Department of Experimental Physics
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Krzysztof Ryczko

AUTHOR'S SUMMARY OF PROFESSIONAL ACCOMPLISHMENTS

WROCŁAW 2017

TABLE OF CONTENTS

1. SCIENTIFIC CAREER

NAME AND SURNAME	Krzysztof Ryczko
1996	MSc Dissertation title: *Influence of excitons on fundamental optical transition of semiconductors in presence of external electric field.* Advisor: Prof. Jan Misiewicz
2000	PhD Dissertation title: *Properties of excitons in p-type single $Al_xGa_{1-x}As/GaAs$ heterostructures* Advisor: Prof. Jan Misiewicz
2000 – 2001	Research-didactic assistant at Faculty of Fundamental Problems of Technology at Wrocław, University of Science and Technology.
2001	Assistant professor at Faculty of Fundamental Problems of Technology, Wrocław University of Science and Technology.
2009 – 2012	Employment in European project SensHy - *Photonic sensing of hydrocarbons based on innovative mid infrared lasers*
2012 – 2015	Employment in European project WideLase - *Monolithic Widely Tunable Interband Cascade Lasers for Safety and Security*
2015 – 2018	Employment in European project iCspec - *In-line Cascade Laser Spectrometer for Process Control*
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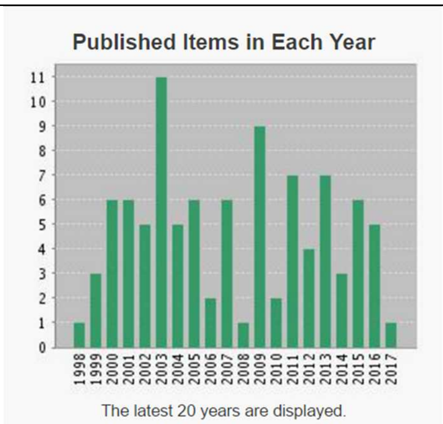
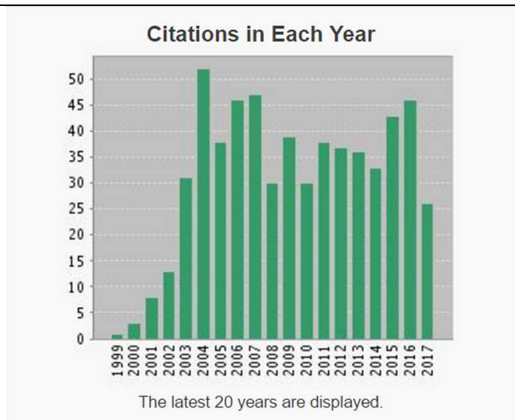
2. BIBLIOMETRIC DATA

<u>Bibliometric data as of 16.06.2017 (*ISI Web of Knowledge*)</u>

Number of publications in IMI Master Journal List	96
Total Impact factor of publications	148,313
H-index (*ISI Web of Knowledge*)	**15**
Number of article citations	597
Number of article citations excluding self-citations	458





Source: *ISI Web of Knowledge*

Results found:	96
Sum of the Times Cited [?] :	597
Sum of Times Cited without self-citations [?] :	458
Citing Articles [?] :	445
Citing Articles without self-citations [?] :	378
Average Citations per Item [?] :	6.22
h-index [?] :	15

Source: *ISI Web of Knowledge*

Mostly chosen journals:
Physical Review B – **6** articles
Applied Physics Letters – **11** articles
Journal of Applied Physics – **11** articles

3. SCIENTIFIC ACHIEVEMENT

The scientific achievement, in acordance with the Article 16 Paragraph 2 of the Act 14 March 2003 on Academic Degrees and Academic Title and on Degrees and Title in Arts (Law Journal No. 65, item 595 as amended), is the series of publications entitled:

3.1 The title of scientific achievement

INVESTIGATIONS OF SELECTED III-V COMPOUND BASED QUANTUM STRUCTURES FOR ENHANCED WORKING PARAMETERS OF SEMICONDUCTOR INFRARED RADIATION EMITTERS

3.2 Series of publications forming scientific achievement

(Data regarding indices come from web pages: (1) Impact Factor - http://www.scijournal.org; (2) Ministry of Science and Higher education list - http://impactfactor.pl/czasopisma and are as of year of publication.)

[H1] **K. Ryczko**, G. Sęk, and J. Misiewicz, *The effect of structural parameters on the in-plane coupling between quantum dashes of a dense ensemble in the InAs-InP material system,* **Journal of Applied Physics** 115, 213502 (2014), [Impact Factor = 2,183, Lista MNiSW=30]

[H2] **K. Ryczko**, G. Sęk, J. Misiewicz, F. Langer, S. Höfling, M. Kamp, *On the oscillator strength in dilute nitride quantum wells on GaAs*, **Journal of Applied Physics** 111, 123503 (2012), [Impact Factor = 2,21, Lista MNiSW=35]

[H3] **K. Ryczko,** G. Sęk, P. Sitarek, A. Mika, J. Misiewicz, F. Langer, S. Höfling, A. Forchel, M. Kamp, *Verification of band offsets and electron effective masses in GaAsN/GaAs quantum wells: Spectroscopic experiment versus 10-band k·p modeling*, **Journal of Applied Physics** 113, 233508 (2013), [Impact Factor = 2,185, Lista MNiSW=35]

[H4]. M. Motyka, **K. Ryczko**, G. Sęk, F. Janiak, J. Misiewicz, A. Bauer, S. Höfling, A. Forchel, *Type II quantum wells on GaSb substrate designed for laser-based gas sensing applications in a broad range of mid infrared*, **Optical Materials** 34, 1107 (2012), [Impact Factor = 1,918, Lista MNiSW=30]

