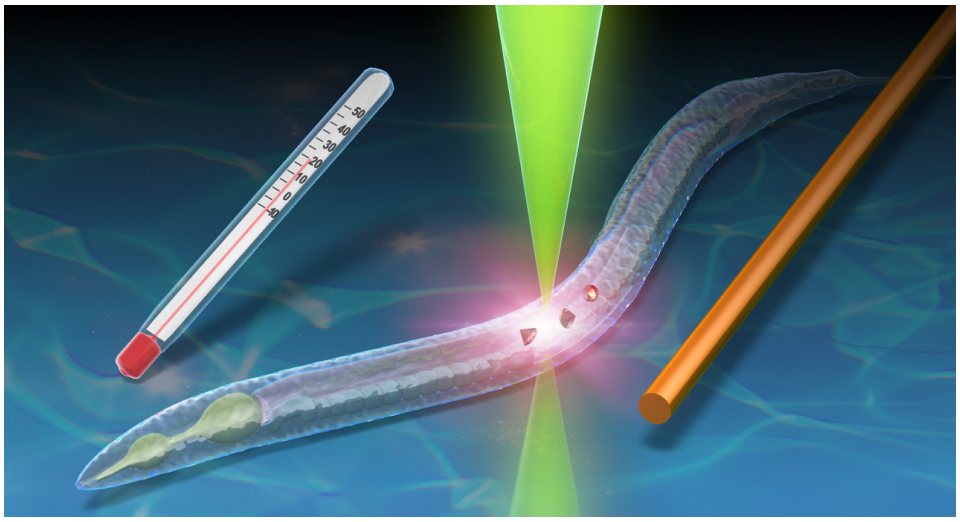
Scientific Highlight

First quantum measurement of temperature in a living organism

Summary:
The exact measurement of temperature with highest spatial resolution in living organisms is of great importance in order to be able to investigate metabolic processes precisely. However, such a measurement was previously impossible due to the lack of precise and reliable nano thermometers or nano temperature probes. An international research team led by Prof. Oliver Benson, member of IRIS Adlershof, and Prof. Masazumi Fujiwara from Osaka City Universitity has now developed a quantum sensor that is only a few nanometers in size and has been able to measure temperature changes in a nematode after administration of a pharmacological substance. The results pave the way for diverse applications of the novel quantum sensors in biomedical research, e.g. for taking high-resolution thermal images.



Scheme of the experiment: With the help of laser light (green), the characteristic microwave resonance line (in orange: microwave antenna) of nanodiamonds in a nematode (typical length 1 mm) can be recorded under a microscope. Since this depends on the temperature, a temperature change can be measured very precisely and locally. (©Masazumi Fujiwara, Osaka City University, e-mail to Oliver Benson)

Further Information:

In their experiment, the scientists used small diamonds with a diameter of a few 10 nanometers (1 nanometer = 1 millionth of a millimeter). These nanodiamonds contain luminous (fluorescent) quantum defects that can be observed under an optical microscope. With the help of radiated microwaves one can change the brightness of the luminous quantum defects. At a very specific microwave frequency, the defects appear a little darker. This so-called resonance frequency depends on the temperature. The researchers were now able to determine the shift in the resonance frequency very precisely and thus precisely determine the temperature change at the location of the nanodiamonds.
The nanodiamonds were inserted into a nematode (C. elegans). C. elegans is a very well understood model system and is examined in a large number of biophysical and biochemical experiments. By administering a certain pharmacological substance, the mitochondria, the “power stations” of the cells, could be stimulated to increased activity in individual cells of the worm. This then showed up as a slight local temperature increase of a few degrees.
The researchers were fascinated by the results of the experiment. "I never would have thought that the new methods of quantum technology would work so well even in living organisms," said Masazumi Fujiwara, professor at Osaka City University. "With these promising results, we are very confident that quantum sensing will establish in biochemistry and biomedicine. "adds Prof. Oliver Benson from Humboldt-Universität zu Berlin. The research teams are now working on further improving and automating their measuring method so that it can be easily integrated into standard microscopy setups.

Real-time nanodiamond thermometry probing in vivo thermogenic responses
M. Fujiwara, S. Sun, A. Dohms, Y. Nishimura, K. Suto, Y. Takezawa, K. Oshimi, L. Zhao, N. Sadzak, Y. Umehara, Y. Teki, N. Komatsu, O. Benson, Y. Shikano, and E. Kage-Nakadai
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