

Takaaki Sato

KEY ACHIEVEMENTS and GOALS

I am the first to make detailed observations of the sliding interfaces between opposing asperities. In other words, I for the first time observed the sliding contact area with atomic resolution while simultaneously measuring the frictional and normal forces. Those experiment are performed by original MEMS-based setup that I developed by myself. The aim of my research is to elucidate the mechanisms of “why friction occurs” and “why wear occurs” from a microscopic viewpoint. The findings could contribute to (1) improving the energy efficiency of automobiles and power generation turbines, (2) reducing environmental pollution through improved lubricants, and (3) more accurately predicting natural disasters such as earthquakes and landslides. For Taiwan and Japan, which has limited energy resources and is strongly affected by nature, research on friction that contributes to these improvements is significantly important for achieving a sustainable society.

EDUCATION

Ph.D. in Graduate School of Engineering **Oct 2008 - Sep 2011**

University of Tokyo

Dept. of Electrical Engineering and Information Systems

Thesis: Real-time TEM observation of nano-shear fracture to elucidate the mechanism of solid lubrication

Advisor: Professor Hiroyuki Fujita

M.S in Graduate School of Engineering **Apr 2005 - Mar 2007**

Seikei University

Dept. Applied Physics and Physico-Informatics

Thesis: Molecular dynamics simulation on thermal fluctuations of nano asperities

Advisor: Professor Naruo Sasaki

B.S in Engineering **Apr 2001 - Mar 2005**

Seikei University

Dept. Applied Physics and Physico-Informatics

PROFESSIONAL EXPERIENCE

Project Researcher **Jun 2022 - Present**

University of Tokyo, Institute of Industrial Science, Tochigi Lab

Visiting Scholar **Dec 2021 - Dec 2023**

University of Pennsylvania, Dept. of Mechanical Engineering and Applied Mechanics, Carpick Lab

Postdoctoral Associate **Nov 2018 - Sep 2021**

University of Pennsylvania, Dept. of Mechanical Engineering and Applied Mechanics, Carpick Lab

Research Associate **Apr 2013 - Oct 2018**

University of Tokyo, Institute of Industrial Science, Fujita Lab

Project Researcher **Oct 2011 - Mar 2013**

University of Tokyo, Institute of Industrial Science, Fujita Lab

Computer Engineer (hardware) **Apr 2007 - Jul 2008**

NEC Corporation. Inc., Computer business unit

THREE PUBLICATIONS OF NOTE

• **My most representative achievement: I observed a sliding interfaces with atomic resolution and got the insight explaining what happens at the contact area.**

- [1] **T. Sato**, Z.B. Milne, M. Nomura, N. Sasaki, R.W. Carpick & H. Fujita "Ultrahigh Strength and Shear-Assisted Separation of Sliding Nanocontacts Studied in situ" *Nature Communications*, Vol.13, Issue.1, 2551 (2022) (Impact factor: **17.69**, First author and corresponding author)

• **I have developed a technique that can calculate the type of chemical bonds and numbers of bonds formed at the contact area. The result shows the relationship between chemical bonding and wear from a microscopic point of view.**

- [2] T.R. Sathwik, **T. Sato**, Z. B. Milne, R.A. Bernal, Y.R. Jeng, Z.C. Muratore, N. R. Glavin, R.W. Carpick & J. D. Schall "Nanoscale Adhesion and Material Transfer at 2D MoS₂-MoS₂ Interfaces Elucidated by In Situ Transmission Electron Microscopy and Atomistic Simulations" *ACS Applied Materials & Interfaces*, Vol.16, Issue.23, pp.30506-30520 (2024) (Impact factor: **9.5**)

• **My most representative skill: I have combined microfabrication techniques with Transmission Electron Microscope to enable observation of phenomena and samples at the nanoscale that could not be observed so far.**

- [3] **T. Sato**, V.A. Menon, H. Toshiyoshi, E. Tochigi "Microfabricated Double-tilt Apparatus for Transmission Electron Microscope Imaging of Atomic Force Microscope Probe" *The Review of Scientific Instruments*, Vol.95, Num.2, 023705 (2024) (Impact factor: **1.5**)

