



Colorado Science and Engineering Fair

2024 Individual Project Abstract Form

Please print 2 copies of the completed form. Sign both copies, keep 1 for your notebook and submit 1 copy to your Regional Fair Director with your other paperwork.

Title of Project: A Novel Way to Significantly Improve TEM Efficiency by Altering Hologram Interference

Finalist's Name: Vikram Raju

School and City: Cherry Creek High School, Greenwood Village

Sponsor's Name: CoorsTek DMRSEF

Category: Physics & Astronomy (PHYS)

Division: Senior (9th - 12th grades)

Abstract (250 words or less):

Off-axis-electron-holography using a transmission-electron-microscope (TEM) is an extremely valuable tool in nanoscience, giving scientists the unique ability to study an object's electromagnetic properties, which are crucial for the observation/manipulation/reorganization/control/measurement of nanoscale materials, leading to breakthrough discoveries at atomic and molecular scales. Off-axis electron holography has one major drawback, however: its reliance on a vacuum reference-wave to produce the hologram. The vacuum for the reference wave takes up space where the specimen could be, reducing available viewing data. Previous attempts at eliminating the vacuum were unsuccessful because now the phase image is the subtraction of two nonzero object-waves, meaning it is scrambled. With my solution, eliminating the reference wave is now possible. I developed a novel mathematical approach to unscramble the phase image using biprism voltage states. I then automated this process using a Python program that I created. This program can unscramble any $n \times n$ sized phase image. I also encountered the problem of biprism tilt angle, which I solved using a trigonometric function. My innovative solution, validated by CU Boulder's FEMM (Facility-for-Electron-Microscopy-of-Materials) TEM Lab, solved a long-standing problem in off-axis-Electron-Holography, increasing the field of view by 100% and enabling breakthrough advances in nanotechnology – impacting a multitude of scientific fields, from medicine to materials science. The annual estimated cost savings are approximately \$1 billion for worldwide TEM installations by shortening research/discovery timelines and increasing sampling efficiencies. My programmatic solution, available as a plugin to TEM users worldwide, allows users to realize these efficiencies.

I hereby certify that the above statements are correct and the information provided in the Abstract is the result of one year's research. I also attest that the above properly reflects my own work.

Finalist's Signature:

Date:

In addition, all students must complete the ISEF Student Checklist (1A), Research Plan, Approval Form (1B), and Checklist for Adult Sponsor (1), and any other ISEF forms required for this type of project. See the International Rules and Guidelines for form requirements. Return COPIES of all of these forms to your Regional Fair Director with your Finalist Verification/Permission Form. A signed copy of this form must be included in your notebook.