therefore portable and easy to integrate into instrumentation.

The commercial relevance of this device will critically depend on the availability of high-quality hBN powder. As this is produced by a slow, high temperature and high pressure process, it may be available in the future only in limited quantities. Further optimization of the growth methods of hBN is therefore essential for successful commercialization of this device.

Hexagonal boron nitride competes with another promising UV-C light emitter, namely diamond, which also uses excitonic properties. Diamond is a wide-bandgap semiconductor with an optical bandgap of 5.47 eV, and shows free-exciton recombination at 235 nm with an exciton binding energy of 80 meV. Diamond is, however, an 'indirect semiconductor'; it is much more difficult to fulfil the energy and momentum conservation laws for recombination, and thus for light emission, than in direct semiconductors. The luminescence emission intensity from diamond at 235 nm is therefore significantly lower than that of hBN[4]. However, diamond semiconductor fabrication technology is much more mature than that of boron nitride. During recent years, growth and doping of diamond have been optimized significantly so that high-quality p-type (boron-doped), n-type (phosphorus-doped) and intrinsic (undoped) layers are now available. The doping is required to add electrons (n-type) or holes (p-type) into the diamond films to make them conductive. The first UV emission from diamond p–n-junction LEDs was reported by Koizumi *et al.* in 2001[9]. In 2007, Makino *et al.*[11] reported significantly improved p-i-n LEDs from diamond with a strong emission at 240 nm, due to enhanced free-excition recombination in the undoped layer of diamond. This device is a fully electronically driven LED (240 nm) and therefore has the potential for intense light emission and true miniaturization. However, diamond shares the same commercial problems as hBN and AlN. The availability of diamond material is limited and large-area diamond substrates are still missing. At present, strong activities are involved in manufacturing larger size, single-crystalline diamond substrates[11]. However, ultimately the success of all these short-wavelength emitters depends strongly on the continued progress of research into the synthesis of their constituent materials. ❐

Christoph E. Nebel is at the Fraunhofer Institut für Angewandte Festkörperphysik, Tullastrasse 72, 79108 Freiburg, Germany.
e-mail: christoph.nebel@iaf.fraunhofer.de

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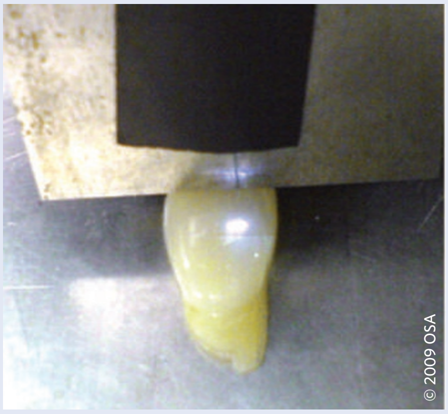
PHOTOACOUSTICS

Laser ultrasound checks tooth health

Photonics looks set to provide dentists with a convenient new way of analysing the mineral content of tooth enamel, an important indicator of the onset of dental decay.

Reporting in the online journal *Optics Express*, scientists from Australia and Taiwan describe how laser-generated ultrasound can be used to measure the elasticity of a human tooth, which relates directly to the level of mineralization in its enamel (*Opt. Express* **17,** 15592–15607; 2009). Although so far the scheme has only been tested on extracted teeth in an experimental set-up, the expectation is that in the future it could be developed into a hand-held probe and applied to patients *in vivo*.

The strength of enamel, the hard outer surface of a tooth that protects the soft dentin underneath, is dependent on having a sufficiently high mineral content. Poor dental hygiene can allow the build-up of acids that dissolve the minerals, leading to weakened enamel and ultimately tooth decay. Having knowledge of the level of mineralization is therefore important for assessing the health of teeth.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Hsiao-Chuan Wang and co-workers from the University of Sydney, Australia, and National Cheng Kung University, Taiwan, illuminated a tooth with a line of ultrashort (~5 ns duration) pulses of UV (266 nm) light emitted by a Q-switched frequency-quadrupled Nd:YAG laser.

The laser pulses excite an ultrasonic surface-acoustic-wave that travels across the tooth and is detected by highly sensitive optical interferometry through the tip of an optical fibre suspended just above the surface of the tooth. The velocity of the ultrasonic waves depends on the elasticity of the tooth; thus, by comparing travel-time and dispersion characteristics for different ultrasonic frequencies, the tooth's elasticity — and thus mineralization — can be determined.

An attraction of the technique is that it is non-destructive, in contrast with conventional physical nanoindentation impact tests, which can perform tooth elasticity measurements but damage the tooth in the process.

Interestingly, this is not the first time that photonics has been used as a diagnostic tool for the early detection of tooth decay. Researchers have also considered the use of terahertz imaging, optical coherence tomography, second-harmonic microscopy, near-infrared transillumination and Raman spectroscopy among others. In all likelihood, you'll be seeing more lasers at your dental surgery in the future.

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