Attachment 1 ***CO-OPERATION WITH ENTREPRENEURS***

PLEASE LIST ALL RESEARCH GROUPS ENGAGED IN CO-OPERATION WITH ENTREPRENEURS AND COMPLETE THE DESCRIPTION OF THE CO-OPERATION

Please ensure that the contracts concluded with entrepreneurs meet the requirements of the EU state aid provisions and the principles of economy

Project title: International Centre for Interfacing Magnetism and Superconductivity with Topological Matter

NO.	RESEARCH GROUP NAME	BUSINESS PARTNER	DESCRIPTION OF CO-OPERATION	LEGAL FORM OF THE CO-OPERATION (E.G. JOINT R&D/ SCIENCE AS A SERVICE/ COOPERATION AGREEEMENT ETC.)
1.	Group of Theory of Topological Matter	VIGO Photonics	**III-V and IV-VI/II-VI infrared detectors** After workshop "Topological matter meets entrepreneurs" organized by MagTop on October 18, 2019, visit of 18 employees of MagTop (all Team Leaders), to Vigo on January 30, 2020: 6 presentations by employees of VIGO, 1 hour long tour in VIGO's labs and production hall for MagTop's employees. "Brain storming": how topological materials, with their specific transport and thermoelectric properties, may become the basis of new devices, jointly designed by VIGO and MagTop. Theoretical studies of optical characteristics of semiconductor quantum superlattices of III-V compounds. Common paper with VIGO: G. Hussain, G. Cuono, R. Islam, A. Trajnerowicz**,** J. Jureńczyk, C. Autieri, T. Dietl, *Electronic and optical properties of*	Collaboration Agreement

			InAs/InAs$_{0.625}$Sb$_{0.375}$ superlattices and their application to far-infrared detectors, J. Phys. D: Appl. Phys. **55**, 495301 (2022), *[open access]*, arXiv:2203.06028 (2022).	
2.	Molecular Beam Epitaxy Group	VIGO Photonics	**III-V and IV-VI/II-VI infrared detectors** Improving quality of molecular beam epitaxy (MBE) grown (Cd,Zn,Mg,Mn)Te/GaAs compliant substrates (removal of hillocks) for possible applications in infrared detectors produced by VIGO. Various aspects of optimizing detector design (long-term stability of ohmic contacts, etching, passivation…) and its testing: (i) deposition of dielectric layers by Inductively Coupled Plasma - Plasma Enhanced Chemical Vapor Deposition (ICP-PECVD); (ii) etching of structures by Inductively Coupled Plasma Reactive Ion Etching (ICP-RIE), and (iii) device characterization (including Readout Integrated Circuits (ROIC)) by Scanning Electron Microscopy (SEM), and Energy Dispersive Spectroscopy (EDS), and magnetotransport studies (including mobility spectrum analysis).	Collaboration Agreement
3.	Molecular Beam Epitaxy Group	PREVAC	**Magnetosputtering of ferromagnetic metals** Optimizing the design of magnetrons and the shape of source charges made of ferromagnetic materials needed for MagTop to produce high-quality topological insulator/ferromagnetic hybrid structures, and for PREVAC to improve its products. On June 08, 2022 an application with the European Patent Office to protect a declaration of priority for the invention: “Device for magnetron sputtering from target” (application number EP22461556.7).	Agreement on joint rights to a patent and joint patent

