Project report 2020

ELiceTrib

Tribology of elastomer/ice contact from nm to mm scale

MAIN PARTICIPANTS

				
Kazue KURIHARA[a]	**Masashi MIZUKAMI[a]**	**Motohiro KASUYA[b]**	**Denis MAZUYER[c]**	**Juliette CAYER-BARRIOZ[c]**

[a] *New Industry Creation Hatchery Center, Tohoku University, Japan*
[b] *Institute of Multidisciplinary Research for Advanced Materials, Tohoku University, Japan*
[c] *LTDS, ECL, CNRS UMR5513, France*

Contact: kazue.kurihara.e7@tohoku.ac.jp, denis.mazuyer@ec-lyon.fr

OVERVIEW *(keep within this page)*

Starting year: 2014 **Current researchers** (permanent/non-permanent): 3 person-month/year

Positioning *(Multiple selection allowed – total 100%)*	**Transportation**	**Energy**	**Eng. for Health**
Materials and structure design	30%		
Surfaces and interfaces	40%		
Simulation and modeling	30%		

Other:

Include partner from ☐ Outside ELyT ☒ Industry

Main funding source(s)
☒ Public project(s) ☒ Industrial ☐ Own resources

IFS CRP/LyC project? ☐ Yes ☒ No

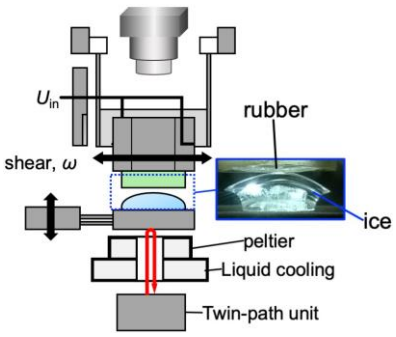
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*

- ANR-JST project, 2020-2026, Multi-scale elucidation of friction mechanisms in ice-rubber interfaces
- Nihon Michelin Tire Co. collaboration research fund, 2015-2018, Rubber-water-glass resonance shear measurement.

Estimated annual budget: 260,000 Euro/year
(32,000,000 yen/ year)

Highlights & Outstanding achievements *(3-5 bullet points)*

- Ice-rubber friction was investigated using a low temperature surface forces apparatus/resonance shear measurement (LowT-SFA/RSM) which we developed.
- Viscosity of ice-premelting layer was evaluated for the first time as functions of temperature and sliding velocity.
- Ice-rubber friction was modified by the ice premelting layer and the viscoelasticity of the rubber in complex manners.
- Ice-rubber(with fillers) friction was dominated by the viscoelasticity of rubber and influenced by roughness at –13 ˚C.



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

Driving on ice can be slippery and leads to poor road safety, therefore, improving the grip of tire on ice is important. The energy loss due to the tire friction also needs to be minimized, requiring complex adjustment of tire materials, one of typical elastic soft materials. In order to achieve sustainable technology and safer society, there is an increasing interest to elucidate and control the interaction between ice and rubber.

Several mechanisms govern the tribological behavior of ice-rubber, such as premelting and melting of ice, rubber viscoelasticity and adhesion of ice-rubber interface. In addition, these mechanisms are known to depend both on temperature (T) and shear velocity (V). These dynamic properties and their coupling result in the complicated friction behavior of ice-rubber interfaces.

Key scientific question (2 lines max; Calibri 11)

Understanding of governing factors of ice-rubber friction and its mechanisms.

Establish a guideline to design innovative rubber materials to optimize friction and energy saving.

Research method (8 lines max; Calibri 11)

LowT-SFA/RSM will be used for characterizing the ice premelting layer, adhesion, and the viscoelasticity of styrene butadiene rubbers (SBRs) surfaces with various T_g and SBRs with fillers. The contribution of each factor and their coupling effect on the ice-rubber friction will be evaluated.

KORI tribometer, developed by ECL, will be used for visualizing the multi-contact spots of macroscopic ice-rubber interfaces, evaluating friction heat as well as adhesion and viscoelastic properties of rubber affect the ice-rubber friction.

