

**International Tutorial Workshop on
Piezoresponse Force Microscopy – 5
第5回国際PFMチュートリアルワークショップ
- Instrumentation, Theory, and Applications -**

Date: August 19 ~ 21, 2009

**Site: National Institute for Materials Science (NIMS),
Tsukuba, Japan 物質・材料研究機構並木地区**

Organized by

**National Institute for Materials Science
International Center for Materials Nanoarchitectonics
Optronic Materials Center /NIMS
Sensor Materials Center/NIMS
Oak Ridge National Laboratory**

Scope of Tutorial workshop

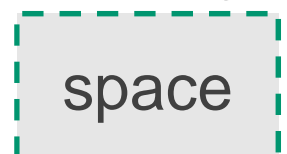
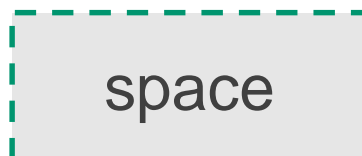
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Map and direction



International Tutorial Workshop on Piezoresponse Force Microscopy

Scope of Tutorial workshop

Nanoscale ferroelectrics and multiferroics are rapidly becoming the mainstay of information technology due to emerging applications in FeRAM, data storage, and tunneling barriers. Utilization Applications of ferroelectrics in electronic and electromechanical devices necessitates probing electromechanical activity, domain structure and dynamics, polarization switching and fatigue mechanisms on the nanoscale, as well as understanding the role of surfaces, interfaces, and defects on these processes. This workshop aims to provide in-depth description and recent advances in Piezoresponse Force Microscope (PFM), including theory of operation, recent technical developments., and multiferroics, polar nitrides, and biological systems. The workshop will introduce basic principles of PFM operation, relevant instrumental aspects, and image interpretation. The theory of cantilever dynamics, PFM contact mechanics, and resolution theory, as well as their implications for qualitative and quantitative data interpretation in PFM, will be presented and illustrated experimentally. The recent technical advance in PFM, including high-frequency (1 -8 MHz) imaging. Imaging and polarization switching in liquids, mapping polarization dynamics in ferroelectric capacitor structures, and switching spectroscopy PFM will be presented. Applications of PFM for mapping nucleation centers in ferroelectrics will be demonstrated. Finally, electromechanical probing of biological, electroactive polymer, and soft-condensed matter systems beyond classical ferroelectric applications will be discussed.

The 3 day workshop aimed for intermediate and advanced PFM users will include lectures given by Dr. S.V. Kalinin (ORNL), Prof. A. Gruverman (U. Nebraska-Lincoln), Prof. A. Kholkin (U. Aveiro,Portugal), Prof. V. Gopalan (Penn. State U.). The lectures are complemented with experimental tutorials on PFM imaging and SS-PFM studies of polarization dynamics. Ultimately, we aim to build a network of advanced PFM practitioners to promote rapid dissemination of theoretical knowledge, experimental protocols, and novel technique development in this rapidly growing area, as well as to establish links to areas such as electrophysiology and physical biology.

The workshop is supported by International Center for Materials Nanoarchitectronics and Optronics Material Center, Sensor Materials Center of NIMS, The center for Materials Sciences at Oak Ridge National Laboratory, and by Asylum Research Corporation.

チュートリアルワークショップの概要

ナノスケールの強誘電体やマルチフェロイクス材料は、FeRAMやデータストレージ、トンネルバリアへの新生の応用により、急速にIT時代の主力材料になりつつあります。電子または電気機械的デバイスへの強誘電体材料の活用には、ナノスケールの電気機械的動作、ドメイン構造やダイナミクス、また極性反転や疲労メカニズムの探索、および表面や界面の役割やプロセスの欠陥の理解が必要になっています。

本ワークショップは、ピエゾ応答力顕微鏡(PFM)に関する、理論や操作の基本原則、またマルチフェロイクス、有極性窒化物、バイオ系などへの応用例を紹介しながら、より深い理解と最近の進歩に関する情報を提供します。

さらにカンチレバーのダイナミクスの理論、PFMの接触力学や解像度の理論、およびPFMで得られる定性・定量的なデータ解釈の意味合い、液中でのイメージングと極性反転、強誘電体キャパシタ構造の極性ダイナミクスマッピング、反転スペクトロスコピーPFMについても紹介します。

