

Progress of the collaborative work and the standardization for film thickness measurement

Development of Prototype Reference Material for XRR Measurement and Alignment

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NIST-NMIJ Collaboration Work on Standardization of Thickness Evaluation by X-ray Reflectometry

NMIJ/AIST
MML/NIST

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Donald Windover

Subjects for Standardization

(i) Measurement protocols

- Calibration methods for instruments
- Condition of measurement (ex. sample alignment, measurement range)
- Handling of sample (ex. pre-treatment)

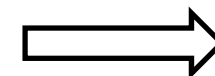
(ii) Data analysis protocols

- Method of analysis
- Judgment of convergence of fitting analysis
- Estimation of uncertainty

(iii) Improvement and expansion of standard materials

Goals

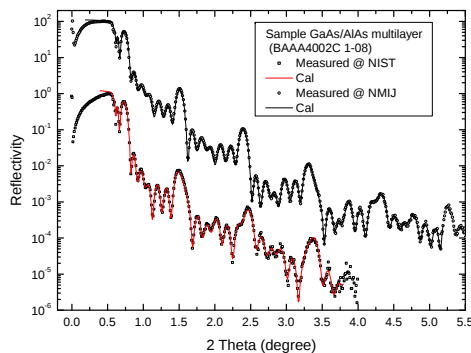
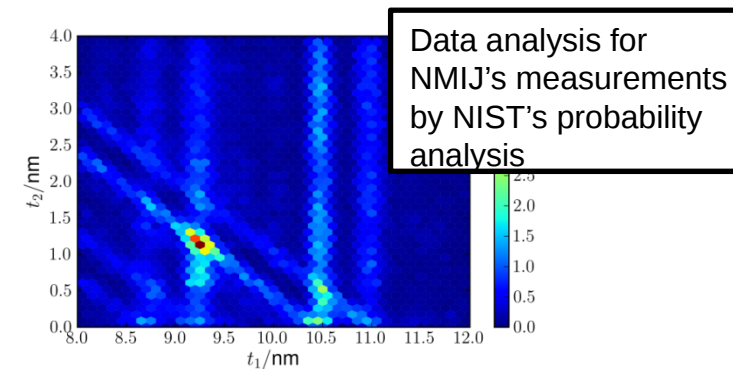
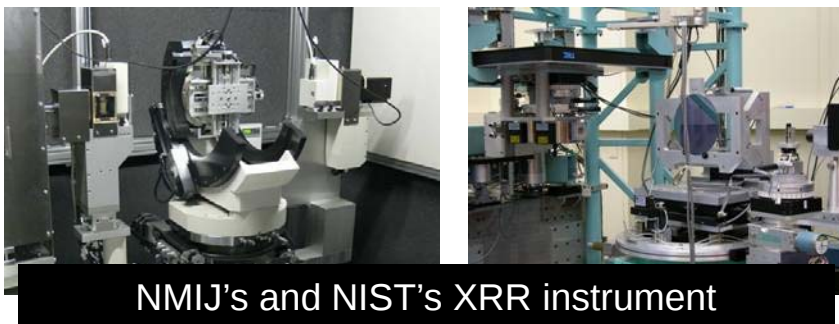
- (i) Guideline for XRR measurement
- (ii) Guideline for XRR data analysis
- (iii) Standard materials for calibration and validation



ISO document

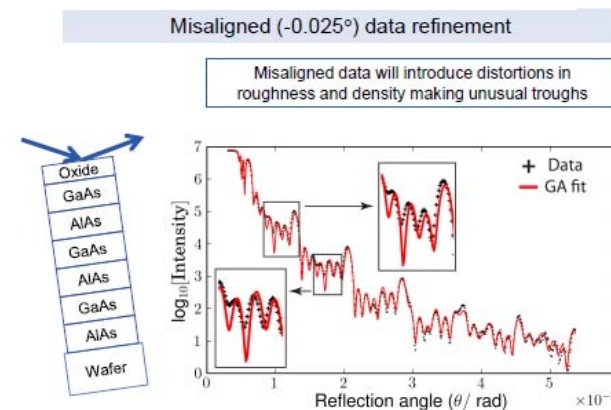
• Collaboration work

- Inter-Lab comparison using GaAs/AlAs superlattice (equivalent quality for NMIJ CRM 5203-a)
- Study on uncertainty of XRR thickness by using NMIJ CRM and NIST data analysis method
- Study on determining sample misalignment errors and angle encoder errors using reference material



