1

Photo 1: Mars Science Laboratory's Curiosity Rover with a VIGO detector

Partnership for Success

How can we make Poland's economy more competitive and productive? By supporting R&D projects pursued jointly by entrepreneurs and scientists and turning their findings into marketable products. This strategy can be very successful, as demonstrated by longstanding collaborative ties between the Military University of Technology and Vigo System S.A., a globally recognized manufacturer of infrared detectors listed on the Warsaw Stock Exchange.

Piotr Martyniuk has been in charge of the Department of Solid State Physics in the Institute of Applied Physics at the Military University of Technology since October 2015. His research interests focus on mid- and long-wavelength infrared barrier detector structures fabricated from AIIIBV compounds (including type II InAs/GaSb supperlattices) and the solid solution of mercury cadmium telluride (HgCdTe).

Adam Piotrowski is CEO of Vigo System S.A. He earned his master's in electronics at the Warsaw University of Technology in 2002 and successfully defended his doctoral dissertation in engineering at the Military University of Technology in 2008. He has authored numerous scientific publications on methods of fabricating infrared detectors and their applications. He is interested in new infrared applications, engineering management, and issues related to the Internet of Things (IoT).

Lt. Col. Piotr Martyniuk, PhD

Military University of Technology, Warsaw
piotr.martyniuk@wat.edu.pl

Adam Piotrowski, PhD

Vigo System S.A., Ożarów Mazowiecki
apiotrow@vigo.com.pl

The collaboration between Vigo System S.A. and the Military University of Technology is a particularly successful example (especially by Poland's standards) of joint efforts undertaken by a team of university scientists and a high-tech company. Scientists from the Department of Solid State Physics at the University's Institute of Applied Physics, led by Prof. Antoni Rogalski (the current dean of Division IV of the Polish Academy of Sciences), have been working closely with Vigo System S.A. for over 20 years. Their common interests are centered around studying the physical processes and phenomena involved in the production of top-notch infrared detectors. The origins of this collaboration date back to the beginnings of both the firm and the Institute. Until the mid-1990s, the Department of Solid State Physics was led by Prof. Józef Piotrowski, who is currently development director at Vigo System S.A., and many types of detectors manufactured by the company were designed under his leadership. Other Vigo executives are also former employees of the Institute of Applied Physics, and the company continues to recruit new talented fellows from the doctoral program at the Institute. As part of the collaborative arrangement, University students can serve internships and do their master's and doctoral level research at the company.


2

Vigo System S.A. is a global leader in the production of uncooled infrared photodetectors (http://www.vigo.com.pl). Vigo-manufactured detectors are used in industry, medicine, military technologies, and research – they can be found in the measurement systems used in the laboratories of the world's most reputable research centers. One example is aboard the Curiosity rover (since 2012), part of the Mars Science Laboratory mission. The firm is proud to be an official supplier of components for NASA. Its shares were floated on the Warsaw Stock Exchange in 2014.

Joint investments

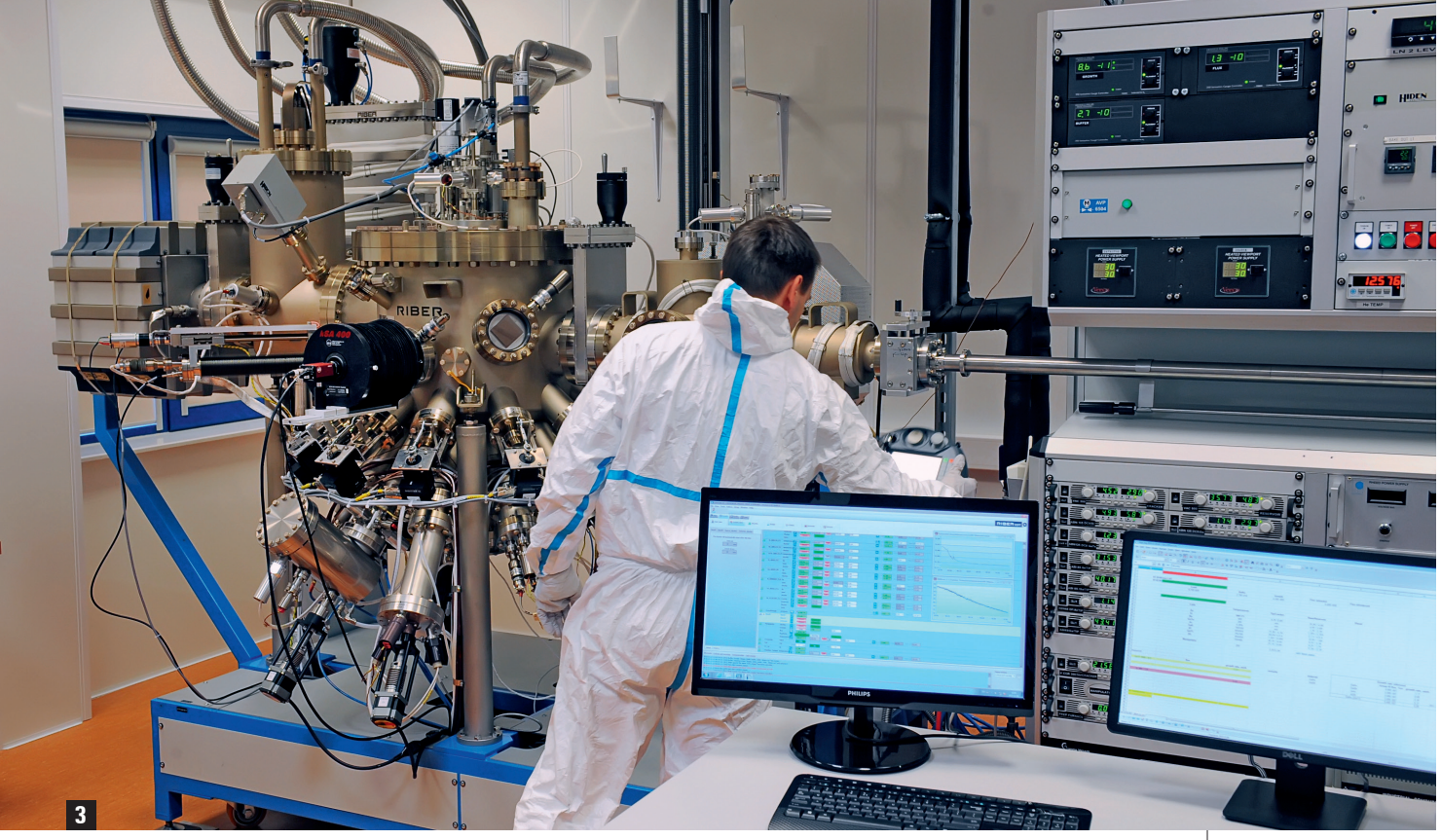
In 2003, the Military University of Technology and Vigo System S.A. established a joint laboratory for HgCdTe epitaxy from metal-organic compounds (using metal organic chemical vapor deposition, MOCVD). MOCVD is a method that enables the deposition of complex multilayer HgCdTe heterostructures with a desired molar composition and doping profile, required for producing high-quality infrared photodetectors. The process relies on the AIX-200 system, manufactured by the company AIXTRON, a global leader in the production of such machines. Situated in Ożarów Mazowiecki, the joint laboratory cost 3.9 million PLN, with 60% of that sum being covered by Vigo System S.A. and 40% by the Military University of Technology.