[H5] **K. Ryczko**, G. Sęk, J. Misiewicz, *Eight-band k·p modeling of InAs/InGaAsSb type-II W-design quantum well structures for interband cascade lasers emitting in a broad range of mid infrared*, **Journal of Applied Physics** 114, 223519 (2013), [Impact Factor = 2,185, Lista MNiSW=35]

[H6] M. Motyka, **K. Ryczko**, M. Dyksik, G. Sęk, J. Misiewicz, R. Weih, M. Dallner, S. Höfling and M. Kamp, *On the modified active region design of interband cascade lasers*, **Journal of Applied Physics** 117, 084312 (2015), [Impact Factor = 2,101, Lista MNiSW=30]

[H7] **K. Ryczko**, G. Sęk, J. Misiewicz, *Novel design of type-II quantum wells for mid-infrared emission with tensile-strained GaAsSb layer for confinement of holes*, **Applied Physics Express** 8, 121201 (2015), [Impact Factor = 2,265, Lista MNiSW=35]

[H8] **K. Ryczko**, G. Sęk, *Polarization-independent gain in mid-infrared interband cascade lasers*, **AIP Advances** 6, 115020 (2016), [Impact Factor = 1,444, Lista MNiSW=25]

[H9] **K. Ryczko,** J. Misiewicz, S. Höfling, M. Kamp, G. Sęk, *Optimizing the active region of interband cascade lasers for passive mode-locking*, **AIP Advances** 7, 015015 (2017), [Impact Factor = 1,444, Lista MNiSW=25]

Co-authors statements specifying individual contribution to respective articles are in „co-authors statements" attachment.

3.3 Detailed description of the scientific achievement

During the recent years there has been an significant progress of semiconductor structures lasing in near- and mid-infrared (NIR and MIR respectively) range. It is worth to mention that division on different ranges of infrared is not unequivocal and differently determined in literature [1, 2, 3, 4, 5, 6, 7, 8]. In this description I will use limits as follows: 0,78 – 2 µm for near infrared and 2 – 15 µm for mid infrared.

The driving force of this development is wide spectrum of possible applications, from quantum communication and efficient single-photon sources in 1,3-1,55 µm range, which covers main waveguide telecommunication windows [9, 10, 11, 12, 13], through laser diodes emitting in NIR, mainly for optoelectronic applications [14], to laser in sensing systems such as environment protection – for finding contamination and biologically active substances [15], medicine – for detecting trace substances in exhaled air [16], security systems [17], and industrial processes control[18].

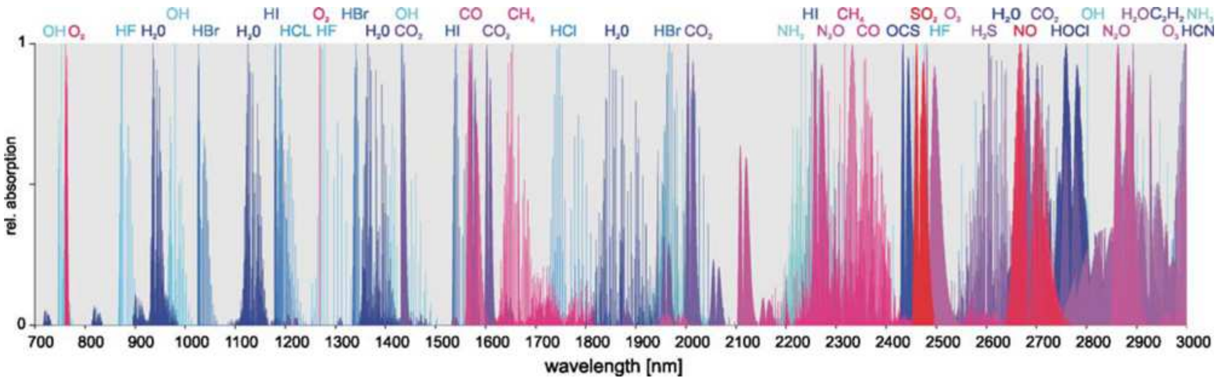


Fig. 1a: Example of absorption lines of certain gases in range from 0,7 µm to 3,00 µm [19].

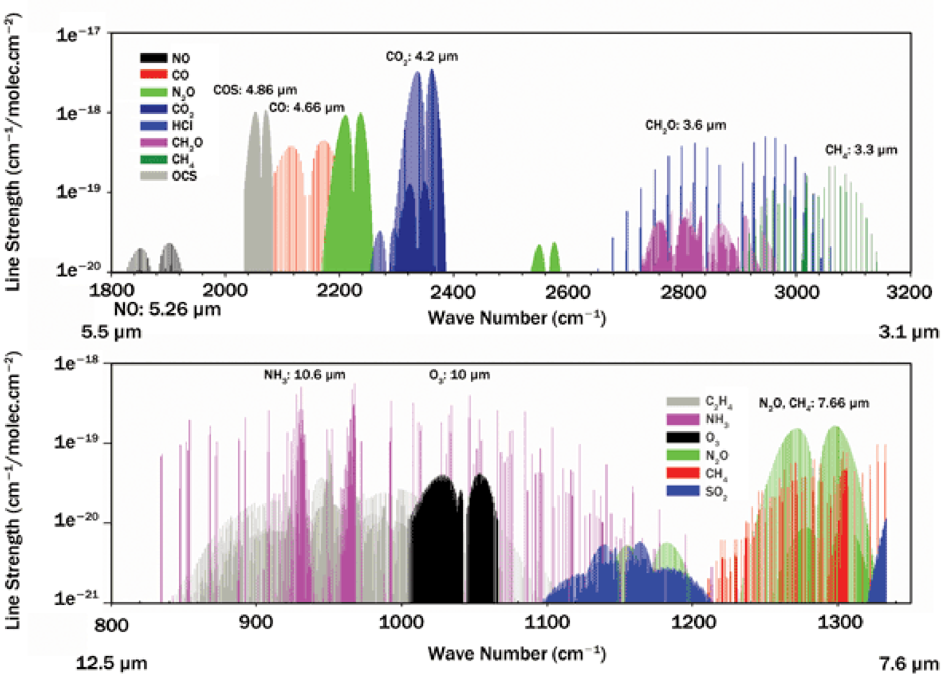


Fig. 1b: Examples of absorption lines of certain gases [20].

