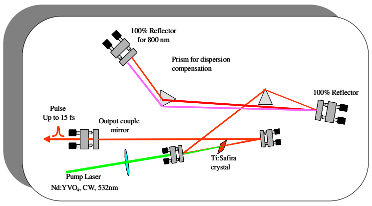

Figure 3: KLM Ti:sapphire femtosecond laser cavity.

In this work we have used a micromachined deformable mirror (MMDM) from OKO technologies to pulse shaping in the phase domain. The mirror in the MMDM is a 600 nm gold-coated silicon nitride membrane (8 mm x 30 mm) suspended over an array of 19 actuator electrodes on a printed circuit board. The maximum deflection is 4 μm with response of 1 ms. Potential applied to the actuator creates an electrostatic attraction between the membrane and the electrode, deforming the mirror surface. The total surface deflection of the mirror is a linear combination of the influence functions for all actuators. Deviation of the mirror surface causes the light to travel a different path, changing the phase of the spectral component in the area of the deformation. The MMDM is placed at the Fourier plane of a zero dispersion stretcher consisting of a 600 grove/mm ruled grating and a 25 cm focal-length mirror. In order to control the deformation of the MMDM we have used a genetic algorithm (GA) program implemented in LabVIEW language. Such program is very powerful in our case of multiple variable problem.

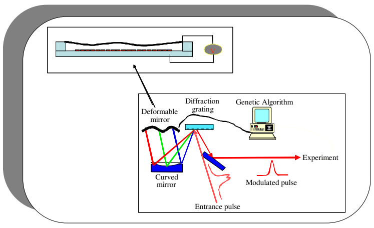

Figure 4: Experimental setup for pulse shaping.

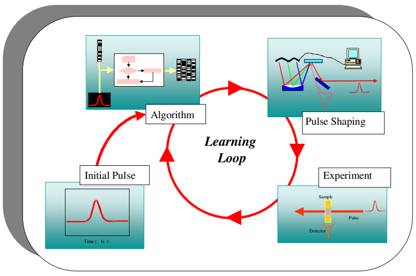

Figure 5: Experimental setup for pulse shaping optimization using GA..

Results

Using our pulse shaping setup we have optimized the 2PEF in our nonlinear samples. The fluorescence was collected either by a fiber spectrometer or a PIN photodetector with lock-in amplifier. The fluorescence signal was used as a feedback signal in the GA optimization code (fitness). The optimization of the 2PEF is obtained using an evolutionary strategy which begins with a set of random pulse shapes whose associated fluorescence signal is measured. Those pulses that produce the most intense fluorescence effect are retained, duplicated, perturbed and reproduced, as the GA requires. This process is repeated until a desired number of interactions (generations). Basically, the GA is a search and optimization methodology inspired in the biological evolution, consequently, the biology concepts such as chromosome (father and children), reproduction, crossover, mutation, etc are applied in the computational GA code.

The figure 6 illustrate the evolution of the fitness parameter during the GA optimization process. The figure 7 illustrate the fluorescence spectra of the two solutions before and after the 2PEF GA optimization.

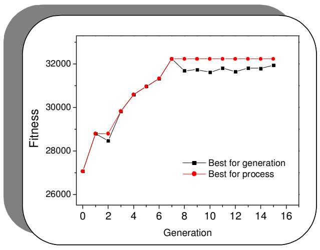

Figure 6-1: 2PEF optimization process achieved for the Meh-PPV.

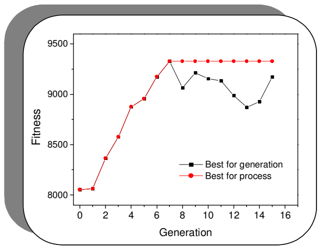

Figure 6-2: 2PEF optimization process achieved for the fluorescein.

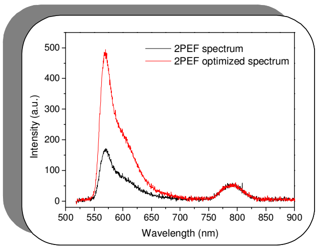

Figure 7-1: 2PEF spectra for the Meh-PPV.

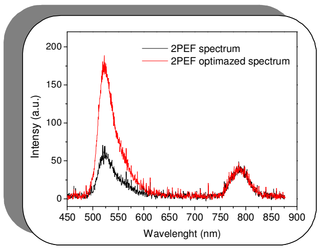

Figure 7-2: 2PEF spectra for the fluorescein.

We have found as the best parameters for our GA to optimize the 2PEF: chromosome number (population)=20, generation number=15, generation gap=90%, crossover rate=90%, mutation=10%.

Conclusion

The present work reports the study of the optimization of the 2PEF in fluorescein and Meh-PPV solutions through the ultrafast pulse shaping. In general, we have observed average gain of approximately 2.5 times of the 2PEF after the optimization process. These results show a good degree of control of the 2PEF processes.

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