Another joint R&D project involves a newly-launched laboratory (opened on 21 April 2015) to develop and produce detectors by molecular beam epitaxy (MBE), a technology for growing semiconductor layers that involves depositing atom-thick layers of materials on top of a crystalline substrate through the evaporation of elements from effusion cells under ultra-high vacuum conditions. Such a method makes it possible to deposit complex multilayer heterostructures characterized by a rapidly changing molar composition and doping, for example type II InAs/GaSb superlattices.

Detectors produced by molecular beam epitaxy complement the range of HgCdTe detectors currently being sold by Vigo. Such detectors can be used, for instance, wherever it proves necessary to ensure greater resistance to difficult operating conditions and a high uniformity of multi-element detector parameters. The project is valued at an estimated 11 million PLN, covered in equal parts by Vigo System S.A. and the Military University of Technology.

Studies and projects

The effectiveness of the collaboration between the Military University of Technology and Vigo System S.A. is demonstrated not only by joint R&D invest-



3

ments but also, or even especially, by joint studies and projects involving fundamental research.

Strategically, the purpose of this collaboration is to focus on aspects of detector development that may in the future lead to the new Polish devices and infrared systems being launched onto the international market. We made a conscious decision not to try to emulate Western studies into the development of cooled infrared detectors. The market for cryogenically cooled detectors is saturated: enormous amounts of money have been invested in this research and industry for military purposes, especially back in the Cold War period. We instead opted to pursue InAs/GaSb superlattice photodetectors without cryogenic cooling in order to develop a technology for producing detectors better than the ones currently fabricated from HgCdTe. Such a technology would make it possible to reduce the manufacturing cost of devices based on infrared technology and boost their functionality, by the same token extending their range of application in industry, science, medicine, and environmental protection, especially out in the field, where cryogenic cooling is impossible or very difficult.

Numerous joint projects of the Military University of Technology and Vigo System S.A. have won competitions organized by Poland's National Center for Research and Development (NCBiR) and National Science Center (NCN). Such projects include designing and developing a new generation of uncooled and minimally cooled mid- and long-wavelength infrared HgCdTe detectors, detectors for Fourier transform spectroscopy in the 3–16 μm range, broadband detectors for free-space optical communication (1 Gb/s) using CO_2 waveguide lasers, detection modules for high-sensitivity sensors of hazardous materials, optical wireless communication systems in the 8–18 μm spectral range, and developing an optoelectronic sensor for detecting explosive vapors.

All told, our research collaboration covers more than 25 joint projects, which have cost around 35 million zlotys. The latter three projects also involve teams from the Institute of Optoelectronics at the Military University of Technology. One successful outcome of the collaboration between Vigo and the Institute of Optoelectronics is the OBRA system, installed in military devices.

Publications and monographs

The scientific publications of the employees of the Department of Solid State Physics and Vigo System S.A. are very favorably received in the world. The "Polish school" has in essence dominated the global set of monographs devoted to infrared detectors. The two teams' publications and monographs have been cited around 5,000 times over the past 10 years, including by the world's most renowned teams of researchers studying infrared detectors, and the h-index of the two teams is estimated at over 40. Prof. Antoni Rogalski's most recent book, *Infrared Detectors* (published by the US publishing house Taylor&Francis in 2011 and translated into Russian and Chinese), is regarded as one of the best monographs on infrared detectors in the past 20 years. Scientific collaboration between the two teams has also resulted in the monograph *High-Operating-Temperature Infrared Photodetectors* (published by SPIE Press in the United States), which summarizes the globally unprecedented results of Polish scientific and production efforts in the field of high-operating-temperature infrared detectors in the long wavelength range.

PHOTOS BY JAKUB OSTAŁOWSKI

Photo 2:
AIXTRON's AIX-200 system for MOCVD growth of HgCdTe epitaxial layers

Photo 3:
RIBER's Compact 21 DZ system for MBE growth of $A^{III}B^{V}$ superlattices

Further reading:

http://www.vigo.com.pl/

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