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0172

Squeezing Molecularly thin Lubricant Films between curved Corrugated Surfaces with long range Elasticity

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The present work investigates the ability of two nm thick lubrication films to stay in a contact and thereby to prevent excessive wear of the surfaces. At this thickness the film is no longer a fluid but it is the very important intermediate between the lubricated and the dry regimes, the latter one being associated with devastating wear progress.

The properties of alkane lubricants confined between two approaching solids are investigated by a model that accounts for the roughness, curvature and elastic properties of the solid surfaces. We consider linear alkanes of different chain lengths, C3H8, C4H10, C8H18, C9H20, C10H22, C14H30 and C16H34, confined between corrugated gold surfaces. Well defined molecular layers develop in the lubricant film when the width is of the order of a few atomic diameters. An external squeezing pressure induces discontinuous, thermally activated changes in the number of lubricant layers between the corrugation tops. The pressure necessary to squeeze out a single layer of lubricant in the case of corrugated substrate is significantly lower than in the case of flat substrate which is mainly due to the smaller radius of curvature in the corrugated contacts. Single layers are squeezed out at higher pressures for longer alkanes than for shorter ones which indicates that longer alkanes are better lubricants. The longest alkanes are capable of domain formations which result in even higher squeeze out pressures. The short alkanes stay fluid-like during the entire squeeze out process. The corrugation of the substrate plays an important role in lubrication in the investigated systems. Its amplitude and periodicity determine the quantity of lubricant that can be trapped and the number of contact points between the block and the substrate. The latter point is important as lubrication enhancing domain formation of longer alkanes in just one contact point can delay the squeeze out of lubricant in other points which should result in less wear. We obtain good correlation between our theoretical results and wear experiments.