この3日間のワークショップを通して、中級または上級レベルのPFMユーザーが、本分野の最先端を研究しているS. V. Kalinin博士(ORNL)、A. Gruverman教授(Nebraska-Lincoln大学)、A. Kholkin教授(Aveiro Portugal大学)、V. Gopalan教授(Pennsylvania州立大学)から講義を受けます。この講義は、PFMイメージングや極性ダイナミクスのSS-PFM測定の実験によるチュートリアルで補い、希望する参加者は、実際に操作法を実習いたします。

ここでの最終目標は、この急拡大する新たな分野において、理論的知識、実験プロトコル、新技術の一刻も早い普及をはかるために、上級レベルPFM測定者のネットワークを構築すること、および電気生理学や物理生物学分野との連携を固めることにあります。大学および企業の研究者、学生の皆様の参加を歓迎いたします。

問い合わせ先:物質・材料研究機構 北村健二 (e-mail:KITAMURA.Kenji@nims.go.jp)

International Tutorial Workshop on Piezoresponse Force Microscopy

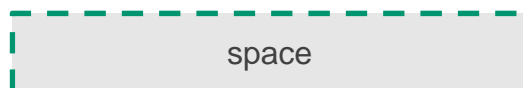
Date: August 19 (Wed) – 21 (Fri), 2009

**Site: Namiki-site of National Institute for Materials Science (NIMS),
1-1 Namiki, Tsukuba, Japan**

〒305 つくば市並木1-1 物質・材料研究機構 並木地区 共同研究棟

Organizers: Kenji Kitamura MANA/NIMS, Japan
Kazuya Terabe MANA/NIMS, Japan
Naoki Ohashi Optronics Materials Center/ NIMS. Japan
Kiyoshi Shimamura Optronics Materials Center/ NIMS. Japan
Haneda Hajime Sensor Materials Center/NIMS Japan
Sergei Kalinin Oakridge National Laboratory

Support : WPI-MANA/NIMS
Optronics Materials Center/NIMS
Sensor Materials Center/NIMS
Asylum Research Corporation



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Registration fee	30,000 JY	Student	10,000 JY
	(with operation training)		
	10,000 JY	Student	5,000 JY
	(without operation training)		

Registration fee includes texts of lectures, abstracts of topical talks, and operation guides

Workshop Dinner 2,000 JY
(On site, cash only)

Lecturers Alexei Gruverman (U. Nebraska-Lincoln)
Venkatran Gopalan (Penn. State Univ.)
Sergei Kalinin (ORNL)
Andrei Kholkin (University of Aveiro)

Topical speakers (Tentative)

James Gimzewski (UCLA)
Jiangyu Li (University of Washington)
Venkatran Gopalan (Penn. State Univ.)
Kenji Kitamura (NIMS)
Kiyoshi Shimamura (NIMS)

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Program

	Wednesday, Aug. 19	Thursday, Aug. 20	Friday, Aug. 21
09:00 10:30	10:00~Registration	Lecture 5 Lecture 6	Topical Talk 1,2,3
10:45 12:15	Lecture 1 Lecture 2	Demo 2a Demo 2c Demo 2c	Topical Talk 4,5,6
	Lunch	Lunch	Lunch
13:30 15:00	Lecture 3 Lecture 4	Lecture 7 Lecture 8	Demo 4a Demo 4c Demo 4b
15:30 17:00	Demo 1a Demo 1c Demo 1b	Demo 3a Demo 3c Demo 3b	
		Workshop Dinner	

8 lecture periods (45 minutes each, English) 4 demonstrations (90 minutes each, English & Japanese)
6 topical talks (30 minutes each, English)

Lectures

- (1) Principle and Applications of Piezoresponse Force Microscopy (A. Gruverman)
- (2) PFM Studies of Polarization Dynamics in Ferroelectrics (A. Gruverman)
- (3) Deciphering Polarization Switching Mechanisms by Spectroscopic PFM (S.Kalinin)
- (4) Novel Dynamic Modes in PFM (S.Kalinin)
- (5) Contact Mechanics and Resolution in PFM (S.Kalinin)
- (6) PFM Characterization for Disordered Materials (A. Kholkin)
- (7) PFM Application for Nanostructures (nanorods, nanotubes). (A. Kholkin)
- (8) Quantitative Piezoelectric Force Microscopy and Near-Field Scanning Optical Microscopy of Ferroelectric Domain Walls (V. Gopalan)

