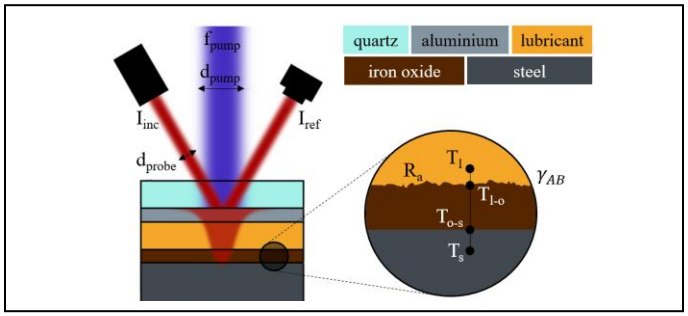
INTERFACIAL THERMAL CONDUCTANCE ACROSS SOLID/LIQUID INTERFACE

Andrea Zovko[a*], Peter K. Petrov[b], Janet Wong[a]
*a.zovko22@imperial.ac.uk
[a] Tribology Group, Department of Mechanical Engineering, Imperial College London, Exhibition Road, London, UK, SW7 2AZ; [b] Department of Materials, Imperial College London, Exhibition Road, London,



UK, SW7 2AZ

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ABSTRACT
Thermal behaviour in rubbing contacts has been a subject of interest since it was observed that two metallic bodies in relative sliding motion may experience exceptionally high surface temperatures (1). Contact temperature has since been established as a critical parameter affecting load capacity of a surface (2). More recently, energy transition demands have placed a heightened focus on thermal performance of lubricants (3).

Experimentally probing thermal properties of rubbing surfaces is challenging, as contacts are subject to interwoven effects of mechanical, thermal, and chemical processes and the contact area itself is physically inaccessible. Techniques for probing temperature in a contact rely on one of the surfaces being transparent, allowing measurement of emitted IR radiation. This approach has limitations due to temperature-dependent thermal properties of interest, such as emissivity and thermal diffusivity. Furthermore, techniques for probing bulk thermal properties (laser flash analysis, hot-wire method) are insensitive to the miniscule length scales relevant to highly loaded contacts where heat generation is a concern. For example, heat flux across a 10nm thick layer of polymethyl methacrylate (PMMA) is limited by interfacial thermal conductance, rather than PMMA's bulk conductivity (4). This is similar to thickness and chemical composition of self-assembled monolayers (SAM) commonly used as organic friction modifiers (OFMs), and not far from film thicknesses in elasto-hydrodynamically lubricated contacts.

In this study, we report the accuracy and sensitivity of a thermoreflectance technique (5), as applied to solid-liquid interfaces relevant to tribological contacts. We consider the experimental parameters such as beam power, modulation frequency, and beam profile geometry and their effects on measured thermal properties. Time permitting, we investigate validity of the assumption of temperature continuity across the interface that is implied in methods used for determining surface temperature in a rubbing contact (6).

Fig.1 Thermoreflectance technique used for studying heat transfer across tribological interfaces

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REFERENCES
1. Bowden FP, Ridler KEW. A Note on the Surface Temperature of Sliding Metals. *Mathematical Proceedings of the Cambridge Philosophical Society*. 1935;31(3): 431–432.
2. Liu HC, Zhang BB, Bader N, Guo F, Yang P. Crucial role of solid body temperature on elastohydrodynamic film thickness and traction. *Tribology International*. 2018;131. https://doi.org/10.1016/j.triboint.2018.11.006.
3. Chen Y, Jha S, Raut A, Zhang W, Liang H. Performance Characteristics of Lubricants in Electric and Hybrid Vehicles: A Review of Current and Future Needs. *Frontiers of Mechanical Engineering in China*. 2020;6. https://doi.org/10.3389/fmech.2020.571464.
4. Losego MD, Moh L, Arpin KA, Cahill DG, Braun PV. Interfacial thermal conductance in spun-cast polymer films and polymer brushes. *Applied physics letters*. 2010;97(1). https://doi.org/10.1063/1.3458802.

5. Jiang P, Qian X, Yang R. Tutorial: Time-domain thermoreflectance (TDTR) for thermal property characterization of bulk and thin film materials. *Journal of applied physics*. 2018;124(16): 161103.

6. Archard JF. The temperature of rubbing surfaces. *Wear: an international journal on the science and technology of friction lubrication and wear*. 1959;2(6): 438–455.