



Masaaki NIWA Ph.D.

実用化開発を含むロジック用先端 CMOS のゲートスタックなどフロントエンドプロセスと MRAM 用磁気トンネル接合素子(MTJ)の極薄絶縁膜の原子レベルの界面制御、物理解析や信頼性物理などデバイスの材料物性関連の研究開発に従事してきました。

これまで培った電子デバイス用極薄誘電体膜に関する技術を通して、未知なる次世代 3D 積層技術の開拓に挑戦中です。

I have been mainly engaged in the Research and Practical development of Front-End-Process and Materials focused on gate stack of Advanced logic CMOS and Magnetic tunnel junction (MTJ) for MRAM including Atomic-scale interface control, Physical analysis and Reliability physics of Ultra-thin Dielectric films.

Currently, I am taking the challenge of unknown next-generation 3D-Stack technology through these potential technologies cultivated so far.

■ 1980– Matsushita Electric Industrial Co. Ltd. (currently Panasonic)

After development of impurity level measurement and formation process of photoconductive films (Chalcogenide amorphous semiconductor, Polycrystalline oxide) for image sensor, Dr. Niwa mainly engaged in the development of Advanced CMOS FETs in charge of R&D of Front-End-Processes focusing on 65-32nm CMOS gate stack process, Interface control, Physical analysis, and Reliability physics.

▶ Until early 2000: **Basic study of ultra-thin gate oxide for advanced CMOS**

- 1990–98: Engaged in atomic-scale planarization of SiO₂/S (001) interface (Joint research with Stanford Univ.) and its analysis aimed at improving channel mobility based on interfacial morphology and breakdown voltage of MOS FETs.
- 1992 - 95: By means of self-developed Ultra-high Vacuum-Scanning Tunneling Microscope (UHV-STM), he focused on initial oxidation mechanism clarification such as atomic-scale observation of oxygen adsorption phenomenon on Si (001) surface. (Joint research with the Univ. of Tokyo)

Meanwhile, he served as a *visiting professor at Kanazawa University* in charge of “VLSI Process Technology”.

- 1999–04: *Visiting researcher at STARC* * under Prof. M. Oshima (Univ. of Tokyo) on "Ultra-high resolution analysis of insulating film/silicon interface and breakdown reliability by Synchrotron radiation"

STARC* : Semiconductor Technology Academic Research Center Inc.

- 2000–02: Started MOS operation and reliability verification of high dielectric constant insulating film (ZrO₂, HfO₂) as an alternative material to gate SiO₂ which has reached the limit of ultra-thinning. (Joint research with Univ. of Texas, Austin (UTA))

▶ Since 2002: **Practical development of logic CMOS with High-k gate dielectric (Chief Engineer, Councilor)**

- 2002–07: He proposed joint research with imec (Belgium) on advanced CMOS and was stationed at imec as an on-site manager of R&D of High-k / Metal gate system for 32nm-CMOS.

Meanwhile, he served as a *visiting professor at the University of Leuven (KU Leuven)* in charge of “Nanoelectronics” as well as jury member of doctoral dissertation.

※ The 32nm-CMOS equipped with High-k / Metal gate system developed with imec has come to fruition as the world's first mass production of ultra-low power consumption system LSI for Blu-ray Disc players in 2010.

■ 2011– Worked at Universities (Univ. of Tsukuba, Tohoku Univ.)

▶ 2011–13: **Professor of Applied Physics Dept. at Graduate School of Pure & Applied Science, University of Tsukuba**

- Engaged in research on Power MOS, lectures on Nano-electronics including Human resource development as well as TIA* nano-project promotion (General manager of TIA Promotion Office)

TIA* : Tsukuba Innovation Arena

▶ 2013–20: **Professor of Research and Development Gr. of Center for Innovative Integrated Electronic Systems (CIES), Tohoku University**

- Engaged in materials science of Magnetic Tunnel Junction (MTJ) for STT*-MRAM elucidating the relationship between MTJ structure and characteristics. In particular, he focused on physical analyses of ultra-thin MgO / CoFeB interface and B behavior by hard X-ray photoelectron spectroscopy (HAXPES*) @ SPring-8*, as well as structural analysis of fine MTJ by means of co-developed electron tomography (STEM*-Tomography) combined with Scanning TEM.