Topical Talks

- 1.The Secret Life of Ferroelectric Domain Walls (V. Gopalan, Pennsylvania State University)
2. Fixing Charged Particles and Molecules on Patterned Domain Surfaces (K. Kitamura NIMS)
3. ----- (Jiangyu Li, University of Washington)
- 4.Domain Switching of Ferroelectric Fluorides (K.Shimamura, NIMS)
- 5.----- (J. Gimjewski, UCLA)
- 6..Under negotiation

Demonstration and training (日本語および英語)

1. Piezoresponse force microscopy imaging and domain writing
(PFMイメージングとドメインの書き込み)
2. Dynamic modes in PFM – dual ac resonance tracking (DART) and band excitation
(PFMダイナミックモード デュアルAC共振トラッキング(DART)とバンド励起)
3. Piezoresponse Force Spectroscopy and spectroscopic mapping
(ピエゾ応答カスペクトロスコーピーとスペクトロスコーピーマッピング)
4. Piezoelectric nanoindentation (ピエゾナノインデンテーション)

Profiles of lecturers

Alexei Gruverman
Associate Professor
Nebraska Center for Materials
and Nanoscience
Department of Physics
and Astronomy
University of Nebraska-Lincoln



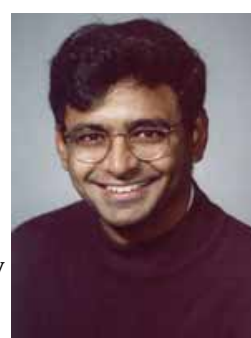
Sergei V. Kalinin
co-Theme Leader for Functional
Imaging on the Nanoscale
The Center for Nanophase
Materials Sciences
Materials Sciences and
Technology Division
Oak Ridge National Laboratory,



Andrei L. Kholkin
Principal Investigator
Center for Research in Ceramic and
Composite Materials (CICECO)
& Department of Ceramics and
Glass Engineering
University of Aveiro



Venkatraman Gopalan
Professor
Materials Science and
Engineering
College of Earth and Mineral
Sciences
Pennsylvania State University



Books Edited by lecturers:

1. "Scanning Probe Microscopy of Electrical and Electromechanical Phenomena at the Nanoscale" edited by S.V.Kalinin and A.Gruverman (Springer, 2006).
2. "Ferroelectrics at Nanoscale: Scanning Probe Microscopy Approach", edited by M. Alexe and A.Gruverman (Springer, 2004).

Book Chapters and Review Papers:

3. A. Gruverman and A. Kholkin, "Nanoscale Ferroelectrics: Processing, Characterization and Future Trends", Rep. Prog. Phys. 69, 2443-2474 (2006).
4. A. Gruverman, O.Auciello and H. Tokumoto, "Imaging and Control of Domain Structures in Ferroelectric Thin Films via Scanning Force Microscopy", Ann. Rev. of Mat. Science 28, 101-124 (1998).
5. S.V. Kalinin, B.J. Rodriguez, S. Jesse et al. "Nanoscale Electromechanics of Ferroelectric and biological Systems," Annu. Rev. Mat. Sci. 37, 189 (2007).
6. S.V. Kalinin, A. Rar, and S. Jesse, "A Decade of Piezoresponse Force Microscopy: Progress, Challenges, and Opportunities", IEEE Transactions on Ultrasonics and Ferroelectric Materials 53, 2226 (2006).
7. A.Gruverman, "Ferroelectric Nanodomains", in Encyclopedia of Nanoscience and Nanotechnology, edited by H. S. Nalwa (American Scientific Publishers, Los Angeles, 2004), Vol. 3, pp.359-375.
8. S.V. Kalinin, S. Jesse, B.J. Rodriguez et al, "Recent Advances in Electromechanical Imaging on the Nanometer Scale: Polarization Dynamics in Ferroelectrics, Biopolymers, and Liquid Imaging," Jap. J. Appl. Phys. 46, 5674 (2007).

