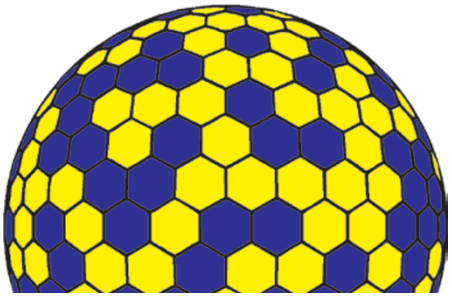
NANOPARTICLES

Determining domains

Angew. Chem. Int. Ed. http://dx.doi.org/10.1002/anie.201102882 (2011)



The surfaces of metal nanoparticles are often coated with a single layer of thiol molecules in which the sulphur atoms at the head of the molecules bind to the surface and the molecular tails extend out into the surrounding medium. Such monolayers can also be formed using mixtures of thiols, and these mixed monolayers can undergo phase separations to form nanoscale domains on the surface. By controlling the structure of the domains, the properties of the nanoparticles, such as their solubility, can be modified. However, characterizing the domains is difficult. John McLean, David Cliffel and colleagues at Vanderbilt University have now shown that mass spectrometry can be used to observe and measure phase separation in gold nanoparticle monolayers.

The nanoparticles are first fragmented using the matrix-assisted laser desorption/ionization process, which frees the gold–thiolate complexes that cover the nanoparticle core. The ionized species are then separated in the gas phase by effective surface area, and subsequently by mass-to-charge ratio. This allows mass spectra that contain only the gold–thiolate ions to be collected. From the spectra, specific gold–thiolate species are extracted and their abundances compared with a theoretical model that represents a random distribution of molecules on the nanoparticle surface. Deviations from the model indicate that nanophase separation is present in the nanoparticle monolayer and can be correlated to the formation of domains.

With the technique, the Vanderbilt team are able to efficiently analyse monolayers prepared with different mixtures and ratios of thiols, as well as by different synthetic procedures. *OV*

PROTEIN CORONA

Particle size matters

ACS Nano http://dx.doi.org/10.1021/nn201950e (2011)

When nanoparticles are exposed to biological fluid, proteins can bind to the surface of the nanoparticle to form a protein corona, which affects how nanoparticles are internalized by cells and cleared from the body. The composition of the corona is thought to depend on the type, size and surface properties of the nanoparticle, but because the human plasma contains a complex mixture of nearly 2,000 proteins, understanding how the corona forms remains a challenge. Now, Richard Stauber and colleagues from various institutes in Germany and the Srinakharinwirot University in Thailand have shown that the binding of proteins depends critically on the size of the nanoparticle.

Stauber and co-workers incubated different sized silica nanoparticles for 1 h in human plasma obtained from healthy volunteers, and characterized 125 different proteins from the corona using liquid chromatography–mass spectrometry and computational analysis. In contrast to previous findings, they found that neither protein size nor charge determined which proteins bound to the nanoparticles, suggesting that electrostatic effects alone may not explain how the corona forms. Using bioinformatic tools, the bound proteins, lipoproteins and proteins involved in coagulation and the complement pathway were found to be enriched on the nanoparticles, whereas other proteins showed low binding affinities. The size of the nanoparticles determined quantitatively, but not qualitatively, the binding of 37% of all the proteins identified. *ALC*

NANOPHOTONICS

Son et lumière

Nature Photon. http://dx.doi.org/10.1038/nphoton.2011.208 (2011)

The novel optical properties of quantum dots are exploited in many different applications, as are those of photonic crystals, so it is not surprising that researchers are trying to develop new classes of devices that combine quantum dots and photonic crystals. Both systems have characteristic wavelengths that depend on their composition and size or structure, and varying these wavelengths with respect to each other is a central challenge in the development of new devices. Now Hubert Krenner, of the University of Augsburg, and co-workers have demonstrated that surface acoustic waves can be used to modulate the resonant wavelength of a photonic crystal nanocavity an order of magnitude faster than before.

Krenner and colleagues — who are based in Germany, the Netherlands and the United States — directed the surface acoustic waves at the nanocavity, which contained indium arsenide quantum dots, and measured how the waves influenced the light emitted by the dots. In addition to modulation frequencies above 1.7 GHz, they demonstrated large wavelength shifts and showed that the quality factor of the nanocavity remained high and that the spatial mode profile did not change. The approach relies on the acoustic waves first stretching the nanocavity and then compressing it, which causes the resonant wavelength to first increase and then decrease. *PR*

GRAPHENE NANORIBBONS

Hot and cold all over

Appl. Phys. Lett. **99,** 113101 (2011)

Graphene's optical and electrical properties receive the most attention. However, graphene also has unique thermal properties — its thermal conductivity is large, with promising applications in thermal management. Yong Chen and colleagues at Purdue University have now predicted that graphene's differential thermal conductivity can also be negative.

The researchers used classical molecular dynamics to model heat flow through a graphene nanoribbon that has two ends fixed at two different temperatures. In general, the thermal current flowing from the hot to the cold end is expected to increase as the difference in temperature across the ribbon increases. However, the simulations showed that for nanoribbons less than 50 nm long and for a sufficiently large temperature difference, the thermal current decreased as the temperature difference increased.

The effect stems from the dependence of the thermal conductivity on the average nanoribbon temperature. Increasing the temperature difference across the ribbon (with the temperature at one end fixed) can lead to a decrease in the average ribbon temperature, and a decrease in the thermal conductivity. The onset and extent of negative differential conductivity can be controlled by adjusting the nanoribbon shape, length and the two end temperatures. The nanoribbon can therefore be considered a two-terminal thermal analogue to a three-terminal electrical device, with the role of the gate played by the dependence of the average temperature on the temperature difference. *MS*

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