Project Title: Plasma-Based Synthesis and Characterization of Lanthanum Nickelate Thin Films

Project Reference Code: Camata-UAB

Name of Project Leader: Renato P. Camata

Host Facility: University of Alabama at Birmingham

Internship Location: University of Alabama at Birmingham

Host Facility Location: 1720 2nd Ave South, Birmingham, AL 35294

Project Description (roughly 300 words):

Pulsed laser deposition (PLD) is a versatile technique for synthesizing advanced materials using laser-generated plasmas. When a high-energy laser pulse strikes a solid target, it produces a rapidly expanding plasma plume containing energetic atoms, ions, and electrons. These species travel toward a heated substrate, where they condense and form a thin film. The properties of the resulting material depend strongly on the plasma dynamics and deposition conditions, including laser energy, background gas pressure, and substrate temperature.

This summer research project will explore the use of PLD to synthesize thin films of lanthanum nickelate, a transition-metal oxide belonging to a family of materials exhibiting fascinating electronic and structural properties. Lanthanum nickelates are of considerable scientific interest because of the interplay between their crystal structures, electron interactions, and oxygen content. Controlling these properties during thin-film growth is important for understanding their fundamental physics and exploring potential technological applications.

The student will participate in experiments investigating how plasma deposition conditions influence the growth and properties of lanthanum nickelate films. Activities may include preparing substrates, assisting with PLD experiments, observing plasma plume characteristics, and studying the effects of deposition parameters on film quality. The resulting samples will be characterized using techniques such as X-ray diffraction, surface microscopy, and electrical measurements to establish relationships between synthesis conditions, material structure, and physical properties.

Through this project, the student will gain hands-on experience in plasma-based materials processing, vacuum systems, laser applications, and materials characterization. The research will provide an introduction to experimental condensed matter physics and materials science while demonstrating how fundamental plasma processes can be harnessed to create and investigate complex functional materials.

Disciplines: Applied Physics, Physics, Chemistry, Engineering, Electrical Engineering, Materials Science and Engineering, Mechanical Engineering, Chemical Engineering, Electrical and Computer Engineering

Importance:

Modern electronics rely on extremely thin layers of materials with carefully controlled properties. Pulsed laser deposition uses a laser-generated plasma to produce such layers, offering exciting possibilities for developing advanced materials. This project focuses on lanthanum nickelate, a material whose electrical properties can be dramatically influenced by its structure and composition.

Understanding how to control these properties could contribute to the development of future electronic devices. Plasma-based deposition techniques are also becoming increasingly important in the microelectronics industry, including applications in wireless communications and miniature sensors. This project connects fundamental materials research with technologies that are transforming everyday life.

Requirements:

- Preferred Major
  - All STEM majors eligible. Physics and engineering preferred.
- Class work
  - Calculus-based introductory physics required. Upper division physics courses preferred.
- Programming knowledge
  - Prior knowledge of programming not required. Working knowledge of Python programming preferred.
- Software knowledge
  - Fluency in standard software for graphing and basic calculations required.
- Other
  - This is an experimental project. Candidates with interest, abilities, and desire to learn how to perform hands-on physics/materials laboratory tasks preferred and encouraged to apply.

Biography (roughly 100-150 words):
Renato Camata received his Ph.D. in Applied Physics from the California Institute of Technology. As an undergraduate physics major, he discovered that the same beauty we apprehend in cosmology and the theory of general relativity, is close at hand in the everyday world of atoms and in how they combine to form the modern materials of solar cells and touchscreens. It was through an undergraduate research project that he learned to locate, inside a crystal, tiny amounts of dopant atoms responsible for the essential properties of the devices in today's computer chips. In his current research, Camata applies plasma processes in the synthesis of quantum materials—compounds that have potential for significant societal and economic impact. In addition to training 9 PhD scientists and 10 MS thesis-level projects, Camata has mentored 76 undergraduates in research activities, while leading an independent research program funded by NSF, NASA, DOD, and industry.

Is U.S. citizenship required to participate in this project? No

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