STT*: Spin Transfer Torque

HAXPES*: Hard X-ray Photoelectron Spectroscopy

Spring-8*: Super Photon ring-8 GeV (Synchrotron radiation facility)

STEM*: Scanning TEM

In addition, he was responsible for execution of the JSPS* Core-to-core program (Advanced research network btw Tohoku Univ. - Cambridge Univ. - Paris-Sud Univ.)

*JSPS: the Japan Society for the Promotion of Science

◆ **Achievement report**

- The above results have been reported in 216 original papers, international conferences, and books, including co-authors.
(Some of recent main published papers are listed at the end.)
- 91 obtained patents including joint applications (domestic & overseas)

■ **Has been incumbent since 2020 (The Univ. of Tokyo)**

▶ 2020–: **Senior Fellow at Advanced Device Research Gr., Systems Design Lab (d.lab), Graduate School of Engineering, The University of Tokyo**

- In charge of general management of NEDO* project on " Post 5G Information and Communication Systems Infrastructure Reinforcement R&D Project / Advanced Semiconductor Manufacturing Technology".

NEDO* : New Energy and Industrial Technology Development Organization

Others;

◆ Activities on various academic societies, associations, and journals

- General chair of VLSI Technology Symp.
- IEDM Executive Com. (Asian Arrangement Chair) & Sub-com. member
- IRPS Device Dielectric com. Chair
- IEEE Technical Field Award (Clelio Brunetti Award) com. Chair
- IEEE EDS Japan Chapter Chair
- IEEE Fellow Evaluation com. Vice chair
- IEEE Semiconductor Interface Specialist Conference (SISC) com. member
- VLSI Symp. Executive Com. Member
- ITRS* - FEP* sub-com. member as Japan's national team

ITRS*: International Technology Roadmap for Semiconductors

FEP*: Front-End-Process

- STRJ* / JEITA* - FEP sub-com. Associate leader in charge of ITRS

STRJ* : Semiconductor Technology Roadmap Committee of Japan

JEITA* : Japan Electronics and Information Technology Industries Association

- MRS Symposium Organizer (High-k Dielectric)
- Appl. Phys. Lett Paper Review com. member
- External member of Senior Research Professor Evaluation com., KU Leuven
- External member of Flanders State Government-Foundation for Scientific Research Belgium/ New Research project Evaluation committee
- External evaluation com. member of Science and Engineering area of Kanazawa University
- External member of Tsukuba University's pre-strategy initiative field-specific evaluation com.
- Kyoto Prize com. member
- Member of NEF (Next Einstein Forum: Sponsored by African Institute of Mathematical Sciences (AIMS))
- Chairman of NEDO-Advanced Semiconductor Expert Committees

In addition, he has served as a member of various committees including the Japan Society of Applied Physics (JSAP) , the Institute of Electronics, Information and Communication Engineers (IEICE) and the Japan Society for the Promotion of Science (JSPS) and other international conferences.

◆ Fellow

- IEEE Fellow (2013)

"CMOS technology using high dielectric constant materials and metal gate"

- JSAP Fellow (2014)

"Materials science research of gate stacks for advanced CMOS and its practical application"

◆ Degree

- Ph.D. (Applied Physics) from Osaka University
- M.Eng. (Electrical Engineering) from Kanazawa University

【Main paper publications of recent years】

- 1) "Structural Analysis of CoFeB/MgO-based Perpendicular MTJs with Junction Size of 20 nm by STEM Tomography"
M. Niwa, K. Kimura, T. Naijo, A. Oshurahunov, S. Nagamachi, H. Inoue, H. Honjo, S. Ikeda, and T. Endoh,
IEEE Trans. on Magnetics, **57**, 2 (2021).
- 2) "Ion Conductive Character of Low-yttria-content Yttria-stabilized Zirconia at Low Temperature"
T. Nishimura, T. Kojima, K. Nagashio, and M. Niwa
Jpn. J. Appl. Phys., **60**, SBBF03 (2021).
- 3) "Effect of Metallic Mg Insertion in MgO on Magnetic Properties observed by Synchrotron X-ray Diffraction Measurements"
M. Niwa, H. Honjo, R. Kumara, H. Inoue, S. Ikeda, H. Tajiri, and T. Endoh
J. of Vacuum Science & Technology B, **38**, 033801 (2020).
- 4) "Effect of Capping Layer Material on Thermal Tolerance of Magnetic Tunnel Junctions with MgO/CoFeB-based Free Layer/MgO/capping Layers"
H. Honjo, T. V. A. Nguyen, M. Yasuhira, M. Niwa, S. Ikeda, H. Sato, and T. Endoh
AIP advances, **9**, 125330 (2019).
- 5) Change in Chemical Bonding State by Thermal Treatment in MgO-based Magnetic Tunnel Junction observed by Angle-resolved Hard X-ray Photoelectron Spectroscopy"
M. Niwa, A. Yasui, E. Ikenaga, H. Honjo, S. Ikeda, T. Nakamura, and T. Endoh
J. Appl. Phys., **125**, 203903 (2019).
- 6) "STEM Tomography Study on Structural Features induced by MTJ Processing"
M. Niwa, K. Kimura, T. Watanabe, T. Naijo, H. Honjo, S. Ikeda, and T. Endoh

