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Silicon strip detectors look for the heaviest element

The Institute of Electron Technology in Warsaw, Poland, has provided state-of-the-art silicon alpha-particle detectors for the nuclear research centre in Darmstadt. The semiconductor devices are currently being used in an experiment aimed at producing the first nuclei of the as yet undiscovered element with atomic number 120.

Silicon alpha-particle detectors developed and built at the Institute of Electron Technology (ITE) in Warsaw, Poland, in cooperation with the Institut für Radiochemie – Technische Universität München (IR TUM) in Munich are currently being used in an international experiment aimed at producing and detecting atomic nuclei of the as yet undiscovered element 120. The experiment, conducted at the Centre for Heavy Ion Research (GSI Helmholtzzentrum für Schwerionenforschung GmbH) in Darmstadt, began a few weeks ago and will continue until the end of the year.

The semiconductor devices designed to detect alpha particles (as well as beta particles and protons) were developed from the ground up in Warsaw by a team of engineers from ITE, and are protected by patents. The devices earned international acclaim and are used in leading nuclear research centres, including the GSI centre in Darmstadt and the Joint Institute for Nuclear Research in Dubna. They contributed, among others, to the discovery of heavy atomic nuclei, including isotope 283 of element 112 (copernicium, Cn) in Dubna, and isotopes 270, 271 and 277 of element 108 (hassium, Hs) in Darmstadt. In 2009 they made it possible to observe a record number of thirteen nuclei of isotopes 288 and 289 of element 114 (flerovium) during a single experiment in Darmstadt. The devices played a crucial role in the experimental confirmation of the island of stability theory. The results of the experiments conducted using the ITE detectors are the subject of highly cited publications in prestigious scientific journals, including “Nature”. The research described in these publications led the International Union of Pure and Applied Chemistry and the International Union of Pure and Applied Physics to officially recognize and add to the periodic table elements 112 and 114.

“In contrast to the majority of semiconductor devices, our detectors have a very large p-n junction area, a thick electrically active area and a high radiation resistance. Many complex technical problems had to be solved in order to build devices with optimum operating parameters,” says Maciej Węgrzecki, MSc, Eng, head of the team developing silicon detectors at ITE.

Detectors from ITE are currently being used in an experiment employing the TASCA (TransActinide Separator and Chemistry Apparatus) ion separator at the Centre for Heavy Ion Research in Darmstadt. The aim of the experiment is to gain an understanding of the physical and chemical properties of elements with atomic number greater than 104, and to produce, for the first time, nuclei of the element with atomic number 120.

Alpha-particle detectors built at ITE are manufactured on silicon plates with specially crafted diffusion regions. When a particle passes through a detector, it creates electron-hole pairs in the semiconductor material, which induces electrical current. State-of-the-art detectors from ITE are double-sided: they have two parallel detecting surfaces, each covered with 16 semiconductor strips. The strips on a one surface are perpendicular to the strips on the other surface. By measuring signals from the strips on both surfaces, it is possible to accurately determine where the particle passed through the detector.

The Institute of Electron Technology supplied the 16-strip silicon detectors to the GSI centre in Darmstadt in January. At the centre they were installed in the Focal Plane Detector Box (FPDB), which forms part of the TASCA ion separator. Eight double-sided strip detectors and two single-sided 8-strip detectors were mounted on FPDB sides.

The Institute of Electron Technology specializes in developing advanced semiconductor devices. The first devices of this type, avalanche photodiodes, were developed at ITE as early as the 1990s. In later years detectors designed for portable neutron dosimeters, capable of registering neutrons in a wide energy range, were developed and built in cooperation with the Institut für Strahlenschutz, Helmholtz Zentrum München. 64-element chromatographic arrays, used in studies of transactinides, were commissioned and developed at ITE in cooperation with IR TUM. In Darmstadt these arrays made it possible to observe complete decay chains of heavy elements, including hassium.

The Institute of Electron Technology in Warsaw (ITE) carries out research in the field of electronics and solid-state physics. It develops, implements and popularizes state-of-the-art micro- and nanotechnologies in photonics and micro- and nanoelectronics. The Institute focuses on optoelectronic detectors and radiation sources, state-of-the-art semiconductor lasers, micro- and nanoprobes, nuclear radiation detectors, microsystems and sensors for interdisciplinary applications, as well as application-specific integrated circuits ASIC. In order to allow easier access to the technology, construction and measurement services for industrial and science and research units, the Institute has established the Centre of Nanophotonics, the Centre of Nanosystems and Microelectronic Technologies and the Laboratory for Multilayer and Ceramic Technologies.

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Silicon strip detectors designed to detect alpha particles developed and built at the Institute of Electron Technology in Warsaw, Poland. (Source: ITE)