

# *X-ray Metrology for the Semiconductor Industry Tutorial*

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## 1. Introduction

The semiconductor industry is in need of new, in-line dimensional metrology methods with higher spatial resolution for characterizing their next generation nanodevices [1, 2]. The purpose of this short course is to train the semiconductor industry on the NIST-developed critical dimension small angle X-ray scattering (CDSAXS) method [3–5]. The topics will include both data processing and instrumentation. The short course will also provide an opportunity for discussion of the requirements for CDSAXS and the necessary improvements in X-ray source technology. Expected audience include semiconductor manufacturers, equipment manufacturers, and component manufacturers. The presentations were made at “X-ray Metrology for the Semiconductor Industry” short course at the National Institute of Standards and Technology on Aug. 25, 2016. Table 1 describes the title and the presenter for each of the tutorial presentations.

**Table 1.** List of presentations.

Title	Presenter
CDSAXS Overview	R. Joseph Kline
Diffraction Theory	Wen-li Wu
Instrumentation I	Scott Barton
Instrumentation II	R. Joseph Kline
Data Processing and Analysis	Daniel F. Sunday

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## 2. References

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**About the authors:** *Dr. Daniel F. Sunday is a staff scientist at NIST. His research interests include developing soft x-ray methods for polymer characterization, block copolymer self-assembly and X-rays for the metrology of periodic nanostructures. He received his B.S. from Carnegie Mellon University in 2006 and his Ph. D. in chemical engineering from the University of Virginia in 2011. He then joined NIST as a National Research Council postdoctoral fellow in 2011.*

*Dr. Wen-li Wu is a NIST Fellow Emeritus after spending 34 years working in the Polymer Physics area at NIST. He has initiated and worked on the X-ray scattering method for dimensional metrology during his last 14 years at NIST. His research interests include the application of X-ray and neutron scattering to polymer related problems. He received his M.S. and Ph.D. in Materials Science at MIT in 1969 and 1972, respectively. He has published more than 250 articles and 8 U.S. patents. He has been elected fellow of the American Physical Society, PMSE fellow of the American Chemical Society and fellow of the American Neutron Scattering Society.*

*Dr. Scott Barton received his B.A. in Chemistry from Franklin & Marshall College and his Ph.D. in physical chemistry from The University of Chicago in 1987, where he used synchrotron radiation to study 2D phase transitions at liquid surfaces. He spent 2 years doing postdoctoral work as a NATO and NSF fellow at the Université de Paris (VI) applying x-ray scattering and fluorescence tools to the study of polymer adsorption. From 1990 to 1996 he was an assistant professor in Polymer Science and Engineering at the University of Massachusetts (Alfred P. Sloan fellow). In 1997, he founded Molecular Metrology Inc which became a primary manufacturer of Small Angle X-ray Scattering instrumentation until 2004, when the business was sold to Rigaku Corp. After working for Rigaku as their SAXS instrumentation developer and product manager, he founded Molmex Scientific Inc in 2008 for scientific instrumentation manufacturing and distribution. Since 2014, Molmex has been co-located with SAXSLAB US in Northampton, MA, USA for the distribution and manufacture of SAXS, USAXS, and the distribution of Dectris X-ray detectors and Light Scattering Spectrometers from LS Instruments.*

*Dr. R. Joseph Kline currently leads the Dimensional Metrology for Nanomanufacturing project at NIST. His research interests include X-ray based dimensional metrology of nanostructures for the semiconductor industry and X-ray structure measurements of soft matter systems. He received a Ph.D. in Materials Science and Engineering at Stanford University in 2005, and B.S. and M.S. in Material Science from North Carolina State University in 1999 and 2000, respectively. He has published more than 90*

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