The obtained results will be integrated in the predictive friction model, and will be utilized to establish a guideline to molecular design of innovative rubber materials.

Research students involved *(gray color for previous years)*

Ph.D. candidates (years, institution):

- Sylvain HEMETTE (2016 -2019, ECL and Tohoku University)

Master/Bachelor students (years):

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Visits and stays *(gray color for previous years)*

FR to JP (date, duration):

- Denis MAZUYER (Dec. 2015, 3 days; Oct. 2016, 3 days; April 2017, 1 week)
- Juliette CAYER-BARRIOZ (Dec 2015; April 2017, 1 week)

JP to FR (date, duration):

- Kazue KURIHARA and Motohiro Kasuya (Nov. 2017, 2 days)
- Masashi MIZUKAMI and Motohiro KASUYA (June 2019, 3 days)
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COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	F. Lecadre, M. Kasuya, S. Hemette, A. Harano, Y. Kanno and K. Kurihara	Ice premelting layer of ice–rubber friction studied using resonance shear measurement	Soft Matter	16	8677-8682	2020	DOI: 10.1039/d0sm00478b
2	F. Lecadre, M. Kasuya, Y. Kanno and K. Kurihara	Ice Premelting Layer Studied by Resonance Shear Measurement (RSM)	Langmuir	35	15729-15733	2019	DOI: 10.1021/acs.langmuir.9b02451
3	S. Hemette, M. Kasuya, F. Lecadre, Y. Kanno, D. Mazuyer, J. Cayer-Barrioz and K. Kurihara	Viscoelasticity of Rubber–Ice Interfaces Under Shear Studied Using Low-Temperature Surface Forces Apparatus	Tribology Letters	67	234156	2019	https://doi.org/10.1007/s11249-019-1187-2
4	M. Mizukami, S. Hemette and K. Kurihara	Mechanical model analysis for resonance shear measurement	Review of Scientific Instruments	90	055110	2019	doi: 10.1063/1.5084117
5	F. Lecadre, M. Kasuya, A. Harano, Y. Kanno and K. Kurihara	Low-Temperature Surface Forces Apparatus to Determine the Interactions between Ice and Silica Surfaces	Langmuir	34	11311-11315	2018	DOI: 10.1021/acs.langmuir.8b01902
6	S. Hemette, J. Cayer-Barrioz and D. Mazuyer	Friction setup and real-time insights of the contact under controlled cold environment: The KORI tribometer for rubber-ice contact application	Review of Scientific Instruments	89	123903	2018	https://doi.org/10.1063/1.5048844

Conferences *(gray color for previous years)*

	Authors	Title	Conference	Date	City	Country	DOI *(if applicable)*
1	K. Kurihara	Resonance Shear Measurement for Studying Contact Mechanics	International Tribology Conference 2019	16-21 Sep., 2019	Sendai	Japan	
2	K. Kurihara, F. Lecadre, S. Hemmette, M. Kasuya, Y. Kanno	*Low-temperature Surface Forces Apparatus*	International Conference on Active Materials	3-8 Nov. 2019	Okinawa	Japan	
3	S. Hemette, J. Cayer-Barrioz, D. Mazuyer	*A multi-physical and scale approach to tackle rubber/ice*	International tribology Conference 2019	17-21 Sept. 2019	Sendai	Japan	

		friction mechanisms					
4	S. Hemette, D. Mazuyer, J. Cayer-Barrioz (Invited talk	*Ice-Rubber Friction Mechanisms*	Fall 2019 American Chemical Society National meeting	25-29 Aug. 2019	San Diego	USA	
5	S. Hemette, J. Cayer-Barrioz, D. Mazuyer	*A multi-physical and Scale analysis of Rubber/ice Friction Mechanisms*	STLE Tribology Frontier Conference 2018	28-31 Oct 2018	Chicago	USA	

Patents *(gray color for previous years)*

	Inventors	**Title**	**PCT #**	**Year**
1				
2				

Others *(gray color for previous years)*

	People	**Event**	**Description**	**Date**
1				
2				