MATERIALS SCIENCE

Revealing water's secrets

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The properties of water and ice under a wide range of temperatures and pressures are well established. However, it is challenging to determine their electronic and dielectric properties under extreme conditions, because of the experimental difficulties of performing the required optical measurements. Now, *ab initio* molecular dynamics simulations of water under pressure performed by Ding Pan and co-workers at the Universities of California and Chicago have enabled the refractive index and electronic gap of water and ice to be precisely calculated for pressures up to 30 GPa. The results reveal that both parameters increase with increasing pressure. This goes against the widely held view that the bandgap of water, like that of many other materials, is inversely correlated to the measured refractive index. It also turns out that the single-oscillator model, which is extensively used to determine the electronic properties of various materials, is insufficient for modelling the properties of water under extreme pressure and hence needs to be revisited. *MM*

SATURABLE ABSORBERS

Low saturable intensity

Opt. Express **22,** 11508–11515 (2014)

High-repetition-rate *Q*-switched fibre lasers are highly desirable for use in a wide variety of applications, including high-resolution photoacoustic microscopy and the realization of high-performance optical parameter oscillators. Various techniques are being investigated for achieving passive *Q*-switching using a saturable absorber in fibre lasers. Of these, the use of topological insulators is particularly promising. Now, researchers at Beijing University of Technology in China have obtained high repetition rates and output powers from an erbium-doped fibre laser by using a film of the topological insulator Bi_2Se_3 as a saturable absorber. They realized a low saturable optical intensity of 11 MW cm^{-2} at a wavelength of 1,550 nm. They claim this is the lowest saturable intensity obtained to date for a saturable absorber made from a topological insulator and ascribe it to the optimization of the reaction conditions. Using this saturable absorber, they were able to achieve repetition rates in the range 459–940 kHz and a maximum output power of 22.35 mW. The saturable absorber was made from a film consisting of about five to seven layers of regular-shaped Bi_2Se_3 nanoplatelets. *SP*

SILICENE

Hydrogen tunes bandgap

Phys. Rev. X **4,** 021029 (2014)

Although silicon is an excellent electronic material, it has limitations as an optoelectronic material because of its indirect bandgap and relatively weak absorption of light. Various methods of modifying the band structure and optical properties of silicon have been investigated. Now, researchers in the USA, China and Korea have proposed a new approach — hydrogenation of bilayer silicene, a two-dimensional hexagonal silicon structure. By performing first-principles calculations in conjunction with the cluster-expansion approach, they systematically evaluated the structural and electronic properties of hydrogenated bilayer silicene. The results predict that hydrogenation can significantly enhance the optoelectronic properties of bilayer silicene and yield a widely tunable bandgap. At low hydrogen concentrations, the researchers identified four single- and double-sided hydrogenated bilayer silicene ground-state structures that are predicted to have dipole-allowed direct (or quasi-direct) bandgaps in the range 1–1.5 eV; these structures are thus promising for solar applications. At high hydrogen concentrations, the scientists found three well-ordered double-sided hydrogenated bilayer silicene structures that have bandgaps in the colour ranges of red, green and blue; these structures could potentially be used to fabricate a silicon-based white-light-emitting diode, and hence hold great promise for solid-state lighting. *SP*

OPTOMECHANICS

Chaotic oscillations

Opt. Lett. **39,** 3543–3546 (2014)

Optomechanics is a very active field that deals with the interaction of light and mechanical resonators as well as the physics and applications of the interplay between the two. Yue Sun and Andrey Sukhorukov of the Australian National University in Canberra have now theoretically investigated the detailed dynamics behind 'spectral bonding' in a pair of closely spaced suspended nanobeam cavities. By simultaneously exciting two specific optical modes, they manipulated a cavity resonance so that it matched a chosen wavelength. The researchers found that, unlike previous findings, the stable solution breaks down because of self-induced oscillations caused by the optomechanical coupling, even in a static optomechanical potential. The team identified a regime where the switching between mechanical deformities of opposite signs is no longer periodic but becomes chaotic. These results provide important insights into how to realize

PLASMONICS

Metallic excitons

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Although excitons, which are electron–hole pairs bound by the Coulomb potential, are expected to arise in metallic systems, it is non-trivial to experimentally observe these quasiparticles in metals because of the screening effect, which occurs on a femtosecond timescale. Now, Xuefeng Cui and co-workers in the USA and Croatia have reported evidence for a transient excitonic response on a silver surface in the time window preceding the full onset of screening. The response was revealed by interferometric pump–probe delay scanning and photoelectron imaging. A multiphoton photoemission process was excited by a non-collinear parametric amplifier system pumped by a fibre-laser oscillator–amplifier system (average power, 80–100 mW; repetition rate, 1.25 MHz, pulse length, ~15 fs). The pulses were focused onto the silver sample at an incidence angle of 45° and with transverse magnetic polarization. Measurements were performed with the single-crystal silver cooled to ~100 K. The team notes that the transient exciton response of the metallic system may help explain multi-exciton generation in organic films. Additionally, strong electron–hole correlations shown in the metal system may fuel studies of non-equilibrium quasiparticle dynamics in strongly correlated materials. *DP*

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