Wide range of applications is connected with the fact that in named spectral range there are absorptions lines/bands (related with oscillation-rotation transitions) of numerous important gases (both environmentally as well as industrially) such as: hydrocarbons, CO, CO_2, N_2O, SO_2, NO, NH_3, etc. [21]. Examples of such absorption spectra are shown on figures 1a and 1b.

Other application of laser in mid-infrared are for example free space communications (transmission windows: I: 0,85 µm; II: 1,3 µm; III: 1,55 µm; IV: 1,65 µm [22]) [23].

Increasing requirements on application side are causing constant need for improvement of parameters of devices working in infrared range. Specifically, new solutions and proposals of optimisation of structures for active areas of lasers are of great importance. That is why in my science activity I focused on analysis of active areas of lasers using interband transitions working in near- and mid-infrared.

- **Quantum dashes in emitters for telecommunication range**

Current level of nanotechnology allows to controllable growth of semiconductor structures of any size and geometry. One of the structures used as active areas in this range are InAs/InGaAlAs quantum dashes grown on InP substrate. Quantum dashes which are characterised by significant elongation in one crystallographic direction in plane perpendicular to growth direction (mostly [1-10] lateral aspect ratio), that is ratio of length to width of an object, which often exceeds 5 [24, 25, 26, 27]. In molecular beam epitaxy quantum dashes sometimes appear naturally [27, 28], and align in very dense matrix of nanostructures (surface density significantly higher than 10^{10} cm^{-2}) and distances between nanostructures within single nanometres. [27]. Application potential of this sort of quantum structures has been presented, among others, by constructing semiconductor laser emitting in the second and third telecommunication windows and having broad band and high gain modulation frequency up to

40 Gb/s [29]. Contemporary manufactured quantum dashes have vast possibilities of, above all, easily obtained spectral tunability in very broad range of near infrared, including telecommunication windows [27, 30, 31], especially C band at 1.55 µm, especially in lasers and optical amplifiers for optoelectronics [32, 33, 34]. High natural planar density of quantum dashes cause average in-plane distance to be much lower than characteristic dimension of a dash, which may suggest efficient tunnelling of carriers between dashes. This significantly influences lasers' and optical amplifiers' properties, in which the whole of nanostructures is used as active area: value of optical gain is significantly changed as well as carrier dynamics and mechanisms and kinetics of their relaxation. Moreover, because of modification of wavefunction of carrier in case of transversally coupled quantum dashes, there is change of oscillator strength of optical transition, as well as change of energy of Coulomb interaction between carriers. On the other hand, recently usefulness of such nanostructures has been shown with regard to single-photon and coupled pairs of photons emission [35, 36, 37]. In such cases, it is also of highly relevance if, or to what degree, the objects can be treated as independent quantum emitters – thus it was very important to examine transversal coupling between quantum dashes.

In [**H1**] work results of theoretical research of energetic structure of coupled quantum dashes have been shown. The research has been performed for quantum structures grow on InP, where quantum dashes were made of InAs, and bareer was made up of quaternary compounds: $In_{0.53}Ga_{0.23}Al_{0.24}As$, $In_{0.80}Ga_{0.20}As_{0.40}P_{0.60}$ and ternary $In_{0.52}Al_{0.48}As$. Such selection of modelled systems, shape and size of nanostructures and barrier materials, was made in order to model conditions in existing structures [27, 38, 39]. Calculations of energy of states of confined carriers and probability densities were performed in one-band kp model for coupled quantum dashes, which were of triangular cross-section [27]. Calculations were performed as a function of lateral distance between quantum dashes. For a partial verification of model a calculation of energy of optical transitions of a single quantum dash has been performed, and then the results were compared with existing theoretical results for a set of dashes, both for room temperature as well as cryogenic temperature. After that, calculations for pairs of laterally coupled quantum dashes have been performed. Results have shown, that energy split-off between the ground state and the first excited state, which is a measure of the coupling is as little as a few meV, both for electron and hole states, and does not depend on the barrier material. Moreover, the results allowed to determine that tunnelling times between neighbouring quantum dashes are of the order of picoseconds. That would indicate very efficient tunnelling process (times are significantly shorter than radiative lifetimes in such structures). The time of tunnelling increases significantly (even as much as three orders of magnitude) in case when two neighbouring quantum dashes (as it is in real structures), differ significantly in size, despite of small distance between them. This results shows that in real structures grown on InP using MBE method, energy structure of large and strongly nonuniform set of quantum dashes may be calculated in first approximation in a language of single quantum dash, and effects of direct tunnelling between them may be negligible, in terms of their impact on the parameters of laser devices. That is why quantum emitters based on such structures may be treated as isolated in terms of their electronic and optical properties. On the other hand, if a matrix of more uniform nanostructures of such type were manufactured, then the effects of coupling between dashes may not be neglected, or even would dominate band, excitonic or optical properties.

*My input to [**H1**] work consisted of creating physical model for two laterally coupled quantum dashes, developing numerical methodology and proper software. I have numerically calculated dependence of number of optical transitions and their energies on the size of a quantum dash for different temperatures. Moreover I have performed calculations of split-off energy in a set of two coupled quantum dashes as a function of their size, distance between them, and the barrier material. I have calculated time of tunnelling of charge carriers between quantum dashes as a function of those system parameters. I have analysed and interpreted obtained data. I estimate my input at 75 %.*

- **Diluted nitrides quantum wells**

Quantum wells manufactured with AIII-BV groups semiconductors diluted with nitrogen, grown on GaAs substrate may be active areas of lasers emitting in near infrared [40, 41]. Adding small amounts of nitrogen (in the order of a few percent) to binary GaAs or ternary InGaAs cause reduction of band gap of a basis material for a few dozens of meV for each 1 % of nitrogen content with simultaneous reduction of lattice constant of newly formed semiconductor alloy [42, 43]. Those factor state application attractivity of this material group, also in construction of active area of lasers in near infrared.