Appl. Physics A, **124**, 72 (2018).

- 7) "Origin of Variation of Shift Field via Annealing at 400°C in a Perpendicular-anisotropy Magnetic Tunnel Junction with [Co/Pt]-multilayers based Synthetic Ferrimagnetic Reference Layer"
H. Honjo, S. Ikeda, H. Sato, T. Watanebe, S. Miura, T. Nasuno, Y. Noguchi, M. Yasuhira, T. Tanigawa, H. Koike, M. Muraguchi, M. Niwa, K. Ito, H. Ohno, and T. Endoh
AIP advances, **7**, 055913 (2017).
- 8) "Impact of Tungsten Sputtering Condition on Magnetic and Transport Properties of Double-MgO Magnetic Tunneling Junction"
H. Honjo, S. Ikeda, H. Sato, K. Nishioka, T. Watanabe, S. Miura, T. Nasuno, Y. Noguchi, M. Yasuhira, T. Tanigawa, H. Koike, H. Inoue, M. Muraguchi, M. Niwa, H. Ohno, and T. Endoh
IEEE Trans. Magnetics, **53**, 11, 2501604 (2017).
- 9) "Failure Analysis of a SiC MOS Capacitor with a Poly-Si Gate Electrode"
S. Sato, K. Yamabe, T. Endoh, and M. Niwa
Materials Science Forum, **858**, 485 (2016).
- 10) "Formation Mechanism of Concave by Dielectric Breakdown on Silicon Carbide Metal-oxide-semiconductor"
S. Sato, K. Yamabe, T. Endoh, and M. Niwa
Microelectronics Reliability, **58**, 185 (2016).
- 11) "Improvement of Thermal Tolerance of CoFeB-MgO Perpendicular-Anisotropy Magnetic Tunnel Junctions by Controlling by Boron Composition"
H. Honjo, S. Ikeda, H. Sato, S. Sato, T. Watanabe, S. Miura, T. Nasuno, Y. Noguchi, M. Yasuhira, T. Tanigawa, H. Koike, M. Muraguchi, M. Niwa, K. Ito, H. Ohno, and T. Endoh
IEEE. Trans. Magnetics, **52**, 7, 3401104 (2016).
- 12) "Driving Force in Diffusion and Redistribution of Reducing Agents during Redox Reaction on the Surface of CoFeB Film"
S. Sato, H. Honjo, S. Ikeda, H. Ohno, T. Endoh, and M. Niwa
IEEE Trans. on Magnetics, **51**, 3400804 (2015).
- 13) "Evidence of a Reduction Reaction of Oxidized Iron/cobalt by Boron Atoms Diffused toward Naturally Oxidized Surface of CoFeB Layer during Annealing"
S. Sato, H. Honjo, S. Ikeda, H. Ohno, T. Endoh, and M. Niwa
Appl. Phys. Lett. **106**, 142407 (2015).
- 14) "Multiple Breakdown Model of Carpet-bombing-like Concaves formed during Dielectric Breakdown of Silicon Carbide Metal-oxide-semiconductor"

Capacitors"

S. Sato, Y. Hiroi, K. Yamabe, M. Kitabatake, T. Endoh, and M. Niwa
Jpn. J. Appl. Phys., **53**, 08LA01 (2014).

- 15) "Generalized Mechanism of the Resistance Switching in Binary-oxide-based Resistive Random-access memories"
K. Kamiya, M. Y. Yang, T. Nagata, S.-G. Park, B. M.-Köpe, T. Chikyow, K. Yamada, M. Niwa, Y. Nishi, and K. Shiraishi
Phys. Rev. B **87**, 155201 (2013).