IMPLANT MATERIALS

Reducing wear debris

ACS Nano http://doi.org/bbwk (2016)

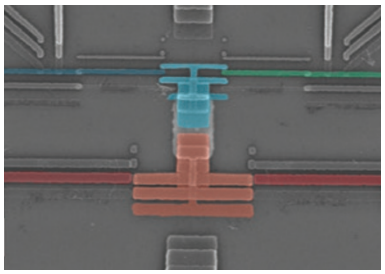
Total joint replacements frequently fail because wear debris from the prosthesis, which is typically made of ultrahigh molecular weight polyethylene (UHMWPE), can trigger an immune response. To prevent this, methods to modify the prosthesis exist including crosslinking of the polyethylene to improve tribological properties, using wear-resistant coatings, or adding filler materials to improve wear resistance. However, these methods can increase oxidation, peeling, and are potentially inflammatory, respectively. Xingyu Jiang and colleagues at the National Center for Nanoscience and Technology, and Southwest Jiaotong Univeristy now show that a composite of nanocrystalline cellulose and UHMWPE can reduce the generation of wear debris.

The composite was prepared by hot-pressing together blends of nanocrystalline cellulose and UHMWPE. Using water as the lubricant, wear resistance tests showed that composites with higher concentrations of cellulose had a lower coefficient of friction, fewer cracks, and less wear. Nanocrystalline cellulose aggregates similar in size to holes on the worn surfaces were seen, suggesting that the aggregates detached from the UHMWPE and helped prevent abrasion. Furthermore, the composite produced fewer and smaller debris than pure UHMWPE samples. When tested in cell cultures, the wear debris from the composite showed significantly lower inflammatory responses and cytotoxicity than pure UHMWPE. Although the results suggest that the composite may be a promising load-bearing material, it would be essential to test these materials under clinically relevant conditions. *ALC*

NANODEVICES

Maxwell's demon on a chip

Phys. Rev. Lett. **115,** 260602 (2015)



APS

Maxwell's demon is a thought experiment conceptualized by James Clerk Maxwell and involves a 'being' (or demon) guarding a tiny hole between two gas reservoirs at the same temperature; the demon can measure the speed of individual molecules and let through only the fast ones, which would create a temperature difference between the two reservoirs without doing any work, in apparent violation of the second law of thermodynamics. So far, all realizations of a Maxwell's demon have required an external control of its functions, making it hard to quantitatively evaluate the thermodynamic parameters — heat, entropy and information transfer — involved in the process. Jukka Pekola and colleagues at Aalto University have now made a Maxwell's demon that works without external intervention.

The system is composed of two aluminium superconducting wires functioning as reservoirs of conducting electrons. The reservoirs communicate through a copper island to form a single-electron transistor. Applying a voltage bias ensures that electrons tunnel only in one direction. Coupled to the island is a second single-electron transistor — the demon. The demon senses the presence or the absence of an electron inside the island by Coulombic interaction and quickly responds by applying a feedback mechanism that forces electrons to tunnel to and from the island always against a potential energy barrier. The net result of this uphill motion is a decrease in entropy of the system, measured as a drop in temperature between the left and right reservoirs. The price to pay, however, is in an increase in entropy of the demon, measured as a temperature rise. Because there is no exchange of heat between the system and the demon, the entropy increase is linked to the amount of information about the system acquired by the demon. *AM*

2D MATERIALS

Hybrid interfaces

Nano Lett. **16,** 497–503 (2016)

Van der Waals heterostructures, which are formed by interfacing two low-dimensional materials such as graphene and transition metal dichalcogenides, offer a unique experimental platform for the development of new device functionalities. Integrating an organic semiconductor into such nanostructures can lead to the emergence of properties that are absent from the structural building blocks. Mark Hersam and colleagues at Northwestern University have now explored the potential benefits of van der Waals organic/inorganic interfaces by examining heterojunctions formed of pentacene and MoS_2.

The researchers created gate-tunable diodes from the pentacene/MoS_2 heterojunctions and investigated their optoelectronic response and charge transport. The transfer curves of the devices were found to exhibit strong asymmetric anti-ambipolar behaviour, which is uncharacteristic of inorganic van der Waals heterostructures and could be advantageous in electronics applications. Moreover, the devices could function as a photovoltaic cell due to type-II energy band alignment at the hybrid interface. However, they had low power efficiency due to reduced absorption within the 2D MoS_2 layer and unfavourable lateral device geometry. Nevertheless, this observation suggests that transition metal dichalcogenides could be used as an acceptor in photovoltaic devices. *OB*

NANOTECHNOLOGY IN FOOD

Silver-lined packaging

J. Nanopart. Res. **18,** 5 (2016)

Silver is well known to have antimicrobial properties. For this reason, silver nanoparticles are currently used in a range of packaging and storage products to increase the shelf life of food. There are, however, concerns about potential transfer of the nanoparticles into the food, especially as the toxicity of silver nanoparticles is not well understood. This has led to some food packaging products being banned from the market in certain countries, at least temporarily. A number of studies have previously examined the total amount of silver released into food from food storage containers. Now, Aiga Mackevica and colleagues at the Technical University of Denmark have examined the release of silver from storage products in terms of particle size, number concentration, and transfer rate, as well as total amount.

The researchers examined four products (two storage boxes and two bags) that were placed in contact with three different food simulants (Milli-Q water, 90% ethanol and 3% acetic acid) and left for 10 days. They then used mass spectrometry, as well as a range of microscopy techniques, to analyse the transfer of material. The total amount of silver found in the food simulants was less than the limit fixed by food authorities such as the European Food Safety Authority. However, the study showed that the silver can be transferred in the form of nanoparticles and the largest nanoparticles were found when using acetic acid as the simulant. The work highlights the need for further research into the toxicity of nanoparticles before a clearer picture on the use of silver in packaging can be formed. *FP*

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