G-ray Switzerland SA

www.g-ray.ch

Developing a breakthrough x-ray medical imaging innovation

Switzerland-based G-ray has identified a unique covalent bonding approach able to facilitate germanium absorbers for x-ray applications in the field of medical imaging and beyond.

G-ray is a prime example of how science-led companies unlock new opportunities. Having set out to disrupt x-ray medical imaging through the use of germanium absorbers, G-ray struck upon a wafer-to-wafer direct covalent bonding approach that opened a broad range of applications covering a wide range of industries. The upshot is that G-ray is now positioned to bring two breakthrough innovations to market, combined in a unique platform.

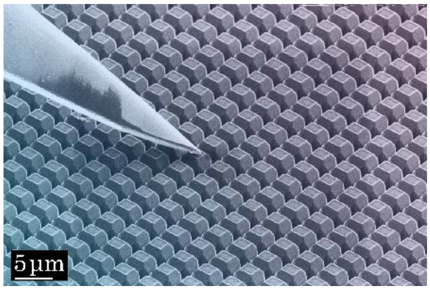
G-ray grew out of cofounder Daniel Rüfenacht's desire to accelerate the pace of change in medical imaging. Rüfenacht, a neuroradiologist, identified a need for better x-ray systems optimized for different medical applications. For interventional procedures, systems that deliver excellent temporal and spatial resolution with low x-ray doses are ideal. In mammography, sensors capable of showing which calcifications are suspicious are very much needed.

These breakthroughs would facilitate personalized, evidence-based medicine; improve health economics; and enable earlier diagnosis of conditions. However, attempts to use the currently available pixel-array detectors to foster such advances have been thwarted by small detection areas and high costs. This has led to the use of scintillators, which expose doctors and patients to high doses of x-rays.

To improve on existing systems, Rüfenacht teamed up with Hans von Känel, a physicist who first filed a patent for the use of germanium absorbers in x-ray detection a decade ago. Subsequently, the thermal-mismatch problem was overcome by the use of germanium grown in the form of columns on a silicon substrate. This breakthrough has applications in medical imaging. G-ray Switzerland SA was formed in 2014, with people bringing deep experience and knowledge in the creation, financing, and strategy development of disruptive companies; the company is now operational in Hauterive (Neuchâtel), Switzerland, with its own large-scale clean room, and bonding and epitaxy equipment.

> "The bonding method also has applications in security, aerospace, transportation, and other sectors

As germanium has a higher atomic number than the widely used silicon, its use as an absorber of x-rays enables excellent resolution while cutting the exposure of patients and physicians to ionizing radiation. The columns of germanium are reminiscent in form and function to photoreceptor cells in the eye.



Pixelated SiGe X-ray Absorber. Courtesy of Fabio Isa, Empa, Swiss Federal Laboratories for Materials Science and Technology.

The combination of ultra-high sensitivity and excellent energy and micrometric resolution enabled by germanium remains key to G-ray's plans. It forms the bedrock of the first planned application of the sensor technology, which will address the need in mammography to differentiate between types of calcification. Other applications will also be considered, including medical navigation systems and *in vitro* diagnostics.

Yet, in overcoming the problems that blocked the advance of the concept to market, G-ray also discovered a technique with applications far beyond mammography.

A wafer-to-wafer bonding breakthrough

G-ray's original idea was to grow germanium crystals directly onto CMOS (complementary metal-oxide-semiconductor) processed silicon wafers. However, CMOS is ill-suited to the temperatures needed for epitaxy, the process of growing a layer of crystal on a crystalline substrate.

This led G-ray to explore covalent wafer bonding. Rather than growing germanium directly on CMOS processed wafers, G-ray sought to separate the two processes. By performing epitaxy away from the CMOS wafer, G-ray could use the optimal conditions for both components. Then, through direct low-temperature wafer-to-wafer bonding, G-ray created a monolithic CMOS integrated pixel-array detector that is free of bump bonding and through-silicon vias (TSVs).

The bonding breakthrough overcame the barrier that was stopping G-ray from marrying germanium x-ray absorbers to CMOS wafers. It also generated new opportunities. By optimizing the bond, G-ray created an approach suited for use with any high-quality semiconductor.

G-ray's near-term focus is on a germanium-rich silicon alloy, which reduces the need for cooling by increasing the resistance compared with pure germanium, but the company now has the scope to use much heavier, higher-resistivity materials. This flexibility will benefit G-ray as it develops flat panels tailored to the optimal energies of different imaging applications. G-ray can match the impedance of its materials to the specific needs of each type of imaging.

The bonding method also has applications in security, aerospace, transportation, and other sectors, which puts G-ray in the unusual position of being a young company with a technology that could affect multiple industries.

G-ray has protected its breakthroughs with half a dozen broad patent applications that cover the use of its bonding technique with all kinds of absorber materials.

Advancing the technology

G-ray is continuing to improve each aspect of its sensor systems. Rüfenacht sees scope to improve the absorber itself, the readout electronics, and the process that bonds them together. The potential is significant.

In principle, every column can act as an individual absorber; therefore, if the columns were paired to readout electronics able to handle the resolution, they could act as single pixels. In practice, such a system may be ill-suited to medical applications, but the science still hints at the potential to deliver incredibly detailed x-ray images to doctors and professionals in other industries.

G-ray plans to unlock this potential in the coming years, starting with a panel that increases accuracy in breast cancer screening.

Beyond that, G-ray will continue doing what has served it so well to date: using its material science expertise to improve imaging while remaining open to pursuing the new opportunities this creates.

contact

Patrick Scherrer, Chairman
G-ray Switzerland SA
Hauterive, Switzerland
Tel: +41 79 200 98 31
Email: patrick.scherrer@g-ray.ch