PRESS RELEASE | PARIS | 30 MARCH 2017

Mini X-ray sensor for high-precision medical applications

The ability to detect X-rays on a tiny scale paves the way for high-precision medical imaging and therapies. Such detection capabilities have been achieved by researchers from the CNRS, the University of Franche-Comté (UFC), and Aix-Marseille University (AMU), who attached an X-ray sensor to the end of an optical fiber. Their work was published in *Optics Letters* on March 28, 2017.

X-ray radiation lets us closely examine matter, whether for medical purposes or inspection of industrial parts. But X-ray sensors are cumbersome, and this limits their medical applications, especially endoscopy. So scientists are grappling with the challenge of miniaturizing them, which is no easy task. X-rays are not directly detected. They are first absorbed by a luminescent material — called a *scintillator* — which in turn emits photons of visible light that are picked up by a camera or photodetector. On a small scale, a scintillator emits very few photons, and they radiate in all directions. The tiny stream of protons that does reach the camera is hard to detect.

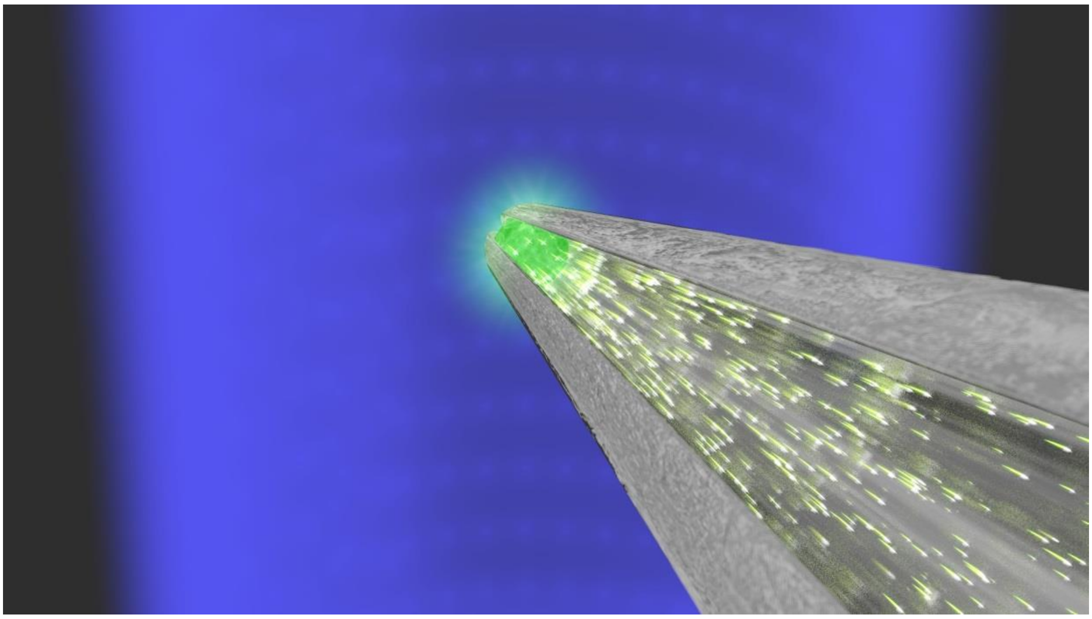
Yet researchers have found a solution, using an optical antenna that redirects and channels photons released by a miniature scintillator. This ultracompact system allows X-ray detection in volumes as small as a few cubic micrometers. Invented by a team from FEMTO-ST (CNRS / University of Franche-Comté / UTBM / ENSMM) in collaboration with researchers from CINaM (CNRS / AMU) and the UTINAM Institute (CNRS / UFC), it is attached to an optical fiber only 125 µm in diameter[1]. The researchers first grew a polymer microtip at the end of the fiber. Then they grafted a tiny cluster of scintillators, or *scintillation cluster*, to this tip. They finally applied a thin layer of metal to complete the optical antenna, whose role is to direct light, just as horn antennas direct microwaves. Thus, when X-rays come into contact with the scintillation cluster, it emits light that the antenna directs toward the fiber. All that remains is to connect a light detector to the other end of the fiber. The goal was to end up with a device ready for industrial production: growth of the optical antenna on the fiber through photopolymerization and grafting of the scintillator are both suitable for low-cost mass production.

Use of the system was demonstrated with low-energy (10 keV) X-rays[2]. To develop medical applications, the team would like to crank it up a notch: tens of kilo–electron volts for radioscopy and hundreds of kilo–electron volts for therapeutic uses. But the researchers also want to pursue other ideas over the long term. Optical antennas could reduce the delay between X-ray absorption and scintillator light emission, making it possible to create much faster X-ray detectors. And although spatial resolution is currently on the order of a micrometer, new procedures could bring it down to 100 nm[3]. The detector might be used as a probe for

1. 1 µm (micrometer) = 0.000001 m (meter)
2. The electron volt (eV) is a unit of energy used in physics and chemistry.
3. 1 nm (nanometer) = 0.000000001 m (meter).

scanning microscopy, with one application being localized analysis of the chemical makeup of composite materials.

This work was funded by the Laboratory of Excellence “ACTION”, and the team of scientists applied for a French National Research Agency (ANR) grant to further pursue basic and applied research in this field.



Optical antenna coupled to a scintillation cluster attached to the end of an optical fiber. The blue beam represents X-ray radiation; the intense, bright green sphere is the scintillation cluster; and the sparks within the body of the optical antenna are the photons emitted by the scintillators after absorbing X-rays. The optical antenna strongly directs this emitted light toward a very narrow single-mode optical fiber.

Bibliography

Ultracompact X-ray dosimeter based on scintillators coupled to a nano-optical antenna. Xie Z et al. Opt Lett. 2017 Mar 28. https://www.osapublishing.org/ol/abstract.cfm?uri=ol-42-7-1361&origin=search.

Contacts

CNRS researcher I Thierry Grosjean I **T (+33) (0)3 81 66 64 17** I thierry.grosjean@univ-fcomte.fr
CNRS press officer I Alexiane Agullo I **T (+33) (0)1 44 96 43 90** I alexiane.agullo@cnrs-dir.fr