

RPPR Final Report

as of 15-Sep-2021

Agency Code: 21XD

Proposal Number: 74205PHREP

Agreement Number: W911NF-19-1-0514

INVESTIGATOR(S):

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Final Report for Period Beginning 17-Sep-2019 and Ending 16-Mar-2021

Title: First Optics and Laser Laboratory at CSULB

Begin Performance Period: 17-Sep-2019

End Performance Period: 16-Mar-2021

Report Term: 0-Other

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Distribution Statement: 1-Approved for public release; distribution is unlimited.

STEM Degrees:

STEM Participants:

Major Goals: The proposal requested for the acquisition of a tunable titanium-sapphire continuous wave (CW) and an ultrafast pulsed laser systems for establishing the first optics and laser laboratory at CSULB. The laboratory will provide both theoretical modeling tools (finite-difference time-domain and COMSOL Multiphysics) as well as experimental measurement tools for the design, development, characterization, and demonstration of optical systems and devices. The requested lasers will enable us to probe various optical phenomena in the ultraviolet (UV), visible (Vis), and near infrared (NIR) regions of the electromagnetic spectrum. The research program will explore a broad range of optical phenomenon with applications ranging from optical communications to bio/chemical sensing. As such, a coherent, tunable, and intense light source is a fundamental requirement for the execution of the research and training programs at CSULB.

The proposal also requested for the acquisition of a finite element numerical modeling tool (COMSOL Multiphysics), an optical spectrum analyzer and a vibration isolated optical table. The simulation software will be used for numerical verification of our hypothesis, performance evaluation, and optimization of the proposed designs. In addition, the software will be used to train students and enable them to independently model optical and electromagnetic phenomena. It should be noted that requested modeling tool is widely used in the industry, defense sector as well as academic research, as such competency in using this tool is highly desirable for students.

One of the educational goals of the new laboratory is to train students and enable them to advance their respective fields. The proposed research work involves analytical calculations, numerical modeling as well as practical measurements and thus will provide training opportunities in all three aspects of the research work.

Both graduate and undergraduate students working in the optics and laser laboratory will learn numerical modeling techniques for simulating electromagnetic and other physical processes using the commercial simulation tools: finite-difference time-domain (FDTD) and COMSOL Multiphysics. The training will be conducted and monitored by the PI and students working in groups will also have the opportunity to learn from senior members of the group as well. FDTD is a dedicated time domain tool for solving Maxwell's equations. Being a time domain method, the FDTD method is an efficient tool for investigate the response of a system over a broad bandwidth using a single simulation run. Typically, the method is employed for the study of small structures compared to the wavelengths involved, such as, nanophotonics, solar cells, metamaterials, photonic integrated circuits etc. COMSOL Multiphysics can model different physical phenomena including electromagnetics, acoustics, heat transfer, fluid flow, and structural mechanics.

In addition, students will have the opportunity to gain hands-on experience using various optical/electronic

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components and instruments including advanced laser systems, develop optical measurement setups, learn how to interface and communicate with various instruments, create automated schemes for data collection, develop signal processing algorithms, and perform analysis of the acquired results.

To further broaden the impact of the acquired systems, Lab visits will be organized for groups of students. Students will learn the working principal of the laser systems and associated optical and electronic instrumentation. A simple demonstration of the system will also be performed to stir the excitement and motivation and attract students towards STEM programs.

Accomplishments: I am pleased to report here that we were able to acquire and install the much-needed equipment requested in this grant. I would like to thank the funding agency for the support which will transform both research and education at our institution.

The period of performance of the project was modified due to COVID19 related delays from the supplier. My request for a six-month extension was approved via Amendment P00001 dated 22nd of Oct. 2020 (please see Appendix D in the upload section of this report).

Unfortunately, COVID19 delayed both the supply and installation of the equipment. The installation was carried out on February 23rd and 24th 2021 by a service engineer from MKS/Spectra Physics (the supplier of the laser systems). The pulsed laser system and the Matisse laser system was installed successfully. However, we ran into an issue for using the frequency doubler as well as the frequency mixing module simultaneously. Some external optics were required for the simultaneous operation which was ordered by the supplier and received on July 1st 2021. The supplier ensured that they would resolve the issue in the next few weeks. At the time of writing this report, most of the system is operational except that the doubler and mixer cannot be used simultaneously. We are hoping that this issue will be resolved in the next two weeks. For more details including images of the installed systems please see the attached final report document.

Training Opportunities: Due to the delayed installation of the system, we were unable to train any students as of now. However, we intend to train both undergraduate and graduate students regularly via lab visits and research projects. Specially students taking electromagnetic and optics related courses.

