Measuring CO_2 from afar

Appl. Opt. **50,** 1560–1569 (2011)

Rising global temperatures have emphasized the need for the continual monitoring of CO_2 concentration in the atmosphere. Shumpei Kameyama and co-workers from Japan have tested the feasibility of measuring CO_2 levels from a satellite using a 1.6 μm continuous-wave modulation laser spectrometer system. In their scheme, continous-wave lasers are first modulated by two continous-wave signals of slightly different wavelengths, which are combined at a coupler and then amplified. They are then simultaneously and coaxially transmitted to the ground, where part of each beam is used as a reference. The transmitted beams are detected and compared with the reference beam after fast Fourier transformation. Comparing the spectra of the reference and transmitted beams gives a measure of the differential absorption optical path in the atmosphere. The team found that for a satellite altitude of 40 km and a receiving aperture diameter of 1 m, the required transmission power is 18 W at an albedo (reflection coefficient of a surface) of 0.31, and 70 W at an albedo of 0.08. The total measurement time was reported to be 4 s, which corresponds to a horizontal resolution of 28 km.

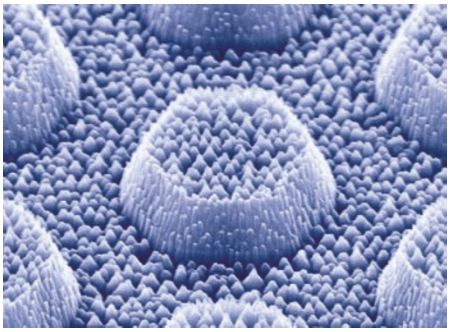
Solar hydrogen production

Adv. Func. Mater. **21,** 126–132 (2011)

A group of researchers from the University of Queensland in Australia have uncovered the excellent photocatalytic and visible light absorption properties of nitrogen-doped tantalum tungstenate ($CsTaWO_6$), which could be important for achieving the efficient solar-induced production of hydrogen. Efficient use of solar energy in such a scheme requires the photocatalyst to have a bandgap of <3 eV. However, most of today's active photocatalysts have wide intrinsic bandgaps of 3.0–3.2 eV. Based on a series of experimental measurements and theoretical calculations, Aniruddh Mukherji and colleagues revealed that nitrogen doping in $CsTaWO_6$ causes the absorption edge to red-shift from 358 nm to 580 nm, thereby significantly increasing the absorption of visible light. In addition, they found that doping reduces the bandgap from 3.8 eV to 2.3 eV because of mixing between the 2*p* orbitals in nitrogen and oxygen, making $CsTaWO_{6-x}N_x$ around 100% more efficient at producing solar hydrogen than its undoped counterpart. This technique not only provides a simple method for significantly increasing hydrogen production, but is also applicable to wide-bandgap semiconductors for the development of more efficient photocatalysts.

Improving LED output

Opt. Express **19,** A157–A165 (2011)



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High-refractive-index LEDs often suffer from low extraction efficiency because of Fresnel reflection and total internal reflection losses. Fabricating microstructures on the surface of an LED is an efficient way of improving its efficiency, but achieving this while also reducing reflection losses has proved to be a significant challenge. Young Min Song and co-workers from South Korea have now developed a bioinspired fabrication technique that uses antireflective subwavelength structures on top of microstructures to dramatically improve the potential light output powers of an LED. They first formed hexagonally patterned microstructures with diameters of 2 μm and thicknesses of 600 nm by dry etching on the surface of a GaP substrate. They then fabricated 120-nm-high cones on top of the microstructures by using thermally dewetted silver nanoparticle masks. The team found that the subwavelength structures and microstructures eliminated Fresnel reflection and total internal reflection, respectively, achieving a combined light output power enhancement of 72.47%. In comparison, an LED with microstructures but no subwavelength structures achieved an enhancement of 35.91%. The researchers say that their technique is compatible with most semiconductor device manufacturing processes and is therefore suitable for various optoelectronic device applications.

Enhancing PV light absorption

Opt. Express **19,** A41–A45 (2010)

Kwang-Tae Park and colleagues from Korea have shown that providing silicon microwires with an 'undergrowth' of shorter nanowires can enhance their light absorption, which may be useful for flexible thin-film photovoltaics applications. The team fabricated the wires on eight-inch wafers through a combination of photolithography and plasma etching. Key to the technique was the ability to control the heights of the microwires and nanowires independently by varying the gas ratio during etching. Keeping the nanowires (~5 μm) much shorter than the microwires (~50 μm) helps to reduce surface recombination. The nanowires exhibit a gradient index that reduces the large index mismatch between the air and the microwires. Microwires with no nanowires exhibited absorption of only 14% in the visible and near-infrared range, whereas microwires with a 300-nm-thick aluminium layer of nanowires demonstrated absorption of over 90%. The researchers were also able to demonstrate flexible devices by embedding their microwire/nanowire structures in a polydimethylsiloxane polymer.

Solar water splitting

Appl. Phys. Lett. **98,** 092108 (2011)

Hematite (α-Fe_2O_3) is an earth-abundant transition metal oxide compound that is relatively cheap, non-toxic to humans, chemically stable and absorbs ultraviolet and high-energy visible light, making it suitable for use in efficient and scalable solar-energy conversion technologies. Although the notoriously poor electronic transfer properties of α-Fe_2O_3 have presented some interesting technical challenges for its implementation into solar-energy conversion devices, strategies that involve doping the lattice while reducing the physical dimensions of the electrode structure have demonstrated notable increases in efficiency. Samuel Mao and co-workers in the USA now present the fabrication and morphological, optical and photoelectrochemical characterization of doped iron oxide films fabricated through oblique-angle physical vapour deposition. The team deposited films onto conductive SnO_2:F-coated glass and SiO_2 substrates in an oxygen environment at a moderate vacuum pressure of 4 mtorr. Deposition occurred from species ablated from a Fe_2O_3:TiO_2 (2.5 wt% TiO_2) target by approximately 130,000 shots from an excimer laser with a laser fluence of ~1 mJ cm^{-2} on the target surface. Photoelectrochemical characterization for water photo-oxidation revealed that the conversion efficiencies of the fabricated electrodes were strongly influenced by the temperature of the substrate during deposition. The researchers discuss these results in terms of the films' morphological features and the known optoelectronic limitations of iron oxide films for applications in solar-energy water-splitting devices.