Technology Development & Commercialization

Few-Layer Graphene as a Dry Lubricant

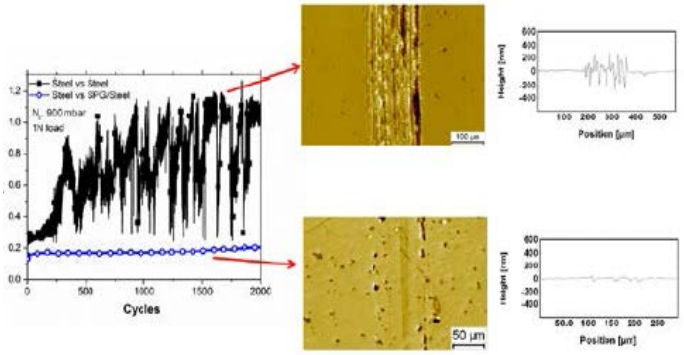
2- to 3-layer graphene reduces friction and wear between contact and sliding surfaces fourfold.

Current Challenges

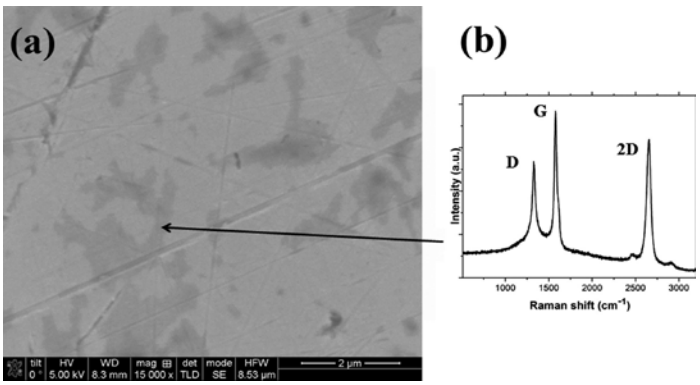
Most traditional methods of controlling friction and wear involve the uses of solid and liquid lubricants. However, finding the most environmentally friendly and cost-competitive lubricant has been difficult endeavor. Current lubricants, such as molybdenum disulfide or boric acid, are required in large amounts and are also environmentally unfriendly. The oil-based lubricants need to be consistently reapplied, producing additional waste. The cost of applying solid lubricating coatings is rather high and, due to finite thickness, they do not last very long and must be reapplied, adding cost. One of the emerging self-lubricating materials is graphene, which has been widely studied for its unusual thermal, electrical, mechanical and recently, tribological properties. Previous studies have focused on nano- to micro-scale friction and wear behavior. Graphene works best in moist air and does not protect the surface from tribo-corrosion. Majority of the dry lubricants require specific deposition processes that limit their application. The quest for finding perfect lubricant, which not only provides the lowest friction and wear, but is also free of harmful additives, still continues.

The Solution

Researchers at the U.S. Department of Energy's Argonne National Laboratory show that 2- to 3-layer graphene deposits from solution-processed graphene (SPG) on steel surfaces reduce friction and wear in air (30% relative humidity) and in dry nitrogen. Very small amounts of graphene from SPG, in tests with sliding steel surfaces, decreased wear by almost 4 orders of magnitude and coefficient of friction by a factor of 6. Very infrequent and regular applications of very small volumes of graphene-ethanol solution maintain friction-reducing properties of graphene on treated surfaces. Under dry conditions for moderate loads, 2- to 3-layer graphene completely eliminates the need for liquid lubrication medium. Even at greater loads, 2- to 3-layer graphene provides effective lubrication without the use of any liquid lubricant. Research at Argonne confirms that graphene layers act as a two-dimensional nanomaterial and form a conformal protective coating on the sliding contact interfaces, and these factors facilitate shear and slow down oxidation (tribo-corrosion), thus drastically reduce wear.



Coefficient of friction demonstrates low stable value indicating graphene layer is providing protection from high wear and steel corrosion.



Scanning electron microscope image of as deposited graphene flakes (a) and Raman spectrum of one of the flakes on steel plate (b). Peak (D) indicates presence of deposited graphene while peaks (G and 2D) help determine number of deposited layers.

Argonne researchers have demonstrated that graphene holds great promise as an effective solid lubricant, which can easily be deposited on tribological surfaces by using SPG.

Benefits

Few layer graphene as a dry lubricant:

- Easily applied on tribological surfaces at room-temperature conditions
- Function as a dry lubricant reducing wear by fourfold and friction by sixfold.
- Eliminates need for liquid lubricant or liquid medium
- Works in humid and dry conditions
- Environmentally friendly
- Cost-competitive with oil-based lubricants

Benefits

Super lubricating graphene film:

- May replace oil-based lubricants in some applications.
- Slows down tribo-corrosion

Development Status

- Method of depositing super lubricating graphene films on steel surfaces has been fully developed.
- Super lubricating graphene films have been tested in tribological tests.
- Further application specific tests are under way.

Licensing Status

This technology is patent pending and available for licensing and partnership development.

Invention Number

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Contacts

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