Article [**H2**] shows results of research on energetic structure and optical properties of type I quantum wells made of III-V nitrogen-diluted semiconductors grown on GaAs substrate. Undertaking this issue was inspired by novel then idea of application this type of quantum wells in structures with wells embedded in optical microcavities utilizing strong light-matter coupling (excitons and photons) which would allow to create coherent light sources called polariton lasers [44, 45, 46], in a telecommunication windows range (e.g. 1.3 µm). The article shows an original material proposition and the purposes of the work were: (a) examining the energy of the fundamental optical transitions and respective oscillator strengths for quantum wells; (b) determining molar fraction of nitrogen in the layers of the structure, for which we obtain maximal value of oscillator strength (relevant parameter influencing coupling with optical modes of the resonant cavity); (c) dependencies of oscillator strength of fundamental optical transition on conduction and valence bad discontinuity in quantum wells, since they were largely unknown. The research was conducted for InGaAsN/GaAs and InGaAsN/GaAsN/GaAs quantum wells. The width of those wells and the value of molar fraction of In and N were chosen to ensure correct wavelength emission – in this case 1.3 µm. The calculation we conducted for two cases i.e. with and without coulomb interaction (of an exciton). In the work there have been presented results showing influence of nitrogen content and conduction band discontinuity between GaAsN i GaAs (Q_C^*) on the value of energy and intensity of fundamental optical transition. There has been proved that in a case when coulomb interaction between electrons and holes is negligible, intensity of a transition is changed significantly with the change of conduction band discontinuity (Q_C^*). While considering forming of an exciton, oscillator strength of a fundamental optical transition increases with nitrogen content, reaching maximum for a specified value of nitrogen molar fraction, depending on the conduction band discontinuity (Q_C^*). That means that in order to correctly foresee the oscillator strength for excitons in such quantum wells, it is essential to experimentally verify the value of band discontinuity (Q_C^*) in such structures. There has also been shown, that the oscillator strength in InGaAsN/GaAs quantum wells can increase even triple when compared to analogical

InGaAs/GaAs quantum wells. This is especially important result indicating possibilities of application of III-V nitrogen-diluted semiconductors in quantum electrodynamics experiment, and possible application in futuristic sources for the telecommunications range.

*My input into [**H2**] publication consisted of developing the idea of the work, preapring models and writing software. I have calculated numerically dependence of energy of a fundamental optical transition as a function of nitrogen contents. I have calculated moduli of squared overlap integral of the fundamental optical transition and its oscillator strength with respect to forming of an exciton as a function of nitrogen molar fraction and conduction band discontinuity. I have analysed and interpreted obtained data. I estimate my input at 55 %.*

The [**H3**] article show results of the research on energy structure of type I quantum wells manufactured with nitrogen-diluted III-V semiconductors grown on GaAs substrate. The inspiration for this work were the conclusions from [**H2**] work, in which dependence of oscillator strength of a fundamental optical transition in a function of band discontinuity in InGaAsN/GaAsN/GaAs quantum wells has been shown, and that result indicated that this parameter depend on the choice of the values of band discontinuity, which were unknown for this material combination, especially on GaAsN/GaAs interface. The purpose of [**H3**] was determination of band edges discontinuities and effective masses of electrons in GaAsN/GaAs quantum wells. An important challenge was to correctly calculate energy levels of carriers in such quantum wells. The 10-band $k{\cdot}p$ model has been used, which is a development of the 8-band model [47] and considers conduction band, heavy- and light-hole, spin-orbit band, and coupling of conduction band states with nitrogen level [48]. In this work influence of band discontinuities in GaAsN/GaAs quantum wells has been analysed, for two different molar fractions of nitrogen in GaAsN on values of energy of interband optical transitions as a function of quantum well width. An analysis of the number of electron states in the conduction band and of hole states in the valence band has been conducted. The results were used as a basic criterion of analysis and interpretation of associated experimental data for such wells. Moreover, there has been performed the calculations of energies of optical transitions in these structures depending on electron effective mass. Comparing these results with optical spectroscopy data for two series of quantum wells has shown, that when nitrogen molar fraction in GaAsN/GaAs quantum well equals 1.2%, then conduction band discontinuity equals 86·4 %, and in the case of fraction being 2.2%, the conduction band discontinuity equals 83±3 %. Other important result was also determination of electron effective mass which was 0,09m_o in case of 1.2% molar fraction in GaAsN, and 0,15m_o in case of 2.2 % molar fraction. Obtained results are important especially with regards to correct analysis of band structure of quantum wells comprising GaAsN such as researched in [**H2**]. The results confirmed predictions regarding an increase of an oscillator strength of an optical transition in InGaAsN/GaAsN/GaAs quantum wells, which are dedicated for optoelectronics based on polariton devices in1.3 μm range.

*My input to [**H3**] work was based on preparing 10-band model for calculating energy structure of GaAsN/GaAs quantum well and preparing according software. I have calculated numerically energies of single-particle electron and hole states depending on nitrogen molar fraction in GaAsN and quantum well width. I have* *determined the dependence of optical transition energies as a function of electron effective mass in GaAsN/GaAs quantum wells. I have taken part in the analysis and interpretation of obtained data. I have participated in working on conclusions and preparing the manuscript. I estimate my input at 35%.*

- **Type II quantum wells and interband cascade lasers**

One of important trend in emitters for mid-infrared is development of diode lasers. These devices utilize interband transitions in type I quantum wells [49, 50, 51], which is shown in the fig. 2a, only that most devices use series of many such wells.