	NIST /nm	NMIJ /nm
Oxide	2.74	1.24
1 st GaAs	9.11	9.10
2 nd AlAs	9.47	9.46
3 rd GaAs	9.27	9.28
4 th AlAs	9.48	9.47
5 th GaAs	9.26	9.27
6 th AlAs	9.46	9.45

Comparative Study - GaAs/AlAs Superlattice
Evaluated thickness of each layer shows a good agreement

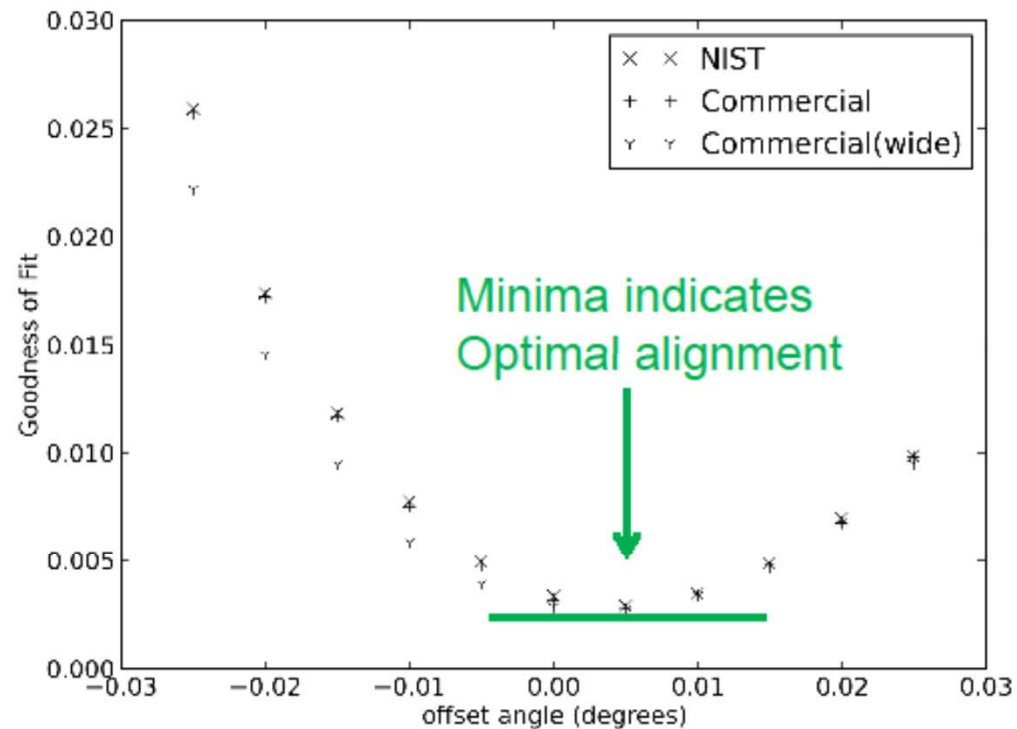


Sample misalignment study

Proposal of the usage of NMIJ CRM to calibrate the sample alignment

Presentation by D. Windover, NIST

XRR Modeling: Goodness of Fit



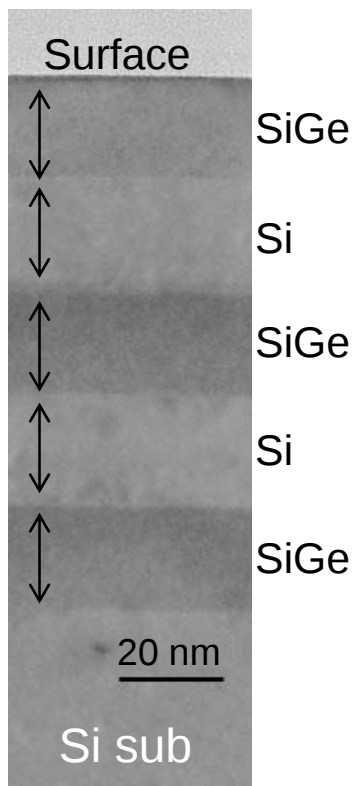
Development of New Prototype Reference Material

