The art of disappearing devices

BIOMEDICAL DEVICES

A biocompatible and biodegradable organic electronic device could change the future of medicine and we are very close to achieving such a device according to researchers from Stanford University [Bettinger et al., Adv Mater (2009) 21, 1]. The difference between organic-based devices and the more traditional silicone-based devices is that the former are cheap and can easily be made into flexible electronics. However, if they also have the added advantage of being biodegradable they could potentially be used in resorbable medical implants or for drug delivery.

In their quest to fabricate such an organic thin-film transistor, Zhenan Bao and Christopher Bettinger chose two inexpensive and commercially available polymers: poly (L-lactide-co-glycolide) (PLGA) and poly(vinyl alcohol) (PVA) to be the substrate and gate dielectric. These polymers are already established components of biomedical devices and are United States Food and Drug Administration (FDA) approved for some applications. Silver and gold, which are biocompatible and inert materials respectively, were used in very small amounts as the metal components, and a potentially biodegradable semiconductor, 5,5′-bis-(7-dodecyl-9H-fluoren-2-yl)-2,2′-bithiophene (DDFTTF) was added to the device. Christopher Bettinger explains their goals when designing the transistor. “Current devices are either:

1) temporary implants composed of biodegradable polymers which have limited electronic functionality or
2) permanent implants composed of silicon which need to be surgically removed after their intended tasks are completed. We aimed to develop a materials system that is able to combine the advantages of biodegradable polymers and silicon for use in medical devices. This work represents the first work towards the use of organic electronics and biomaterials for biomedical device applications.”

In vitro studies show that the new devices operate stably in vitro and then lose structural integrity within 50 days. The byproducts should be released through metabolic pathways.

“Regarding future work, there is a lot of work that must be done in order to engineer appropriate encapsulation strategies. Some of the initial goals are to demonstrate the operation of these devices in buffer solutions with high salinity. These demonstrations would suggest that we can achieve stable operation of organic electronic devices implanted in the human body. Other goals include the fabrication of other electrical components based on biomaterials and organic electronic systems,” says Bettinger.

Katerina Busuttil

Microscopically wearing issues

MICROSCOPY

A new diamond probe tip for the atomic force microscope has been developed and modelled by researchers in the USA. The new hard-wearing probe has the big advantage of not wearing down as quickly as standard silicon nitride AFM probes. It could allow materials scientists to image surfaces for longer periods of time without losing resolution.

Atomic force microscopy is one of the most powerful analytical techniques available to science. It can probe surfaces and material properties at the nanoscale, as well as be used to generate pattern of organic and inorganic molecules on a substrate by relocating clusters, or even individual atoms. “In all cases, knowledge of the tip geometry and its evolution with continued use is essential,” says Horacio Espinosa of the McCormick School of Engineering and Applied Science at Northwestern University.

The resolution of AFM is limited by the sharpness of the tip and its geometry. Unfortunately, tips degrade during a scan leading to imaging artifacts and errors in the measurements, the step heights, of surface features, all of which distort the picture of the surface the scientists hope to observe.

The same wearing issue afflicts researchers using AFM to build nanoscopic patterns on surfaces using techniques such as dip-pen nanolithography, nanofountain probe patterning, and scanning probe contact printing.

Espinosa and graduate student Ravi Agrawal and co-worker Nicolaie Moldovan, of Advanced Diamond Technologies, have demonstrated that a diamond probe tip is ten times more durable than standard probes [Espinosa et al., J. Appl. Phys. (2009) 106, 064311]. The team tested AFM probes made of silicon nitride, undoped ultrananocrystalline diamond (UNCD) and nitrogen-doped UNCD. Argonne National Laboratory supported this work by providing nitrogen-doped UNCD films. The researchers scanned the AFM probe across a hard UNCD substrate and found that for a constant applied force, there is a linear relationship between wear volume and total dissipation energy.

The tip radius increases as the probe wears; the change in radius is proportional to the square root of the distance scanned, the team adds. Tip evolution can now be estimated if the initial tip radius and the scanning conditions are known, the team says.

Researchers had assumed that diamond would outperform other probe materials but Espinosa and his colleagues have now modelled the process of tip wear and corroborated rigorously that diamond is an order of magnitude more wear resistant than silicon nitride. As such, the researchers assert that diamond should be the tip material of choice for scientists using AFM.

David Bradley