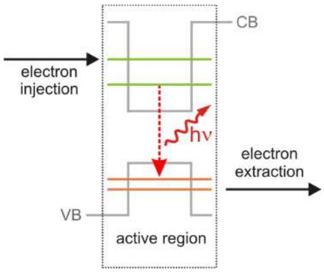


Fig. 2a: Schematic sketch of band profile and active region processes in diode lasers.

In such systems, because of limitations arising from properties of used material, as well as irradiative losses, such as Auger process, it is difficult to achieve emission beyond 3 µm. Most recent data indicate record emission wavelength of 3.73 µm [51].

Another type of sources, from which emission may occur in the mid-infrared range are quantum cascade lasers [52]. They are emitters of coherent radiation, which utilize intraband radiative transitions (usually for electrons in conduction band) and the process of their tunnelling through a system of many barriers in the conduction band to next identical segments of a system, which is shown on fig. 2b.

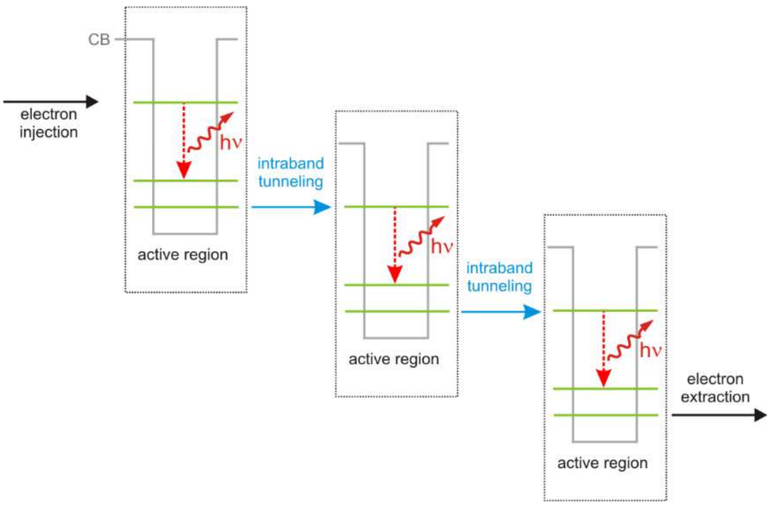


Fig. 2b: Schematic sketch of band profile and active region processes in quantum cascade lasers.

This type of laser consists of two parts: an active area, where laser action takes place, and an injector region, which is responsible for carrier transport between neighbouring active areas. This cause a cascade, which allows multiplied generation of photons due to injecting one charge carrier, which increases quantum efficiency of such a device. Owing to the fact, that we only have a carrier in the conduction band, the problem of bandgap width is eliminated. That allows to shift emission more towards longer wavelengths, exceeding 10 μm in continuous mode in the room temperature [53] and providing high output power. It is worth mentioning, that quantum cascade lasers are composed of very high number of layers (even couple of thousands), which need to be manufactured with high accuracy, as it is a condition of proper functioning of a device. It causes that manufacturing of such a structure in a means of epitaxy is difficult and expensive. Moreover, their functioning demands applying external electric field and high threshold currents, which cause high energy consumption, and as a consequence significantly limits their application in battery-powered mobile devices.

Another source, that emits mid-infrared radiation is interband cascade laser [54, 55, 56, 57, 58]. The idea of such a semiconductor laser joins principles of laser diodes with its using of interband transitions, with quantum cascade laser with its carrier tunnelling through adjacent cascades of a system. Schematics of its principle is shown in the fig. 2c.

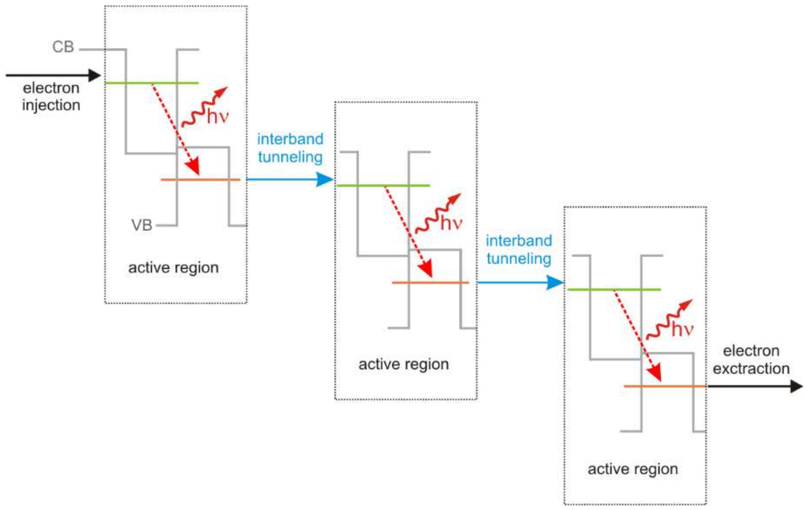


Fig. 2c: Schematic sketch of band profile and active region processes in interband cascade lasers.

The principle of action of such a semiconductor laser uses interband optical transition in type II quantum well, i.e. when electrons and holes taking part in radiative recombination are localised in materials of neighbouring layers. Like in a quantum cascade laser, in the interband cascade laser we have active and injection regions. Active are usually consists of layers of AlSb/InAs/GaInSb/AlSb, where quantum well for electrons in the conduction band is simultaneously a barrier for holes in the valence band, and is made of InAs, and a quantum well for holes is made of GaInSb and is a barrier for electrons. AlSb layers are barriers for both electron and holes. In a single active area a photon is generated due to recombination of an electron (from InAs well) and a hole (from GaInSb) well. After the recombination the electron is transferred to the injection region, and the to the next active area, which is possible because of applied external electric field. Schematics of an active and injector area is shown on figure 3.