Results Dissemination: The grant was publicized via college of engineering website of California State University Long Beach.

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: Nothing to Report

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Partners

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I certify that the information in the report is complete and accurate:

Signature: Aftab Ahmed

Signature Date: 7/4/21 5:05PM

Aftab Ahmed, CSULB

FINAL TECHNICAL REPORT

FUNNING OPPORTUNITY: Research and Education Program for Historically Black Colleges and Universities and Minority-Serving Institutions Equipment/Instrumentation (FY-2019)

AWARD/CONTRACT NUMBER: W911NF1910514

TITLE: First Optics and Laser Laboratory at CSULB

PRINCIPAL INVESTIGATOR: Aftab Ahmed

INSTITUTION: California State University Long Beach

TOTAL AMOUNT: \$449,320

REPORT DATE: June 21, 2021

First Optics and Laser Laboratory at CSULB

1. Equipment Requested and Acquired:

This proposal requested for the acquisition of tunable titanium-sapphire continuous wave (CW) and ultrafast pulsed laser systems for the first optics laboratory at California State University Long Beach (CSULB). I am pleased to report here that we were able to acquire and install the much-needed equipment requested in this grant. I would like to thank the funding agency for the support which will transform both research and education at our institution. The laboratory will provide both theoretical modeling capabilities as well as experimental tools for the design, development, and demonstration of optical systems and devices in a wide range of areas from renewable energy to communications.

The major requested equipment included three laser systems along with a frequency double to extend the spectral range to shorter wavelengths:

1. Tunable CW titanium-sapphire (Ti:Sapphire) laser
2. Tunable ultrafast pulsed laser
3. C-band laser

In addition to the laser systems, the proposal also requested for the acquisition of a finite element numerical modeling tool (COMSOL Multiphysics), an optical spectrum analyzer and a vibration isolated optical table. A modification was made to the requested equipment via email request dated Oct. 24th 2019 which was approved on Oct. 31st 2019, a copy of the email approval notification is attached as appendix A.

Table 1 below presents the list of the originally request equipment, the modified list of equipment and the acquired items. The modification requested for the removal of items numbered 6 and 9 and inclusion of items 10 and 11 to increase the spectral range of our CW laser system. Further, items 6 and 9 were no longer need as we purchased them using internal funding prior to the approval of the grant application. Please see appendix B for the invoices for the major items in this activity. Further details are provided in the final financial report submitted by the Office of Research & Economic Development, CSULB Research Foundation.

Please note that item # 7, the optical spectrum analyzer was requested but we were unable to purchase it from the supplier due to price increase of the item during the application review process. Please see appendix C for the email conversation with the supplier.

	Originally Requested Equipment	Modified Requested Equipment	Acquired? YES of NO	Cost USD
1	Matisse CS Ti:Sapphire laser	Matisse CS Ti:Sapphire laser	YES	78,000
2	Millennia eV – 25 W Pump laser for Matisse	Millennia eV – 25 W Pump laser for Matisse	YES	38,000
3	Mai Tai HP Pulsed laser	Mai Tai HP Pulsed laser	YES	105,000
4	WaveTrain 2 Frequency doubler	WaveTrain 2 Frequency doubler	YES	25,000
5	Chiller Rack WW	Chiller Rack WW	YES	6,400
6	COMSOL Multiphysics	--	NO	
7	Optical spectrum analyzer	Optical spectrum analyzer	NO	
8	Vibration isolated optical table	Vibration isolated optical table	YES	11,610
9	C band tunable laser	--	NO	
10	--	Mix-SFM-19 Frequency mixer	YES	54,000
11	--	AP-SF1-1950 Single Frequency fiber laser – 1950 nm	YES	30,850

Table 1. Requested and acquired equipment.

The period of performance of the project was modified due to COVID19 related delays from the supplier. My request for a six-month extension was approved via Amendment P00001 dated 22nd of Oct. 2020 (copy attached - Appendix D).

2. Delivery and Installation:

Figure 1 below shows some of the items at the receiving station at CSULB.



Figure 1. Optical table and Matisse CS laser system accessories at the receiving station at CSULB.

All items were moved to the newly developed optics and laser laboratory at CSULB. The laboratory is located on the ground floor in the VEC building and consists of rooms 135 and 136. Room 135 is dedicated for providing numerical simulation facilities, where four desktop computers are installed. Room 136 is dedicated for housing the two optical tables and the laser systems. Figure 2 below shows the basic layout of the lab.

