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Cite of special scientific interest

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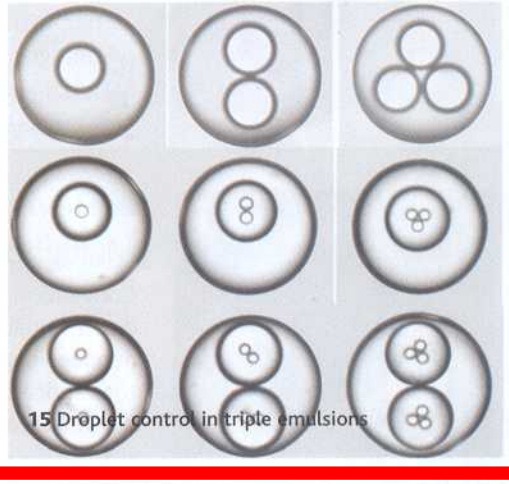


Spacers bind nanotubes and nylon together

COMPOSITES

Composites incorporating carbon nanotubes abound, but similar efforts to beef up the mechanical properties of nylon – one of the world's most industrially relevant polymers – haven't met with great success. According to researchers from the University of Pennsylvania and Rice University, the key lies in flexible 'spacers' to link the two components [Moniruzzaman *et al.*, *Nano Lett.* (2007) doi: 10.1021/nl062868e].

Karen I. Winey of the University of Pennsylvania wanted to apply the group's patented *in situ* polymerization method, which overcomes problems in dispersing single-walled nanotubes (SWNTs), to nylon 6,10. However, native SWNT/nylon composites didn't show much improvement in mechanical properties over nylon. Simply mixing the two doesn't exploit the extraordinary mechanical properties of SWNTs.

More conventional composites have been made for decades by chemically modifying the interface as a means to optimize mechanical performance. So when Winey learned of SWNT functionalization work by W. Edward Billups at Rice University, a collaboration was born.

By functionalizing the SWNTs with flexible alkane spacers of the form $-(CH_2)_nCOCl$, where n is either 4 (C-4) or 9 (C-9), the nanotubes covalently bond to the nylon 6,10. The resulting composites show marked improvement in mechanical properties. The C-4 linkages result in a 162% improvement in Young's modulus over native nylon and a 149% rise in tensile strength, all the while maintaining the intrinsic toughness. For C-9 linkages, results are similar with a sharp rise in the strain-at-break, some 368% higher.

D. Jason Palmer

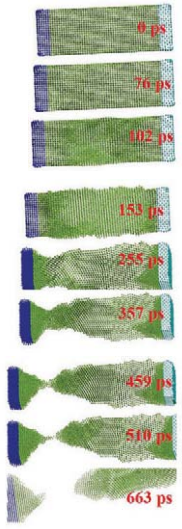
Pinpointing nanowire failure

MECHANICAL BEHAVIOR

As the utility of nanowires in microelectromechanical systems and molecular devices increases, knowledge of their failure mechanisms will become more important.

New research from Nanjing University in China has identified three strain-rate-dependent breakage mechanisms that result in differing breakage positions [Wang *et al.*, *Nano Lett.* (2007) doi: 10.1021/nl0629512]. The researchers used molecular dynamics simulations of single-crystalline Cu nanowires under continuous pulling at varying strain rates to investigate the failure modes.

Regardless of strain rate, the crystalline lattice near the center of the nanowire collapses beyond a critical strain into small domains, forming clusters of a few atoms that tend to reduce the stress. The final breakage mechanism, however, is dependent on the strain rate.



Snapshots of a nanowire breaking. (Courtesy of Jianwei Zhao.)

At a rate of 1.3%/ps, the clusters disintegrate into an amorphous configuration, resulting in a 'neck' being formed. As superplastic elongation proceeds, the breakage point is near the middle. For a rate of 0.13%/ps, the clusters migrate to the nanowire ends, and the 'neck' and ultimate breakage point forms at one end or the other. At the lowest strain rate of 0.016%/ps, the clusters tend to recrystallize and there are many slippages along {111} planes until an ultimate breakage, again near the middle of the nanowire.

D. Jason Palmer

Control key to materials advances

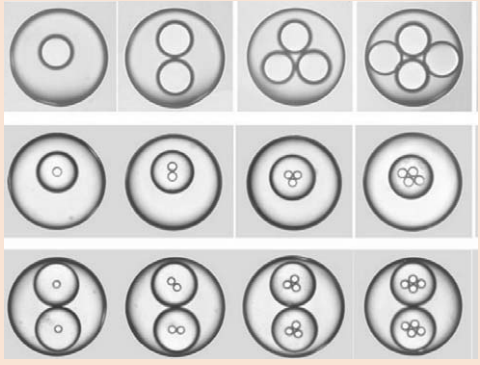
CONFERENCE NEWS

A number of talks at the Materials Research Society Spring Meeting in San Francisco show how care in controlling fabrication can lead to outstanding results.

Emulsions are often made by adding a surfactant to two immiscible fluids and applying shear, but this gives no control over the individual droplets formed. David Weitz's group at Harvard University is using capillary microfluidics to gain exquisite control over the droplets. By placing one capillary inside another, thousands of precisely sized drops of one solution can be formed every second inside a different, flowing liquid containing a surfactant. Using more capillaries allows the researchers to create double emulsions with controlled numbers of droplets inside larger drops. And why stop there? In their latest work, they've created triple emulsions for the first time (shown).

Because each level in the double and triple emulsions can be controlled separately, novel vesicles and polymerosomes can be created with different materials in the core. This could be useful for encapsulating sensitive flavors or drugs. The group are also investigating how reactions can be carried out within the droplets for high-throughput screening.

A compact system developed by Anup Singh and coworkers at Sandia National Laboratories aims to allow dentists to carry out assays for periodontal disease in a matter of minutes. The microfluidic chip at the heart of the system uses fluorescently labeled antibodies to probe microliter saliva samples for markers associated with the disease. Antibody-antigen complexes are detected optically after separation by electrophoresis on a gel cleverly introduced into the microfluidic channels.



Examples of double and triple emulsions. Scale bars are 200 μm. (Courtesy of David Weitz, Harvard University.)

John A. Rogers showed movies of a prototype printing press for constructing flexible electronic devices in high yield. The device, developed at the University of Illinois, Urbana-Champaign, uses a soft-lithography approach to transfer solid nanoscale components from wafers, where they have been fabricated, onto large-area flexible substrates. By repeating this room-temperature process, complex electronic devices can be constructed layer-by-layer.

Jonathan Wood