RESEARCH NEWS

Water hygiene

Water disinfection with ozone

While chlorine and ultraviolet light are the standard means of disinfecting water, ozone is equally effective in killing germs. To date, ozone has only been used as an oxidation agent for treating water in large plants. Now, however, a project consortium from Schleswig-Holstein is developing a miniaturized ozone generator for use in smaller applications such as water dispensers or small domestic appliances. The Fraunhofer Institute for Silicon Technology ISIT has provided the sensor chip and electrode substrates for the electrolysis cell.

Compared to conventional means of disinfection such as chlorine or ultraviolet, ozone dissolved in water has a number of advantages: it is environmentally friendly, remains active beyond its immediate place of origin, has only a short retention time in water and is subsequently tasteless. Due to its high oxidation potential, ozone is very effective at combating germs. It breaks down the cell membrane of common pathogens. In Germany, ozone is chiefly used to disinfect swimming pools and drinking water and to purify wastewater. Yet it is rarely used to disinfect water in domestic appliances such as ice machines and beverage dispensers or in other fixtures such as shower-toilets. MIKROOZON, a project funded by the State of Schleswig-Holstein and the EU, aims to change this. Researchers from Fraunhofer ISIT have teamed up with the Itzehoe-based company CONDIAS GmbH, which was founded in 2001 as a spin-off from the Fraunhofer Institute for Surface Engineering and Thin Films IST, and CONDIAS partner Go Systemelektronik GmbH, from Kiel. The three partners are developing a miniaturized ozone generator with integrated sensor technology and microprocessor control system.

Direct production of ozone via water electrolysis

"The ozone generator is very compact and can be integrated in systems and appliances that require regular disinfection," says Norman Laske, researcher at Fraunhofer ISIT. "You simply connect it up to the water line, and it will produce the right amount of ozonized water whenever required." The ozone generator is only a couple of cubic centimeters in size and comprises an electrolysis cell, a sensor chip, control electronics to regulate current and voltage, and electronics to read the sensor signals. "The two electrodes are separated by an ion-conducting separator membrane," Laske explains. "When a voltage is applied across the electrodes, the water is split by a process of electrolysis. Because of the diamond layer coating the electrodes, this process first forms hydroxyl radicals, which then react to form primarily ozone (O_3) as well as oxygen (O_2)."

Editorial Notes
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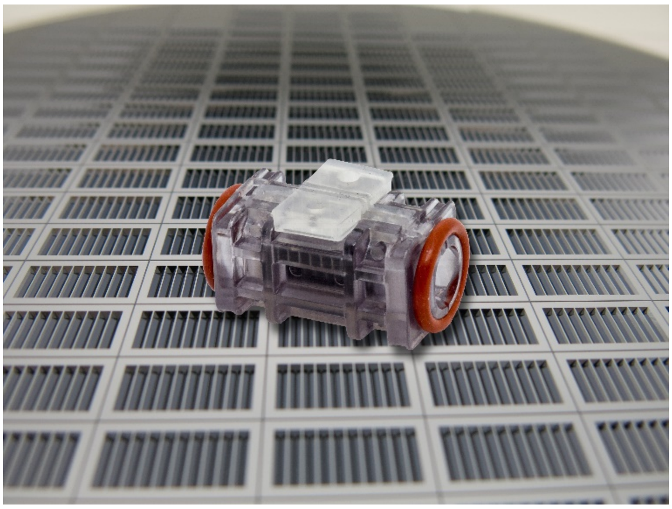
Diamond-coated silicon electrodes

How the electrodes with their boron-doped diamond layer are made is the know-how that has given CONDIAS GmbH its name. The company already uses a chemical vapor deposition process to coat large-scale electrodes required to disinfect the ballast water of marine vessels. However, the electrodes required for the MIKROOZON generator are much smaller. They are made of silicon and have finely etched trenches that run through the electrodes to form narrow slits on the reverse side. In order to be able to etch these trenches with the required precision, the researchers from Fraunhofer ISIT had to have wafer material manufactured to their own specifications.