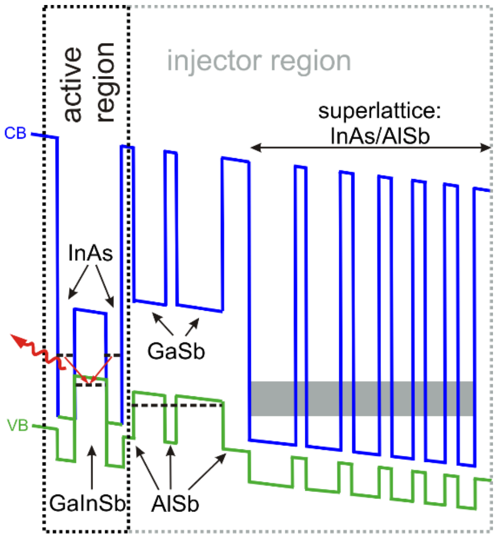


Fig. 3: Conduction and valence band profiles for one stage of an interband cascade laser under bias, along with the succeeding stage's active region. The active and injector regions are indicated.

One of the results of a spatial separation of electrons and holes in the active area of an interband cascade laser is reduction of disadvantageous processes such as Auger recombination [59, 60], which is one of the advantages of such lasers as compared with laser diodes emitting beyond 3 μm [61]. The others are: possibility of spectral coverage of range beyond 3 μm [62, 63], low threshold current densities and low power consumption [55], ease of achieving population inversion [54], continuous wave mode in room temperature [60]. Equally important is the possibility of single-mode work. Because of mentioned features and emission possibilities in application important spectral region, interband cascade lasers are of growing importance.

Increasing demands on the application side caused that new solutions and proposals of optimisation of structures for active areas of interband cascade lasers were targets of a few projects realised by our team: 7th European Union Framework Programme: SensHy – Photonic sensing of hydrocarbons based on innovative mid infrared lasers (realised in years 2008-2011) and WideLase – Monolithic Widely Tunable Interband Cascade Lasers for Safety and Security (realised in years 2012-2015), and another iCspec – In-line cascade laser spectrometer for process control (realized in years 2015-2018) as a part of EU programme Horizon 2020, in which I was main contractor. During realisation of these project I was responsible for designing and modelling of new kinds of active areas. Their subject was mainly concerning novel gas sensors utilising semiconductor lasers. In these projects I collaborated with teams from Würzburg University (where structures were manufactured by MBE process), and companies nanoplus GmbH and Siemens AG in Germany, Airoptic from Poznań, Poland, which were manufacturing devices based on these structures according to instructions and optimising steps which were results of theoretical modelling conducted by me. The experimental verification was performed by other members of the Laboratoty of Optical Spectroscopy of Nanostructures.

In [**H4**] article properties of band structure have been examined as well as optical properties of type II quantum wells used in active areas of interband cascade lasers ane made of layers of AlSb, GaInSb, and InAs on GaSb substrate. This publication shows results of research which aimed towards finding conditions (in a sense of layers layout and band structures) allowing to increase the oscillator strength of a fundamental optical transition with simultaneous providing possibly widest spectral range in which named wells can emit. Figure 4 shows dependence of bandgap on lattice constant for chosen III-V semiconductors, which were used is these structures.

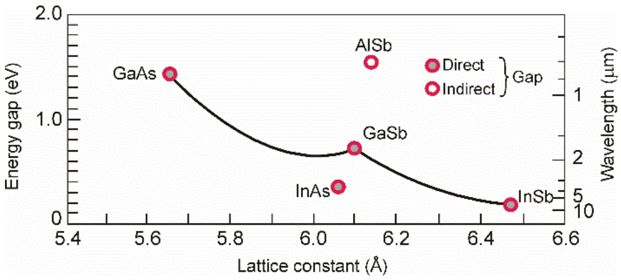


Fig. 4: Band gap versus lattice parameter for some of the more common semiconductors.

Materials such as InAs and InSb are characterised by narrow band gap, which caused necessity of including the interaction between valence band and conduction band [64]. That is why I applied 8-band $k{\cdot}p$ (including conduction band, heavy- and light-hole band and spin-orbit split-off) [65]. Because applied materials are lattice mismatched to GaSb substrate, I have included a hamiltonian describing strain [66]. Moreover, due to the fact that lasing structures work in condition under external electric field, it has also been included by adding to the hamiltonian proper part related to electric field.

In order to increase the value of oscillator strength for the fundamental optical transition in the GaSb-AlSb-InAs-GaInSb-AlSb-GaSb material system, which very often is used in construction of active areas of interband cascade lasers, which is very often used in construction of active area of interband cascade laser, another layer of InAs is applied. Figure 5 shows schematic layer systems, and conduction and valence band edges of such a structure. This structure is called W-shaped quantum wells, because of characteristic band edges shape resembling letter „W". In this structure an electron is located in double InAs quantum well, while a hole has its maximum of probability density in GaInSb layer. The GaInSb layer is simultaneously a barrier separating electron state. The results of energy calculations of the fundamental electron and the fundamental heavy-hole states as a function of InAs layer width have shown a possibility of achieving emission from the mid-infrared, i.e. 3-5 μm range.

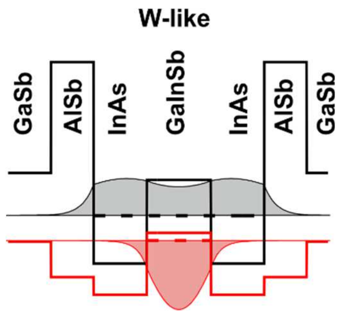


Fig. 5: Schematic sketch of band profile for W-like active region. The shape of wavefunction squared moduli for an electron and a heavy hole in such a structure are indicated.

Moreover, in this work the value of the oscillator strength of a typical type II quantum well has been compared with the oscillator strength of a fundamental optical transition realised in W-shaped. The results have shown an increase of transition intensity in case of a W-shape quantum well.

