TOOLBOX

Flexible implant records brain activity in rats for more than a year

BY **CHLOE WILLIAMS**

3 JUNE 2020

A new flexible electrode array can detect the activity of neurons in a rat's brain at high resolution for more than a year[1]. The device could be used to study how neuronal activity is altered in autism.

Arrays usually have wires connected to each electrode to pick up its signal, but this design is bulky and works only in arrays consisting of 100 electrodes or fewer, limiting the array's coverage and resolution.

Devices with thousands of electrodes have integrated switches to consolidate signals into fewer wires. But these devices usually have a lifespan of only a few days. Their polymer-based coatings are often permeable to water or contain tiny defects that allow body fluids to seep into the device and current to leak out, damaging both the device and brain tissue.

The new device combines electronic switches and a specialized protective coating so that scientists can record activity at the surface of the brain at high resolution over extended periods of time.

The array, called Neural Matrix, consists of 1,008 surface electrodes laid out in 28 columns and 36 rows. Switches, or transistors, built into the array combine signals from all the electrodes in a column to a single output wire. The signals from each electrode in the column are recorded via the wire in a specific sequence, making it possible to separate them later.

The device is also coated with thermally grown silicon dioxide — a glass-like substance created by exposing silicon plates to oxygen inside a furnace. The material is defect-free and provides a reliable seal. However, it is still thin enough to be flexible, which helps the implant conform to the brain's surface. The entire array is less than 30 micrometers thick.

Unlike traditional devices that sense neural activity directly through exposed metal electrodes, the new device is completely sealed. Thermally grown silicon dioxide allows for capacitive sensing, in which neural activity induces a charge on the outside of the device's coating that can trigger an underlying electrode.

Lasting layer:

To test the device, the researchers built a smaller 64-electrode version that covers about 10 square millimeters and implanted it in the brains of five rats. They then recorded brain activity in response to sounds every one to two weeks.

The team recorded neural signals in the rats for 287 days, on average, and for 435 days in one animal. Measurements showed that the silicon dioxide coating dissolves by 0.46 nanometers per day on average in rats, which suggests that the 1 micrometer-thick coating could last about six years, the researchers reported in April in *Science Translational Medicine*.

The team also tested the ability of the 1,008-electrode version of the device, which covers about 83 square millimeters, to record brain activity in macaques. In one experiment, the macaque performed a task, reaching toward a target on a touchscreen; in another, the macaque was anesthetized.

Recordings reveal distinct brain-activity patterns depending on which direction the macaque reaches, right or left, during the task. The signals obtained through Neural Matrix in the anesthetized macaque are also similar to signals recorded with more traditional, brain-penetrating electrodes. This suggests that the two methods can acquire comparable information, the researchers say.

The device could be scaled up and used to study brain activity patterns in animal models of autism, the researchers say. They are currently working on a 65,000-electrode device. Ultimately, they plan to tailor the technology for use in people.

REFERENCES:

1. Chiang C.H. *et al. Sci. Transl. Med.* **12**, eaay4682 (2020) **PubMed**