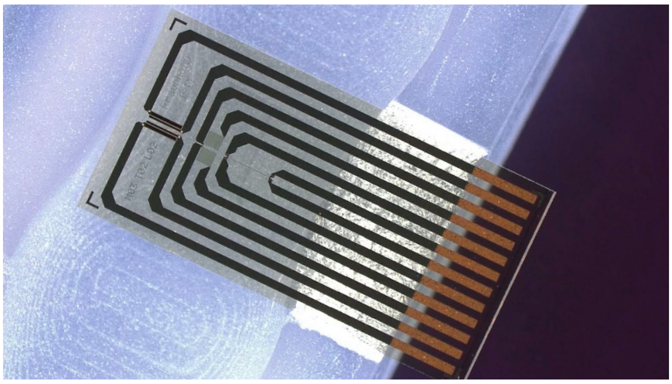
To build an ozone generator, pairs of these electrodes are mounted back to back, with a separator membrane between them. The gases are released at the interface to the separator membrane and then escape through the trenched structure to the other side of the electrode, where the turbulence of the water flow ensures that they are efficiently dissolved and dispersed.

The sensor chip from Fraunhofer ISIT is equipped with three sensors to measure conductivity, mass flow and temperature. These parameters need to be monitored in order to control the electrolytic process. The sensor chip provides the data that is required to control ozone production in line with the quality and the amount of water used. “In order to ensure that there is enough ozone available over the period required, the temperature has to be monitored,” Laske explains. “This is because ozone decomposes more quickly at higher temperatures.” Conductivity correlates to the degree of water hardness: the harder the water, the higher the conductivity – meaning that more current must flow in order to achieve the desired effect. When equipped with a system to monitor these parameters, the ozone generator should be capable of processing up to 6 liters of water per minute – without the sensor chip, it is currently specified for 0.5 to 1.5 liters.

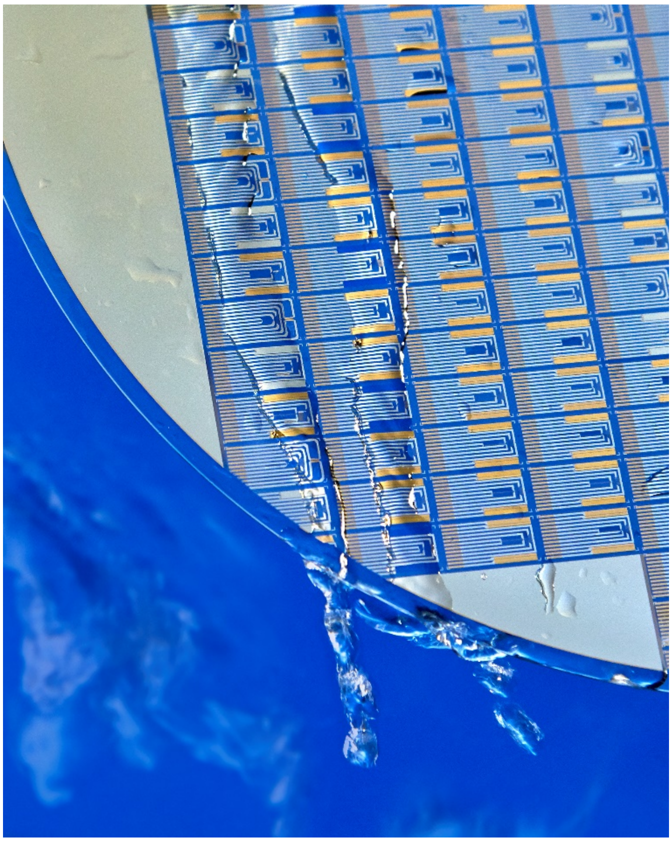
CONDIAS is marketing the minigenerator under the brand name of MIKROZON®. “Each partner has contributed years of experience from their own area of specialization,” says Volker Hollinder, CEO of CONDIAS GmbH. “This has created a product that can now be manufactured on an industrial scale. The spread of the coronavirus has underlined the importance of disinfection. The use of chemical disinfectants is often problematic, because they leave harmful residues. Our system uses electrolytically generated ozone to eliminate germs. It therefore does not produce any residues from disinfectants.”



Picture 1: The electrodes for the ozone generator are made of silicon wafers with precisely etched trenches.



Picture 2: Sensors measure mass flow, temperature and conductivity.



Picture 3: The Fraunhofer ISIT sensors are incorporated in glass wafers.