Electric field present in operating laser impacts both on the optical transition energy, as well as on the oscillator strength. Applying external field to the active area cause that because of the quantum confined Stark effect the emission wavelength and the oscillator strength both decrease..

In work [**H4**] there has been shown how the decrease of the oscillator strength can be compensated by introducing a difference in InAs layers widths creating quantum wells for electrons, and that such compensation can be achieved for any well in different spectral ranges. The impact of change of width of one of two InAs layers on fundamental transition energy, and on the value of squared moduli is shown in figure 6.

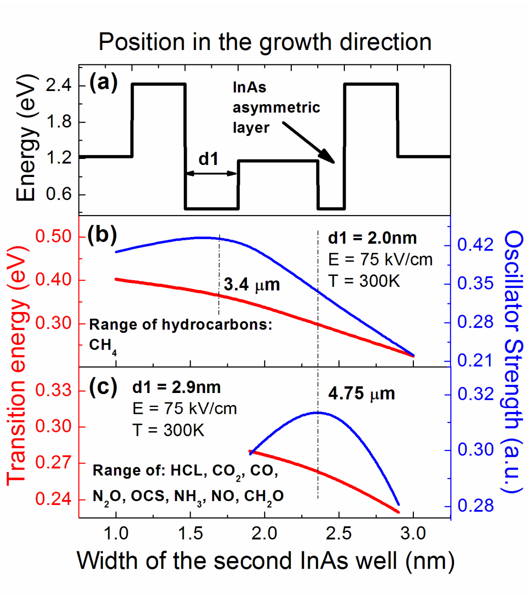


Fig. 6: Schematic diagram of the confined profile for electrons in asymmetric W- shaped type II QW (panel a). Overlap integral as a function of the second QW width in case of the first QW width d1 = 2 nm (panel b) and d1 = 2.9 nm (panel c). [**H4**].

In work [**H4**] there has been presented how the decrease of the oscillator strength of a fundamental optical transition can be compensated by introducing differences in widths of InAs layers creating quantum wells for electrons, and that such compensation can be achieved for any quantum well in different spectral ranges. The influence of width change of one of two

InAs layers on the enegry of a fundamental transition and on an overlap integral squared modulus is illustrated in fig. 6. That is especially significant result showing application possibilities for this kind of quantum wells in active area of laser acting in mid-infrared range, where there are characteristic absorption lines for many environmentally important gases such as CH_4, HCl, CO_2, N_2O, and NH_3. The spectral tunability has also been experimentally verified in this work.

*My input in work [**H4**] consisted of preparing a model and writing software. I have performed calculations of dependence of electrons and holes energies of a fundamental optical transition and the oscillator strength as a function of InAs well in two cases: (a) for type II quantum well and (b) for a W-shaped quantum well. I have calculated numerically aforementioned dependencies in a situation with applied external electric field to the active area. I have taken part in interpretation of results of the whole work and I have taken part in redaction of a manuscript and forming conclusions. I estimate my input at 35 %.*

The [**H5**] work is a next step of research on W-shaped quantum wells. Its purpose was searching for new material solutions in order to improve work parameters of interband cascade lasers.

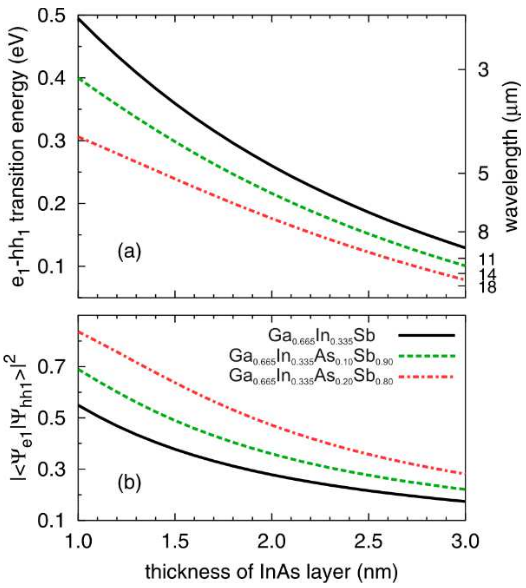


Fig. 7: (a) Transition energy and (b) the square of the wave functions overlap, in the type-II W-design AlSb/InAs/$Ga_{0.665}In_{0.335}$AsSb/InAs/AlSb QW as a function of the InAs well width for three different values of As content: 0% (black solid line), 10% (green dashed line), 20% (red dashed-dotted line). The GaIn(As)Sb layer thickness is 3.5 nm. [**H5**].

In this article I proposed a change of ternary GaInSb for a quaternary GaInAsSb material. The conduction and valence band edges' location has been analysed as a function of arsenic content in $Ga_{0.665}In_{0.335}$AsSb material deposited on GaSb and InAs surfaces. Next, an influence of Ga/In content in GaIn(As)Sb, which is one of the layers of AlSb/InAs/GaIn(As)Sb/InAs/AlSb active area, on the value of energy of the fundamental optical transition and squared modulus of wavefunction overlap integral of carriers taking part in this transition for different InAs well widths has been examined. The results of calculations have shown that introducing arsenic as a fourth element into GaIn(As)Sb can effectively increase overlap integral square modulus, with additional possibility of significant widening of emission wavelength for such structures. Together with changes in InAs width it allows to achieve emission even beyond 10 µm, with retaining sufficiently high intensity of an optical transition, as shown in fig. 7. That makes, that using such an active area becomes a potential solution in construction og long-wave ICLs. That is why, for selected parameters of examined system, impact of external electric field on the fundamental transition energy and respective squared modulus of the overlap integral has been calculated, in order to simulate conditions in a real device. This work has shown for the first tie, that by such a band structure engineering (composition and thicknesses in type II structure), it is possible to tune the emission in broad range above 10 µm, even beyond 15 µm in extreme cases.

