

CCNY College-wide Research Vision (CRV) Initiative Concept White Paper

Tabletop Ultra-supercontinuum and Higher Harmonic Generation Source for UV and X-ray Microscopy (UXM) in Condensed Matter Physics, Chemistry, Biology, and Medicine

Project Team:

Principal Investigator: Dr. Robert Alfano, Distinguished Professor
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Other Key Personnel: Dr. Roger Dorsinville (EE/GSOE); Dr. Pouyan Ghaemi (Physics/Science);
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Project Concept Description: (Maximum 2 pages)

Keywords: UV and X-ray Microscopy, Multi-photon Effect, Kerr Effect, Self-phase Modulation, Continuum Generation, Higher Harmonic Generation.

Objective: The project focuses on developing a table-top UV and X-Ray microscope (UXM) using a coherent Ultra-Supercontinuum and Higher Harmonic Generation from an intense femtosecond pump laser source for applications in science, medicine, and engineering.

Approach: The first two years will be devoted to designing and building an Ultra-supercontinuum and Higher Harmonic Generation Microscopy- a compact UV X-Ray Microscope (UXM) based on Fig-1 and the patent application. The underlying effect to create UV and X-ray arises from nonlinear optical effects creating the ultra-broadening and Higher Harmonics due to the instantaneous change of refractive index $n(t)$ from the electric field $E(t)$ of the femtosecond intense pump laser. The pump laser in operation at CUNY-IUSL at CCNY has necessary energy above 1 mJ in a beam diameter of 20 μm creating a huge intensity greater than 10^{16} W/cm^2 . The third-year will be devoted to applications by the multi-disciplinary research team from the different departments to use and test the capabilities of UXM.

Outcomes: The outcome is to develop and demonstrate a new type of super-resolution high power coherent UV to X-ray beam for microscope applications in various materials for science and medicine way beyond the current X-ray tubes and large-scale UV X-ray sources such as Synchrotron and Cyclotron.

Expected Products: A new market will be created to sell UXM as a new type of coherent microscope spanning the UV to X-ray region.

Merits: The merit of this initiative is to create new tools for microscopy which is not available today. A compact UXM unit can enhance the field of science, medicine, and engineering by discovering new physical phenomena using high-resolution imaging beyond the visible range of common microscopes. The UXM will form a new user resource facility for research at CUNY and the state of New York way beyond public and private universities in the North-East and possibly East coast.

Impact: The UXM units will enhance the semiconductor computing industry by creating small scales and medical and biology areas by probing the genes in the tissues and cells to study new diseases.

Milestones:

Year 1: The first year will be devoted to designing and ordering the optical components and doing test results in the vacuum for the Ultra-supercontinuum and Higher Harmonic Generation Microscopy- a compact UV X-Ray Microscope (UXM).

Year 2: The second year will be devoted to assembling and testing the UXM.

Year 3: The third year will be devoted to using the UXM for various applications by the multi-disciplinary research team from the different departments. For example, UXM can be used to create chips below 5 nm in the semiconductor field, and for the biology/medical areas, the imaging and alteration of genes will be crucial for new knowledge.

A proposal will be written in the second half of the year to acquire funding from DOE, AFOSR, and NIH for various uses of the UXM to form a center of excellence in microscopy in linear and nonlinear optical processes using UUV and X-rays. (Initial interaction has been started with Dr. Andrew Stickrath from AFOSR to support this novel concept of creating a table-top UXM from several materials).

Budget (Maximum Budget \$200K):

No summer salary requested for the faculty members in the UXM team.

Staff	Number	Individual Salary	Total
Post-doc	1 (Full-time)	\$50,000	\$50,000
Graduate Student Assistant	1 (Full-time)	\$32,000	\$32,000
Technician	1 (Part-time)	\$20,000	\$20,000
Administrative Assistant	1 (Part-time)	\$10,000	\$10,000
MS Student Assistant	1 (Part-time)	\$15,000	\$15,000
Undergraduate Student	2 (Part-time)	\$2,500	\$5,000
Fringe Benefit	Rate	Salary	
Part-time	9%	\$50,000	\$4,500
Full-time	34%	\$82,000	\$27,880
Supplies (Vacuum Chambers and parts, optics parts, galvo scanner, mounts)			\$30,620
Travel (SPIES, Optica, APS, and topical meeting)			\$5,000
Total			\$200,000

UXM conceptual design is based on the paper published in Optik [R. R. Alfano, S. F. B. Mazhar, and L. Shi, "Higher harmonic and supercontinuum generation arising from electronic self-phase modulation under ultrafast laser pulses for various states of matter", *Optik* 247, 167872 (2021)] and a patent application "Table-top Ultra Supercontinuum and Higher Harmonic Generation Source for Microscopy" [U.S. Provisional Patent Application No. 63/116,527]:

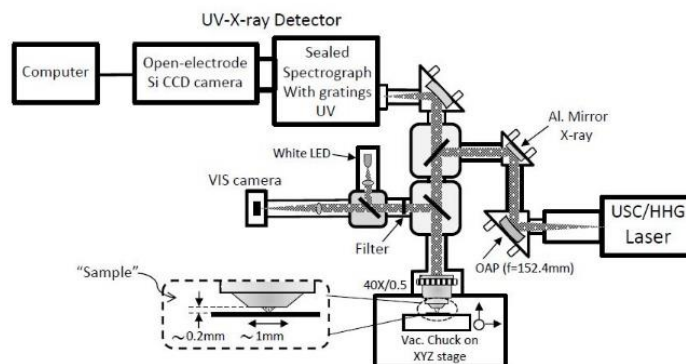


Fig-1: UXM design