4 OTHER SIGNIFICANT PUBLICATIONS

- [4] J-H. Liang, Z. Milne, M. Rouhani, Yi-Pan Lin, R.A. Bernal, **T. Sato**, R.W. Carpick, Y.R. Jeng "Stress-Dependent Adhesion and Sliding-Induced Nanoscale Wear of Diamond-Like Carbon Studied Using In Situ TEM Nanoindentation" *Carbon*, Vol.193, pp. 230-244 (2022) (Impact factor: **11.307**)
- [5] W. Cha, M. F. Campbell, K. Hasz, S. M. Nicaise, D. E. Lilley, **T. Sato**, R.W. Carpick, and I. Bargatin "Hollow Atomic Force Microscopy Cantilevers with Nanoscale Wall Thicknesses" *Small*, Vol.17, Issue 51, 2102979 (2021) (Impact factor: **13.28**)
- [6] T. Ishida, **T. Sato**, T. Ishikawa, M. Oguma, N. Itamura, K. Goda, N. Sasaki and H. Fujita, "Time-Lapse Nanoscopy of Friction in the Non-Amontons and Non-Coulomb Regime" *Nano Letters*, Vol. 15, pp.1476-1480 (2015) (Impact factor: **11.189**)
- [7] L. Jalabert, **T. Sato**, T. Ishida, H. Fujita, Y. Chalopin and S. Volz "Ballistic Thermal Conductance of a Lab-in-a-TEM Made Si Nanojunction" *Nano Letters*, Vol.12, No.10, pp.5213-5217 (2012). (Impact factor: **11.189**)

HONOR AND AWARDS (selected only representative)

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| [1] UJA Outstanding Paper Award | 2024 |
| [2] NF Foundation R&D Encouragement Award | 2016 |
| [3] Japan Society of Tribology Encouragement Award. | 2014 |
| [4] University of Tokyo, Graduate school of Engineering, Department of Electrical Engineering and Information Systems, Best Doctoral Dissertation Award (Top honors) | 2011 |

GRANTS (selected only representative)

Budget from Government (JSPS, Kakenhi)

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| [1] in-situ TEM Observation for Elucidating the Transfer Mechanisms of 2D Materials
Kiban Kenkyu (C), 4,550,000¥ (PI 100%) | Apr 2024 - Mar 2026 |
| [2] The suggestion of a lubrication, adhesive and the reveal of the mechanisms of
friction, wear using MEMS-in-TEM system
Wakate Kenkyu (A), 30,000,000¥ (PI 100%) | Apr 2016 - Mar 2019 |

GRANTS (selected only representative) Continued

[3] Real-time Observation of Actual Contact Area using a Micro-nano Machine Combined with a TEM
Wakate Kenkyu (B), **3,670,000¥ (PI 100%)** **Apr 2014 – Mar 2016**

Budget from Company (Kifukin)

[4] Development of MEMS-TEM setup to enable “in-situ observation” at atomic scale
The Precise Measurement Technology Promotion Foundation, **2,000,000¥ (PI 100%)** **Apr 2017 – Mar 2019**

[5] Real-time observation of nano-contact for elucidating microscopic mechanisms of friction and wear
NSK Foundation for the Advancement of Mechatronics, **2,000,000¥ (PI 100%)** **Apr 2016 – Mar 2017**

TECHNICAL SKILLS

• **Silicon microfabrication technique:** **DeepRIE** (Predeus(SPP technologies), Multiplex-ICP SR(STS inc)), **Electron beam lithography exposure** (DWL66+(Heidelberg)), **Lithography, Sputtering deposition, Wet etching**

• **Sample evaluation technique:** **TEM**(NeoARM(JEOL), JEM-ARM200F(JEOL), JEM-F200(JEOL), JEM-2100HC (JEOL), HF2000UHV(Hitachi)), **FIB**(S8252X(Tescan), Helios5(ThermoFisher), Scios2(ThermoFisher)), **AFM** (MFP-3D(Asylum)), **XPS** (PHI5000VersaProbe1(ULVAC-PHI))

• **Programming languages:** Matlab, LabVIEW, Mathematica, Fortran, C++, JavaScript, Svelte

LANGUAGES

Japanese: Native

English: Proficient