			On November 29, 2023 application was published by European Patent Office (Bulletin 2023/48, patent application number: EP4283011A1). In the agreement on joint rights to a patent and joint patent, MagTop granted PREVAC the right, against payment, to use the invention in a new line of two inch sputtering sources manufactured by this company. Extensive collaboration on various aspects of ultra-high vacuum deposition system design, including MBE and sputtering systems.	
4.	Molecular Beam Epitaxy Group	PUREMAT	**Innovative structures grown by MBE, containing Mn or Mg, exhibiting topological properties** Experiments on MBE growth of Two-Dimensional Electron Gas structures with Mg and Mn produced by PUREMAT and aimed at improving 2D carrier mobility, as well as long-term stability and stability in terms of thermal cycling (growths on bulk substrates produced by PUREMAT). Development of optical lithography, wet and dry etching procedures for telluride-based device structure. Development of procedures for low temperature deposition of SiO_2 and $SiON_x$ layers. Experience with such a deposition of insulating layers vital both for MagTop (making gated 2D topological insulator structures based on the strongly temperature sensitive HgTe) and for PUREMAT (x-ray CdTe-based detector).	Collaboration Agreement
5.	Molecular Beam Epitaxy Group	MeasLine S.A	**Ultrahigh vacuum equipment, design and manufacture of systems for non-standard applications** Modification of multi-chamber UHV system containing MBE growth chamber for metals and the Omicron Scanning Probe	Collaboration Agreement

			Microscope. Possibility to transfer the structure between this metallic system and semiconductor MBE system under UHV conditions Collaboration on various aspects of ultra-high vacuum deposition system design, including MBE and sputtering systems. Design of specialized substrate holders for the growth of “step-like” structures (namely structures with profiling in the direction perpendicular to the growth axis).	
6.	Group of Characterization and Processing	VIGO Photonics	**III-V and IV-VI/II-VI infrared detectors** Development and fabrication of prototype designs of plasmonic microstructures for enhanced light detection by electron beam lithography. The structures were further processed (metal deposition and lift-off) and characterized (photodetection performance) by VIGO.	Collaboration Agreement
7.	Group of Physics of Majoranas	Robert Bosch	**Identifying topological invariants in superconductors with machine learning** Development of methods to determine the topological invariants of two-dimensional superconductors from experimentally accessible local density of states with the help of a neural network (European patent application number: EP4184389A1). Studies open important new directions for future research, including the further development of the protocol for quality control of real-world topological quantum devices. Common paper: Paul Baireuther, Marcin Płodzień, Teemu Ojanen, Jakub Tworzydło, Timo Hyart, *Identifying Chern numbers of superconductors from local measurements*, SciPost Phys. Core 6, 087 (2023).	Join Invention Agreement

8.	Group of Physics of Majoranas	VIGO Photoncs	**III-V and IV-VI/II-VI infrared detectors** Theoretical studies of optical characteristics of semiconductor quantum superlattices of III-V compound. Common paper with VIGO: G. Hussain, G. Cuono, R. Islam, A. Trajnerowicz**,** J. Jureńczyk**,** C. Autieri, T. Dietl, *Electronic and optical properties of InAs/$InAs_{0.625}Sb_{0.375}$ superlattices and their application to far-infrared detectors,* J. Phys. D: Appl. Phys. **55**, 495301 (2022), *[open access]*, arXiv:2203.06028 (2022).	Collaboration Agreement
9.	Weyl Group	PUREMAT	**PbTe-CdTe crystalline nanocomposites for thermoelectric energy conversion** Developing a method to produce a bulk thermoelectric nanocomposite of Lead Telluride and Cadmium Telluride (PbTe-CdTe) by mixing compounds in temperature in which at least one compound is in a liquid form, followed by solidification. On December 7, 2022 the European Patent was granted for the invention described in the patent specification A method of obtaining bulk PbTe-CdTe nanocomposite. Patent no. EP4036057**.** In December 2023, periodic fees were paid for maintaining the patent in Poland, Germany, France and the United Kingdom.	Collaboration Agreement

10.	Weyl Group	VIGO Photonics	**III-V and IV-VI/II-VI infrared detectors** Several structures of the optically active area of the infrared detectors were designed taking into account the photonic effects, and fabricated using MBE growth method. On the basis of this structures VIGO, using industrial processing methods, has built and successfully tested a series of prototype detectors operating in the wavelength range of 1 to 4 µm. Proposing a new solution for IR detectors based on superlattices made of IV-VI narrow gap PbTe and II-VI wide gap CdTe. Preparation of two patent applications for new types of infrared detector with a tunable detection wavelength.	Collaboration Agreement

Date: 05.02.2024

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