Final Report

May 5, 2004

IPRO 309

Integrated Turn-Key X-Ray Fluorescence Analysis System
Using Bent Laue Optics

Project Team

Instructor: Dr. Grant Bunker, IIT BCPS

Sponsor: Quercus X-Ray Technologies, LLC

Team Members: Jim Adduci, Justin Ferguson, Isaac Martis, Ken McIvor, Josh Sammons, Kelli Shaver, George Takhtamyshev, Deepti Yadlapalli

Introduction

Quercus, the sponsoring company, has developed and is presently selling Bent Crystal Laue Analyzers for use in x-ray fluorescence analysis. Currently this product is desirable to only a select group of people, specifically trained in x-ray spectroscopy, for research purposes. Quercus desires to produce an integrated system that could be used a component on a beamline thereby increasing the potential user market.

This integrated system will increase the user market by decreasing the technical expertise needed to operate the system. The technology of the BCLA is made easier to use and more versatile by including all technologies need to complete calibration and x-ray analysis into one drop-in-place system. The components included will be the bent crystal laue analyzer, the detectors to complete the x-ray spectroscopy, a calibration system consisting of motors and stages, and a user interface system.

Along with the ease of use, the component system will offer more benefits for the researcher. Through the purchase of this system the user will procure a design that will

emphasize performance, reliability, simplicity, and manufacturing cost. The IPRO team will research potential technologies applicable to the system, procure technologies, and evaluate their use in a prototype design.

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Project Background

Bent Crystal Laue Analyzers select a particular wavelength of incident x-ray photons and reject photons of other energies. The primary application of this technology is to select specific x-ray fluorescence lines emitted from samples during x-ray fluorescence and x-ray absorption fine structure (XAFS) experiments. Unlike conventional solid state x-ray detectors, BCLAs allow for the rejection of undesired photons before they are detected, reducing the chance of detector saturation. Not only is this is a vital characteristic in circumstances where there is a small signal masked by a large amount of background, but it enables the design of a fluorescence analysis system that does not require an expensive sold state detector.

This system with involve the complex interaction of several different entities. The beamline is the facility at which the experiment is taking place. The fluorescence analysis system is what is being devised in this IPRO. This consists of the controller, BCLA stage, motors, kinematic mounts, detectors and a control interface

Project Purpose

This semester's focus was on the research part of the problem. The group researched current and emerging technologies that could be applied to this device. This includes the research of motors and stages, detectors, and interfaces. This allows for Quercus to keep their SBI grant under the objectives they laid out in their proposal. Also, with the completion of the research group white papers, tangible information will be passed down to the next semester's IPRO group on the technologies looked into so more informed decisions can be made.

The physical beginning of the prototype was conceived at the end of this semester. The alignment process was focused on most. This involves the controller, motors, stages, and user interface. This is a step that next semester can build on with the recommendations of the current group.

Research Methodology

Areas of technology relevant to the development of an integrated x-ray fluorescence analysis system which uses BCLAs were researched this semester. The IPRO project team divided into three groups, each of which researched a different area of technology.

- **X-Ray Detection –** solid-state detectors, ionization chambers, Lytle detectors, PIN diodes, and the supporting electronics each technology requires.
- **Positioning and Motion Control –** stages, hexapod platforms, motors, and motor control electronics.
- **Data Acquisition and Control –** D.A.C. software, computer platforms, operating systems, and end-user applications.

❖ Each group prepared and presented a short presentation on their findings and recommendations for the selection of concepts and products to evaluate.

❖ Each group wrote a survey document detailing the results of their research into their assigned area of technology. Additionally, these documents present the recommended concepts and projects and the reasons for their recommendations.

❖ Using the group recommendations, the IPRO project team selected some concepts and products from each area of technology for evaluation.

❖ After acquiring these components, the IPRO project team began evaluating their suitability. This effort culminated in the completion of a basic BCLA stage prototype.

Team Organization

X-Ray Detection - Justin Ferguson, Isaac Martis, Deepti Yadlapalli

Positioning and Motion Control - Jim Adduci, Kelli Shaver, George Takhtamyshev

Data Acquisition and Control - Ken McIvor, Josh Sammons

Additional Individual Assignments

Team Manager – Kelli Shaver

Webmaster – Ken McIvor

IPRO Project Team Tasks

Task	Jim	Justin	Issac	Ken	Josh	Kelli	George	Deepti
Project Plan								
Meeting Minutes								
Research Technologies								
Present to Teams								
Mid-Term Progress Report								
X-Ray Detection Whitepaper								
Motion Control Whitepaper								
DAC Whitepaper								
Prototype Construction								
Software Development								
Alignment Algorithm								
Website								
IPRO Day Poster								
Abstract								
Presentation Content								
Presentation Slides								

	Jim	Justin	Issac	Ken	Josh	Kelli	George	Deepti
Final Report								
CD-ROM								

Barriers and Obstacles

Through the course of the semester, the team has negotiated several obstacles: a lack of sufficient laboratory space, computer failure, and system integration issues. The greatest obstacle to overcome was the time constraints imposed by product acquisition (shipping, wrong parts). Despite these difficulties, the team has successfully laid the groundwork for the continuation of this IPRO.

Results and Conclusions

Research was conducted successfully, leading to the completion of whitepapers on the topics of X-ray detection, positioning and motion control, and data acquisition and control. Additionally, the team has identified promising technologies and has begun the process of acquiring and evaluating products. Over the course of the next two semesters, the IPRO team should focus their efforts on continuing the evaluation of the recommended technologies, developing and testing prototypes, and refining their designs.

Recommended Next Steps

- Further evaluate acquired products
    - Motor usage
    - Detector Capabilities
    - Algorithm selection
- Complete user interface
- Integrate components into a functional prototype
- Evaluate system performance in actual test
- Optimize system through new selection of:
    - Algorithm
    - Amplifier
    - Data Acquisition System

- Detector type
- Motor and Stage setup
- User interface

Acknowledgements

Dr. Carlo Segre assisted in determining the correct shaft coupler to purchase to connect the Thomson Microstage and the IMS MDI-17 motor. Dr. Chait Karanfil and the BCPS Machine Shop provided invaluable assistance in the construction of the prototype BCLA stage assembly.

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