Target

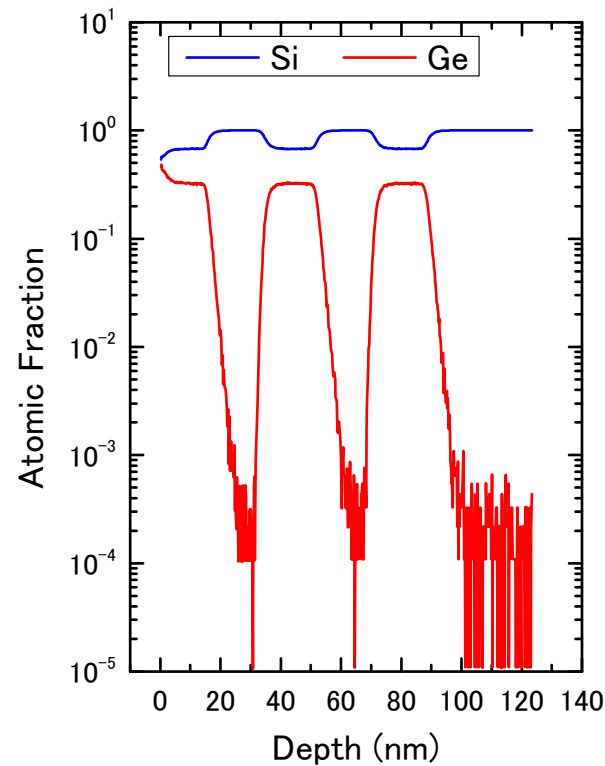
- Silicon based multilayer system with steep interface $\longleftrightarrow$ GaAs/AlAs CRM

Structure

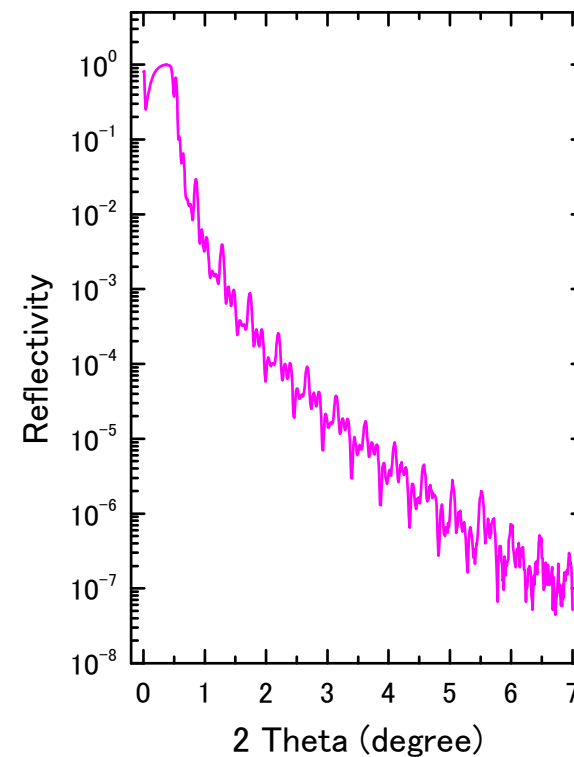
- SiGe (20 nm) / Si(20 nm) / SiGe(20 nm) / Si(20 nm) / SiGe(20 nm) / Si sub.



TEM image



SIMS Depth Analysis



XRR Profile

- Standardization

ISO/TC 201/WG 3 (X-ray reflectometry WG)

(i) ISO 16413 :2013 (Published) PL: Italy, Japan edited the draft.
“Evaluation of Thickness, Density and Interface Width of Thin Films by
X-ray Reflectometry – Instrumental requirements, alignment and positioning, data
collection, analysis and reporting”

(ii) Preparation of NWIP (Form 4 for NWIP has been prepared.)

USA & Japan proposal

Leader Professor Richard MATYI (CNSE, the University at Albany - SUNY)

Coleader Dr. Toshiyuki FUJIMOTO (NMIJ/AIST)

“Guidelines for Reference Materials for Specular X-ray Reflectometry

Scope of NWIP

This document will describe guidelines for the preparation of reference materials (RM) for specular XRR, to be analyzed on a competent specular X-ray reflectometer as described in ISO 16413. The primary focus of this document will be for thin film materials consisting of a single layer on a substrate; special conditions for multilayer materials are presented later in this document. These guidelines are intended to aid in the development of reference materials for many fields where XRR is employed.

Progress is delayed

Summary

- The collaborative work between NIST and NMIJ for thickness evaluation by XRR has been carried out since 2009FY in order to support the activities for the standardization of the thickness evaluation.

Progress: Development of New Prototype Reference Material
SiGe (20 nm)/Si(20 nm) multilayer film

- ISO16413 : 2013 has been published.
- NWI concerning RM for XRR will be proposed on ISO/TC201 WG3 in 2015FY by USA and Japan.

Acknowledgement: This work supported by Ministry of Economy, Technology and Industry (METI)