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Underwater opportunities

Activity in using photonics for subsea wireless communications and power generation is starting to make waves.

The use of photonics underwater may at first glance seem like a lost cause given the strong optical absorption of water in the infrared, which is home to the most well-developed optical technology. However, there is a narrow window of transparency in the blue–green wavelength region that researchers and companies are now increasingly looking to exploit for applications including solar energy generation and free-space optical communications. The motivation is easy to appreciate, given the desire to equip subsea sensors, remotely operated vehicles (ROVs) and even divers with cable-free forms of high-speed communication and power – opening the way for an autonomous 'internet of underwater things' (IoUT).

In this issue of *Nature Photonics*, we explore the progress that has been made in the area. Jason Röhr, Edward Sartor, Jason Lipton and André Taylor describe in a Perspective the achievements, opportunities and challenges for underwater photovoltaics. The vision is that suitably robust and efficient solar cells could be used to power remote sensors or communication devices, or recharge batteries for ROVs or other instrumentation.

A key takeaway message from the Perspective is that the dominant material of choice for terrestrial solar cells, crystalline silicon, is not suitable as its bandgap of 1.1 eV (~1.1 microns) coincides with strong water absorption. Instead, success likely lies with the use of a higher-energy bandgap material such as perovskite, GaInP, CdTe or amorphous silicon, with a bandgap of 1.8 eV or higher. Furthermore, new testing protocols and certification standards are necessary as is a solution to biofouling, the rapid growth of biofilms on submerged optical windows.

However, when it comes to making an IoUT, the realization of a convenient source of autonomous electrical power is just one half of the story. The other half is obtaining fast and reliable information transfer underwater. In a Q&A in this issue we interview Boon Ooi from KAUST, a leading researcher in underwater communications. He tells *Nature Photonics* that it is now possible to perform underwater wireless optical communications at speeds of hundreds of megabits per second over tens of metres using blue lasers or LEDs. He says that the next milestone is 1 Gbit s^{-1} over 100 m and that some companies working in the area now claim to be able to do this.

Interestingly, the area has attracted significant commercial interest with a raft of firms in Europe, the USA and Japan all recently releasing high-performance optical-based underwater communications systems. For example, Sonardyne, a UK-based underwater consultancy that was founded in 1971, offers its BlueComm200 system. BlueComm200 is depth rated to 4,000 m and uses an array of blue LEDs outputting 6 W at 450 nm and a photomultiplier tube-based receiver to provide data transmission of 2.5–10 Mbit s^{-1} over a distance up to 150 m. An ultraviolet variant of the system that is immune to artificial light offers similar performance over 75 m. The company says that the system is suitable for live video streaming and extraction of large data volumes from seafloor instruments and sensors.

In a similar vein, Hydromea, a Swiss firm based in Lausanne, offers the Luma family of underwater communications products. Its latest flagship offering, Luma X, which was launched in 2020, is depth rated to 6,000 m (with a staggering 12,000 m available on request) and supports data transmission rates of up to 10 Mbit s^{-1} over 50 m. A UV-variant is also available. Hydromea says that Luma X is capable of HD and 4K video streaming.

Last year, Shimadzu of Japan launched its MC500 system. Unlike other systems, the MC500 makes use of blue and green lasers outputting 17 W at 445 nm and 9 W at 525 nm to enable data transmission at switchable speeds of 1, 10 and 20 Mbit s^{-1} up to 80 m. Shimadzu says that the MC500 is designed to provide a ROV with high-speed data transmission so that it can perform tasks such as real-time remote inspection of subsea cable, pipes, and subsea wind turbine structures. Also in Japan in November 2021, Trimatiz, a firm based near Tokyo, claimed to have successfully performed 1 Gbps × 100 m ultra-high-rate underwater optical wireless communication in a trial with the Japan Agency for Marine-Earth Science and Technology.

Unsurprisingly, the military is also interested in the technology. As long ago as 2010, SA Photonics, a developer of photonics-based equipment for the defence sector, announced it had developed a system called Neptune that was capable of 50 Mbit s^{-1} communication over an unspecific distance.

One thing is for sure, the use of photonics in subsea applications is here to stay, and further progress and proliferation can be expected.

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