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Registration Form 参加申込用紙



Registration fee 30,000 JY Student 10,000 JY (with training)
 10,000 JY Student 5,000 JY (without training)
 ご希望のコースの を塗りつぶして下さい。

振込先 常陽銀行 並木支店 普通預金 口座番号 ××××××
 名義 ITWS 代表北村健二 (未開設)

Participants from abroad can use only On-site registration, and only cash in Japanese Yen can be accepted,.)
 Workshop Dinner 2,000 JY (On site, cash only)

Name (氏名)	_____			Title Prof. Dr. Mr. Ms.	Japanese (漢字)
	First	Middle	Last		
Affiliation (所 属)	English (英名)				
	Japanese (和名)				
Address (連絡先)	住所 〒				
	Tel ()		Fax ()		
	E-mail address				

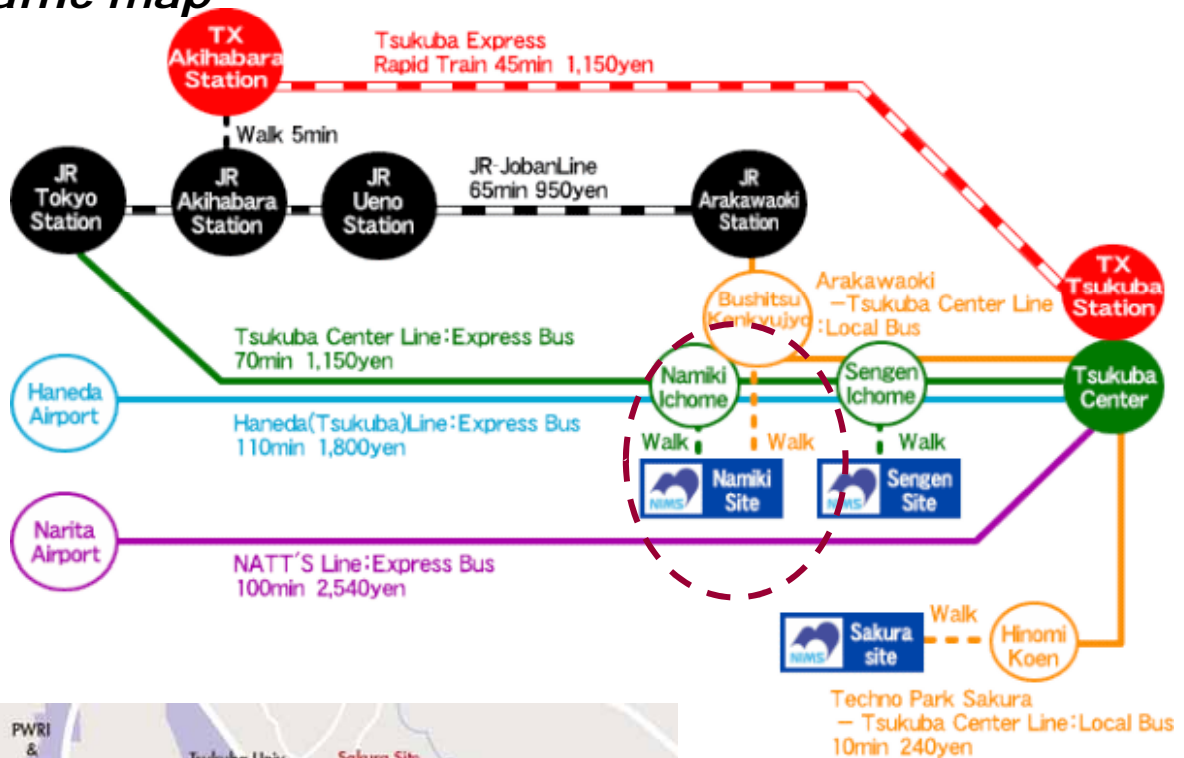
申込み先 Fax 029-851-6159

Please print out this page and fax to the number above.

問い合わせ先 Mieko Abe (Abe Mieko)
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 Tel : +81-29-860-4692

Independent Administrative Institute National Institute for Materials Science

Traffic map



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Fax: 029 -851-6159

Independent Administrative Institute National Institute for Materials Science

**Map of
Tsukuba**



Here !

Site:
Kyoudou-tou 4F
Oral : Conference room
Poster : room No.408-410

