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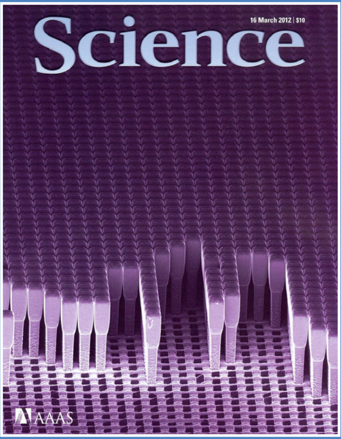
Nexray

NETWORK OF INTEGRATED MINIATURIZED X-RAY SYSTEMS OPERATING IN COMPLEX ENVIRONMENTS



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What it's about…

Enabling completely new modes of X-ray imaging, which will e.g. be extremely useful for applications ranging from emergency medicine to landmine detection.

Context and project goals

This project targets the development of novel pocket X-ray sources and X-ray direct detectors that will be combined in a distributed network to facilitate X-ray imaging in areas where it was not used up to now.

Miniaturized X-ray sources based on carbon nanotube (CNT) cold electron emitters combined with advanced microsystems packaging technology, together with X-ray direct detectors based on crystalline Germanium ab-sorption layers integrated in CMOS sensor chips open the way to radical new approaches to X-ray imaging, in-cluding X-ray time-of-flight (xTOF) measurements based on Compton or static tomography without any moving parts.

How the project differentiates from similar competition in the field

CNT based electron emission, vacuum tight MEMS packaging, epitaxy of hetero-layers and pulse counting circuits per se are not completely new. The novelty of this approach is the combination of these technologies to enable radically new modes of operation in X-ray imaging. In this sense this project is unrivalled in the scientific landscape.

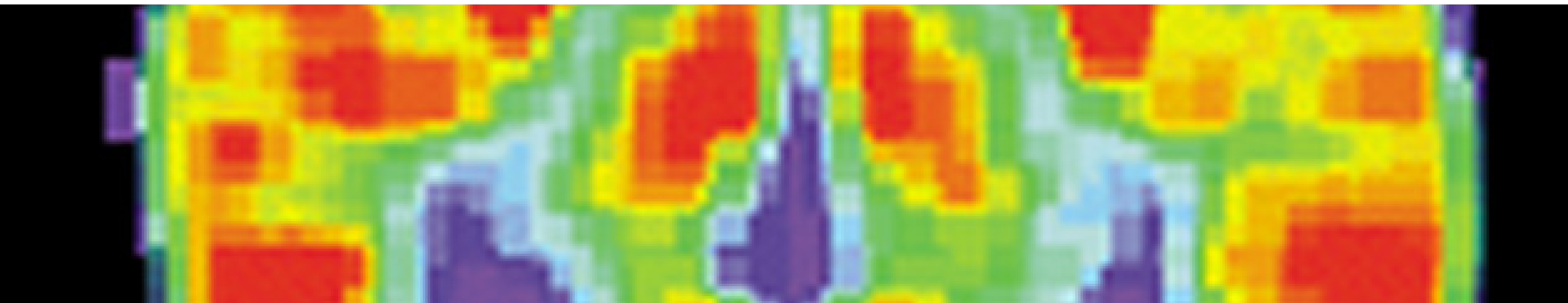
Quick summary of the project status and key results

The consortium produced pocket X-ray sources with a size of about 0.1 cm^3, carbon nanotube electron emitters and a vacuum level $< 10^{-3}$ mbar. These sources produced X-rays of about 3 keV. On the detector side the team produced technology demonstrators with monolithically integrated Ge absorption layers on a CMOS chip, which could detect X-rays of 8 keV energy. In parallel a fully functional CMOS circuit was developed.

The main scientific achievements are a breakthrough in epitaxy to grow thick layers of Ge on Si, which made it on the cover page of the Science magazine in March 2012 and generated ample scientific press coverage. Other scientific successes include the development of high-vacuum tight MEMS packaging technologies and a novel carbon nanotube production method.

Patent

Hans von Känel, Leo Miglio: US2013037857 (A1)



Success stories

The most striking success story is certainly the structured epitaxial growth of thick Germanium layers on Silicon. This was a major breakthrough which was used as a cover story of the Science magazine on March 16th, 2012 and which was also mentioned in many other media.

The team also managed to prove that these structured Ge layers can be grown on preprocessed CMOS wafers with a high temperature metallization and that such devices are capable of detecting X-rays. This is a proof of concept that the planned devices work.

In parallel a fully working CMOS circuit was developed and produced which fulfills all specs and shows a very good uniformity and noise-level.

For the X-ray sources it was possible to show that X-rays could be produced in a vacuum chamber with more than 3 kV acceleration voltage and less than 5 mm spacing between cathode and anode. This is a great step towards an integrated, miniaturized source. The proof was made using a dental X-ray film.

A clear highlight was also the development of a novel carbon nanotube cathode fabrication technology based on the soldering of macroscopic multiwall nanotube films, which outperforms the existing CNT cathode arrays in terms of the minimally required extraction field. This new development gives the consortium much more flexibility in choosing an optimized CNT cathode depending on the target application.

Another success story is the development of high-vacuum tight MEMS packaging methods. A package bonded with a vacuum level of 2x10-5 mbar was able to hold successfully hold a level ≤ 10-3 mbar, which is already close to what is required for the final device.

Main publications

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