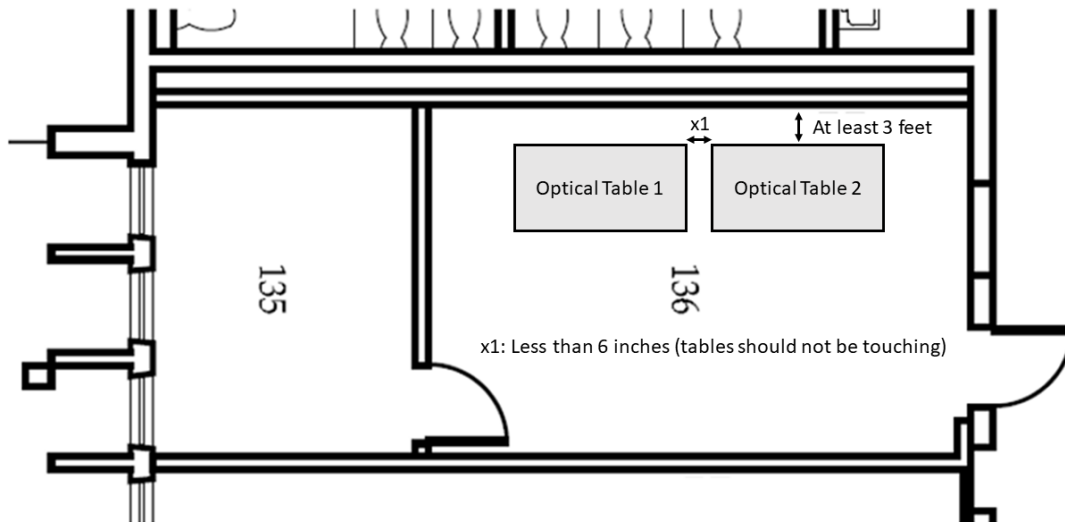


Figure 2. Layout of the newly developed optics and laser laboratory at CSULB.

Aftab Ahmed, CSULB

Figure 3 below shows some of the components of the laser systems before the installation.



Figure 3. Various components of the CW and pulsed laser systems before installation.

The installation was carried out on February 23rd and 24th 2021 by a service engineer from MKS/Spectra Physics (the supplier of the laser systems). Figure 4 and figure 5 below shows some of the progress during the installation process.

The pulsed laser system and the Matisse laser system was installed successfully. However, we ran into an issue for using the frequency doubler as well as the frequency mixing module simultaneously. Some external optics were required for the simultaneous operation which was ordered by the supplier and were received on July 1st 2021. The supplier explained the delay by saying that their service engineer has left the company and because of that they are behind on a few job orders. The supplier ensured that they would resolve the issue in the next few weeks. So at the time of writing this report, most of the system is operational except that the double and mixer cannot be used simultaneously. We are hoping that this issue will be resolved in the next two weeks.

