(Fig. 2). The increasing noise leads to an adjustment of the switching time between the bistable states to the modulation period. In the work of Monifi *et al.*, when the pump power is increased, the system enters into a nonlinear dynamical regime where switching possibly occurs between several chaotic attractors, thus realizing the multi-stability condition towards the observation of stochastic resonance[12].

This work demonstrates how the interplay between nonlinear science and nonlinear optics can improve both device functionalities and performances. Although chaos, by definition, is unpredictable dynamics, it is remarkable to realize that different but connected oscillators can copy–paste their chaotic properties. Chaos broadcasting is a well-known property of optically coupled chaotic oscillators and has been analysed in the context of chaos synchronization and chaos-based communications[13]. It is also demonstrated by Monifi *et al.* for optical oscillators that are 'mechanically' coupled. Systems based on coupled optomechanical oscillators have much to bring to chaos-based applications and to the physics of collective behaviours of a large number of coupled nonlinear oscillators. Although this field was initially developed with coupled lasers or hybrid optoelectronic oscillators, the ease of integration, scalability and engineering of the nonlinearity in optomechanical systems makes them good candidates for further studies including the investigation of chaotic properties at the quantum level. However, most of the experimental studies related to optomechanical oscillators and chaos remain confined to a small number of coupled modes[8] and at relatively low frequencies (here MHz, but GHz oscillations have been demonstrated[14]). Chaos of low dimension and with limited bandwidth is considered a drawback for implementing chaos-based secure data communication at high bit rates[13]. In the light of recent works[15], application of optomechanical chaos to a physical source of entropy at a high bit rate seems, however, feasible. The sensitivity of the chaotic dynamics to slight changes in the incoming light power or frequency also makes these devices interesting for chaos-based sensing applications. ❐

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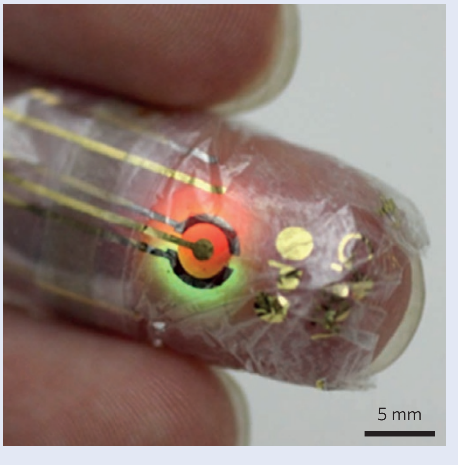
OPTICAL SENSORS

Ultraflexible on-skin oximeter

An organic pulse oximeter that can be laminated onto a fingertip to determine the concentration of oxygen in the blood has recently been developed by researchers in Japan (*Sci. Adv.* **2,** e1501856; 2016).

The sensor, built by Tomoyuki Yokota and co-workers from the University of Tokyo, comprises two organic polymer light-emitting diodes (PLEDs), operating at 517 nm (green) and 609 nm (red) respectively, shaped as semi-circles that enclose an organic photodetector (OPD; pictured).



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The PLEDs and the OPD each have a thickness of 3 μm, which is one order of magnitude thinner than human epidermis. The light-emitting diodes and the photodetector are manufactured on an organic Parylene substrate and are protected by an organic–inorganic passivation layer. Indeed, the latter ensures that the PLEDs and OPD do not deteriorate in air. For example, the authors observe that the passivation layer extends the operational half-life of the PLEDs from 2 to 29 h. Additionally, the thinness of the individual components ensures mechanical flexibility, with the PLEDs emitting light even when crumpled between two fingers.

Before assembling the pulse oximeter, Yokota and co-workers separately characterized the light emitters and the photodetector. The PLEDs exhibited quantum efficiencies around 13% at a current density of 10 mA cm^{-2}. When illuminated with a solar simulator at 1 sun, the power conversion efficiency of the OPD was found to be 1.46%, and the spectral responsivity indicates that the detector covers wavelengths between 400 nm and 650 nm.

The flexible oximeter is laminated onto the skin with adhesive tape. When it is wrapped around a finger, the assembled device operates in reflection mode: the two PLEDs emit red and green light into the skin and the OPD collects the light that is reflected back. As with conventional oximeters, the peripheral capillary oxygen saturation can be determined from the ratio of the amplitudes of the reflected green and red optical signals, as the absorption of light by haemoglobin at these wavelengths is sensitive to the level of oxygen in the blood. The organic oximeter shows good stability in air over a few days of operation, and the measurements are in agreement with the read-out from a commercially available system.

Given these encouraging results, the authors anticipate that further optimization of the fabrication of the passivation layer may lead to flexible optical sensors that can be laminated directly onto organs after surgery, or for everyday monitoring purposes of biological functions.

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