Tiny biodegradable circuits for releasing painkillers inside the body

August 7 2019

Matthieu Ruegg holding his device. Credit: EPFL 2019/ Murielle Gerber

Patients fitted with an orthopedic prosthetic commonly experience a period of intense pain after surgery. In an effort to control the pain, surgeons inject painkillers into the tissue during the operation. When that wears off a day or two later, the patients are given morphine through a catheter placed near the spine. Yet catheters are not particularly comfortable, and the drugs spread throughout the body, affecting all organs.

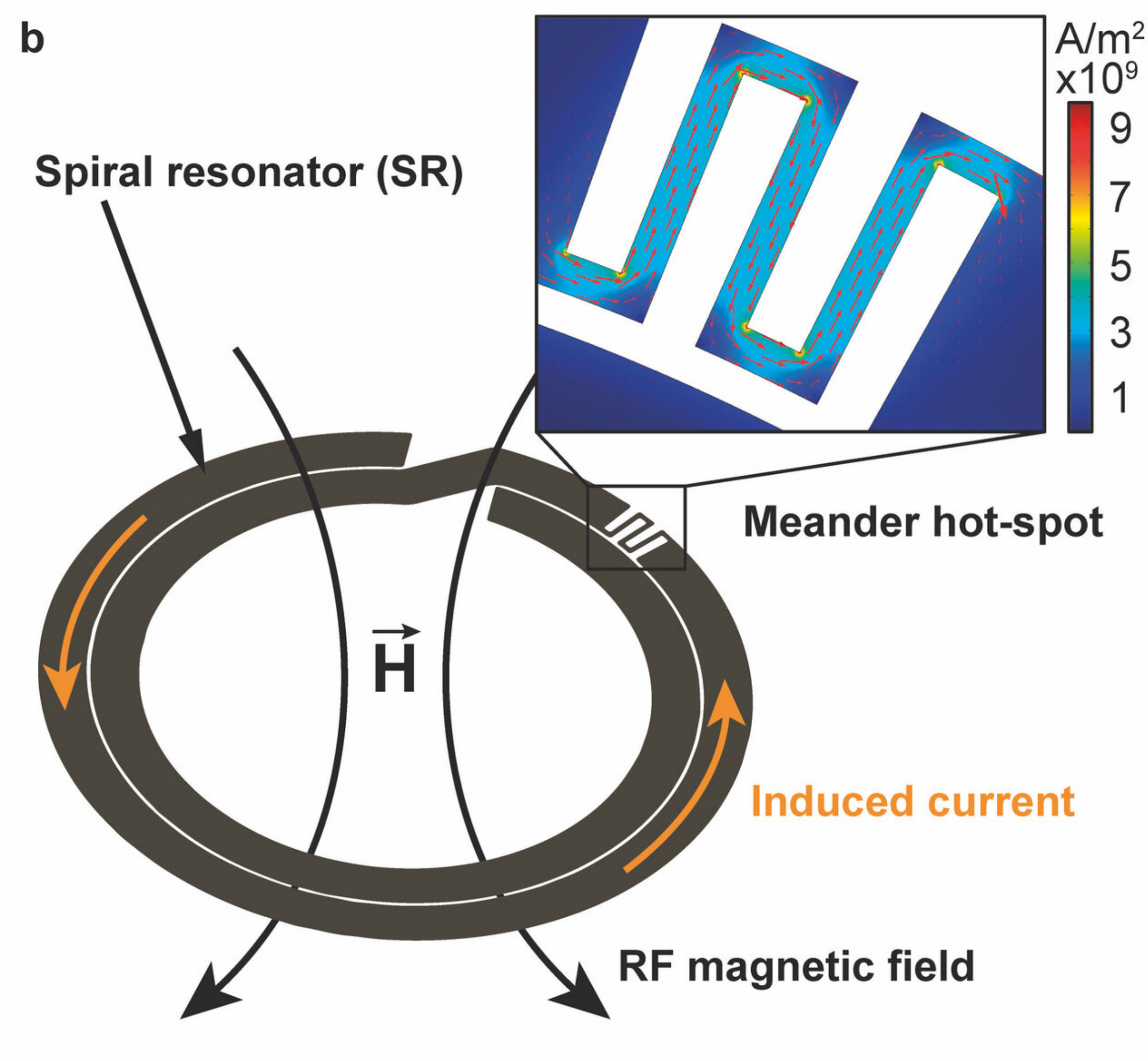
Researchers in EPFL's Microsystems Laboratory are now working on a biodegradable implant that would release a local anesthetic on-demand over several days. Not only would this implant reduce patients' post-op discomfort, but there would be no need for further surgery to remove it. They developed a tiny biodegradable electronic circuit, made from magnesium, that could be heated wirelessly from outside the body.

Once integrated into the final device, the circuit will allow the release of controlled amounts of anesthetic in a specific location over several days. After that, the implant will degrade safely inside the body. This research has been published in *Advanced Functional Materials*.

One capsule with several reservoirs

The electronic circuit—a resonant circuit in the shape of a small spiral—is just a few microns thick. When exposed to an alternating electromagnetic field, the spiral resonator produces an electric current that creates heat.

The researchers' end-goal is to pair the resonators with painkiller-filled capsules and then insert them into the tissue during surgery. The contents of the capsules could be released when an electromagnetic field sent from outside the body melts the capsule membrane.



The circuit. Credit: EPFL 2019

"We're at a key stage in our project, because we can now fabricate resonators that work at different wavelengths," says Matthieu Rüegg, a Ph.D. student and the study's lead author. "That means we can release the contents of the capsules individually by selecting different frequencies." The heat-and-release process should take less than a second.

A novel manufacturing technique

The researchers had to get creative when it came time to manufacture their biodegradable resonators. "We immediately ruled out any fabrication process that involved contact with water, since magnesium dissolves in just a few seconds," says Rüegg. They ended up shaping the magnesium by depositing it on a substrate and then showering it with ions. "That gave us more flexibility in the design stage," he adds. They were eventually able to create some of the smallest magnesium resonators in the world: two microns thick, with a diameter of three millimeters.

The team's invention is not quite ready for the operating room. "We still need to work on integrating the resonators into the final device and show that it's possible to release drugs both *in vitro* and *in vivo*," concludes Ruegg.

More information: Matthieu Rüegg et al, Biodegradable Frequency-Selective Magnesium Radio-Frequency Microresonators for Transient Biomedical Implants, *Advanced Functional Materials* (2019). DOI: 10.1002/adfm.201903051

Provided by Ecole Polytechnique Federale de Lausanne