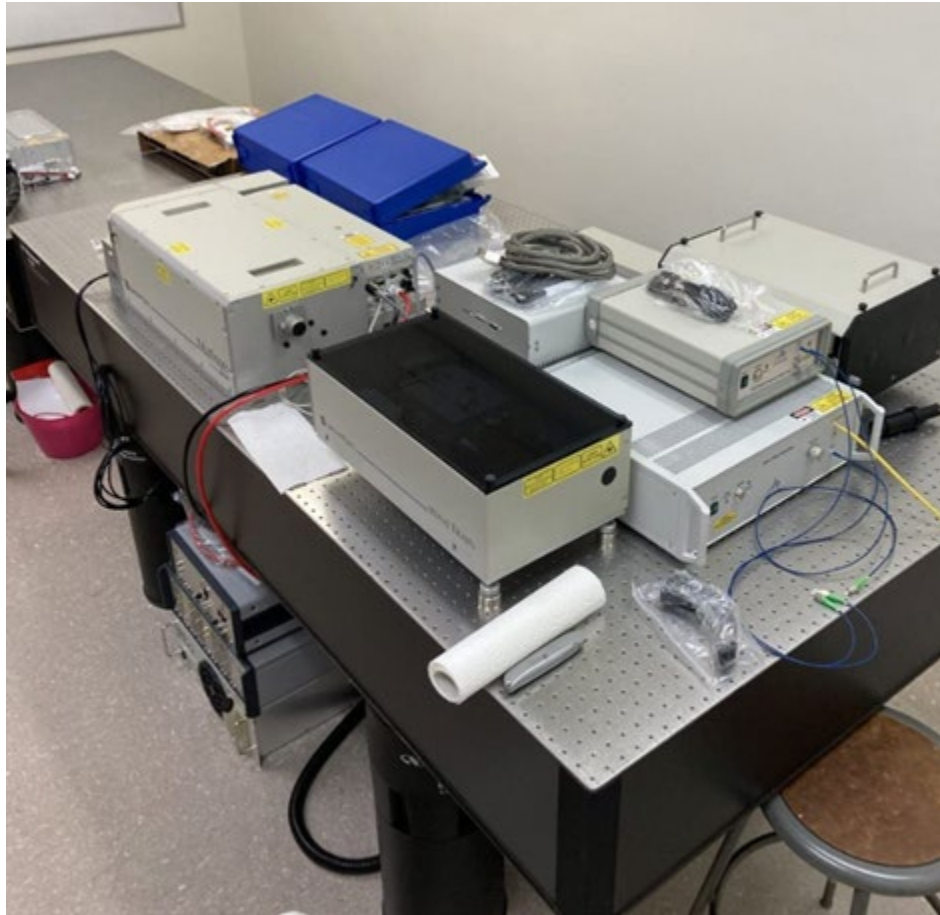


Figure 4. Optical tables in VEC-136 and various laser components during installation.



Figure 5. Installation – the power supply

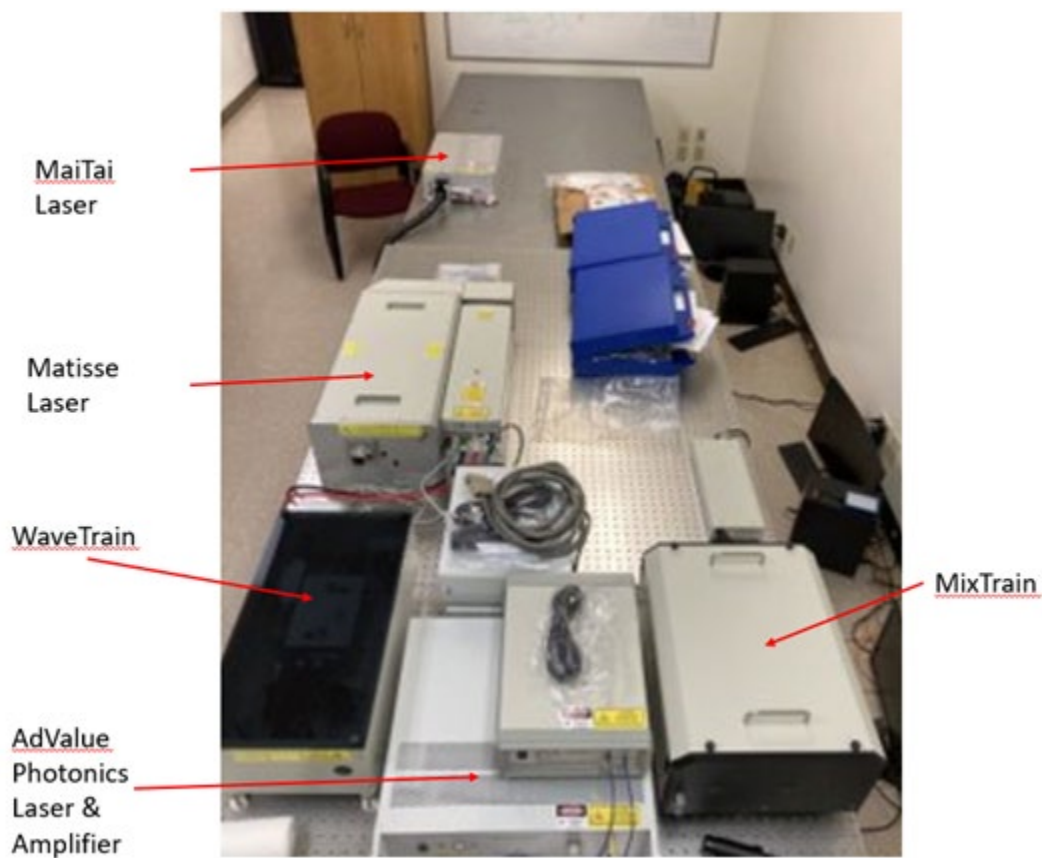


Figure 6. Installation process – labeled various items of the laser systems.

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Research and Educational use of the Equipment:

The new lab will enable us to carry out research activities in the areas of biomedical sensing, spectroscopy, optical communications, energy efficient electronics and photonics, fast optical switching, nonlinear optics, modeling of advanced electro-optic semiconductor materials and devices and reconfigurable devices.

Based on the numerical modeling capabilities of the lab, we were able to perform preliminary work for the design of optical biosensors and plasmonic optical modulators. The preliminary results were used to apply for two external research grants from NSF.

The delays in the delivery and installation process have limited our ability to perform experimental work, however we are very excited and enthusiastic to start utilizing the laser systems in near future for our research and educational goals.