EDITORIAL

Micro-tribology

Technological developments over the last few decades have introduced new and powerful techniques into the field of tribology enabling the scale of experiments to be drastically decreased and micro-tribology to efficiently fill a measurement gap between classical tribological experiments and atomic force microscopy (AFM) based on nanotribological techniques. Micro-tribological studies provide an important link between science and engineering enabling the development of micro and nanoscale structures in magnetic storage systems, micro- and nanoelectromechanical systems (MEMS/NEMS) and other emerging applications involving tribological contact at the submillimetre scale. Moreover, the macroscopic behaviour of tribological systems is determined by the interaction between contacting surfaces at micro- and nanoscales; hence, micro-tribology experiments allow tribologists to build a fundamental understanding of frictional and lubrication processes.

The seven selected papers published here were presented orally during the Sixth International Colloquium on Micro tribology held in Osieck (near Warsaw), Poland on 9–13 September 2012. They were submitted by the authors after the colloquium to this special issue of Tribology – Materials, Surfaces & Interfaces.

The introductory paper by **Kim *et al.*** focuses on special lubrication effects in the presence of condensed water vapour. The surface chemistry in such an environment influences dramatically on the wear of copper and glass surfaces. The friction and wear behaviours of glass and silica might be expected to be similar since both are based on amorphous Si–O networks and their moduli are similar. In many studies, the silica surfaces are used as a model for more complicated glasses. However, their wear behaviours in humid environments are drastically different. Similarly, one expects that when a copper surface is rubbed with a cutter grade (much harder) stainless steel ball, the copper surface would always wear. But in high humidity conditions, the harder steel ball wears instead of the copper. These observations can be explained only when we fully understand the mechanochemical interplay at nanoscales between the solid surfaces and molecules adsorbed from the environment.

The next paper by **Gebeshuber and Macqueen** presents the new Asian case method and its introduction to micro/nanotribology. This case method (inspired by the trademark of professional education of the Harvard Business School) can lead to increasing the potential in micro and nanotribology research and development, by structuring the ways of thinking and approaching problems contributed by students/researchers/engineers/business people and by establishing the case method in tribology for the more efficient transfer to other fields of science and engineering.

The third paper by **Vite-Torres *et al.*** reports the micro-abrasion dental wear of restorative porcelains and amalgam. This is a very complex phenomenon in the situation described in tribology as 'three body abrasion' since the environment of the tooth to tooth contact is complex: the presence of food abrasive particles, tooth abrasive debris and restorative dental material debris or abrasive toothpaste particles. The results of the wear tests of the dental porcelains and amalgam in the presence of deionised water and artificial saliva with SiC abrasive particles are presented and discussed in this interesting paper.

The next paper by **Abetkovskaia *et al.*** reviews the application of AFM to study the mechanical and tribological properties of materials for the application in MEMS devices. In the presented study, the approach presented enables establishing the influence of nanoscale polymeric layer thickness on its elastic, adhesive and frictional properties. The thermoheating stage was applied to perform AFM measurements versus temperature in the range of 20–120°C.

The fifth paper by **Beake *et al.*** presents the recent progress in the nanoscratch testing methodology. The importance of the probe choice, scan parameters and high lateral stiffness of the test instrument in obtaining reliable nanoscratch data is discussed. The film thickness and scratch orientation relative to grinding marks were shown to have a large influence on the critical loads obtained in the progressive load nanoscratch test. The experiments have led to significant progress in determining and clarifying the key test parameters and expected data for input into a best practice guide for nanoscratch testing and subsequent standardization activity.

The next paper by **Nolbert and Rymuza** presents the model and the results of computer simulations enabling the minimization of friction and adhesion during sliding contacts. This is crucial for the designing and industrial fabrication of many MEMS/NEMS devices as well as in nanotechnological processes, e.g., in nano-imprint lithography (NIL), where a silicon mould is used to fabricate polymeric nanostructures by imprinting. The intensive studies of the contact between the mould and PMMA polymeric resist film via advanced modelling and computer simulations have been carried out. The properties of the contacting surfaces have been identified with the AFM and nano-indentation, as well as wettability tester applied for the identification of the surface free energy. A model of contact has been elaborated and adequate original software was used to calculate the frictional and adhesive forces in particular at the silicon mould–polymeric resist interface.

The sliding and rolling of individual micro-sized glass particles on rough silicon surfaces is discussed in the last paper by **Stealer**. The process dynamics of many granular media is dominated by the interaction between individual particles and particles and walls. Up to now, this behaviour is only partially understood. A focused ion beam (FIB) system was used to create appropriate holders for various small spherical silica particles with diameters of several to 100 μm. Experimental nanoindentation results correlating particle radius, surface

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roughness, adhesion and normal load with contact deformation, as well as sliding and rolling friction, are presented and discussed.

The meeting in Osieck provided a fruitful forum for a group of experts in this unique area of tribology, and allowed the exchange of information and ideas in the pleasant environment of a small village in the beautiful Mazowiecki Landscape Park on the eastern side of the Vistula River, near Warsaw. We are very grateful to the participants of the conference and the authors for their work and contribution to this special issue. The readers are strongly encouraged to read the full text of these stimulating articles.

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