> *My input to [**H5**] work is a proposition of usage of quaternary alloy for W-shaped quantum wells in interband cascade lasers and development of a conception of such an active area. I have prepared an appropriate model and modified software. I have performed calculations of dependence of electron and holes states, the fundamental optical transition energies, and respective overlap integral square moduli as a function of InAs width, as well as GaIn(As)Sb composition and thickness used in a construction of an active area based on W-shaped quantum wells on GaSb and InAs surfaces. I have numerically calculated abovementioned dependencies also in a function of external electric field in order to simulate conditions closer to existing in a real device. Moreover, I have taken par in the interpretation of results, as well as in developing conclusions and preparing the manuscript. I estimate my input at 75 %.*

Publication [**H6**] concerns research on new (significantly modified) active area as compared to W-shaped quantum wells typically utilised in interband cascade lasers. The purpose of [**H6**] work was designing such an active area that would allow spectral tuning towards further infrared with simultaneous increasing of value of overlap integral squared modulus (oscillator strength of an optical transition).

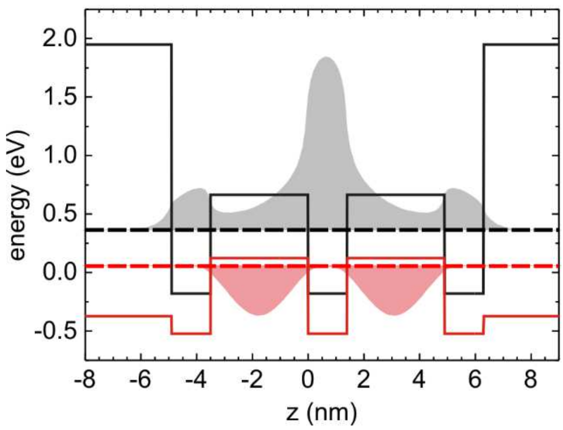


Fig. 8: Conduction and valence band edges and the squared moduli of wavefunctions for an electron and a heavy hole in AlSb/InAs/GaInSb/InAs/GaInSb/InAs/AlSb structure.

It has been shown, that it is possible to achieve in a system of multiplied InAs/GaInSb quantum wells. An example of conduction and valence band edges and the shape of squared moduli of wavefunctions for an electron and a heavy hole in such a structure is shown in figure 8. The results of calculations have shown that introducing additional InAs layer causes lowering the energy of an optical transition, i.e. shifting towards longer wavelengths, with simultaneous increase of the value of squared moduli of the overlap integral. Research has been conducted on the number of InAs wells on these system parameters – this result is presented in figure 9. An increase in the number of layers leads to saturation of both dependencies, which is expected, since it means effective broadening of the quantum well and weakening of the spatial confinement. This result shows that repeating the structure for more than 4 times does not cause significant improvement to optimised parameters, and the biggest advantage is obtained while changing the structure from double to triple.

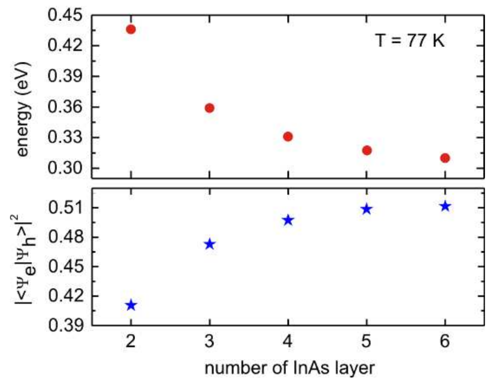


Fig. 9: Dependence of energy of the fundamental optical transition and respective square of modulus of the overlap integral as a function of the number of InAs layers from which the active area AlSb/InAs(1.4nm)/ /$Ga_{0.665}In_{0.335}Sb$(3.5nm)/InAs(1.4nm)/$Ga_{0.665}In_{0.335}Sb$(3.5nm)/InAs(1.4nm) /AlSb is constructed.

It is important to mention, that an increase to the number of layers in a system causes a necessity of precise control of thicknesses of a few ultrathin layers, making it is more demanding in terms of technology. That is why in the next part of the work, an influence of external field has been analyse, in order to optimise this complex system under conditions occurring in an device, and to compensate the adverse impact of the field. For this purpose, width of two layers of InAs, from which the active area was constructed, was changed. The results are shown in figure 10.

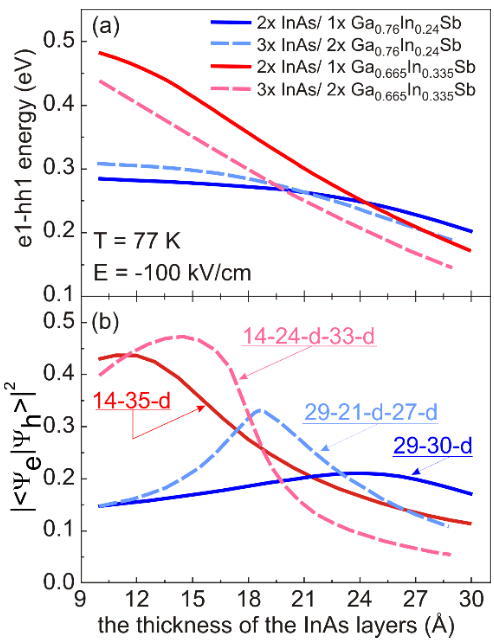


Fig. 10: Calculated transition energy - (a), and squared wave functions overlap integral - (b) versus the thickness of the InAs layers (labeled "d") for two active areas: (i) AlSb/InAs/GaInSb/InAs/AlSb; (ii) AlSb/InAs/GaInSb/InAs/GaInSb/InAs/AlSb in external electric field [**H6**].

Obtained results have shown, that using such a solution when constructing active areas of interband cascade lasers can have great significance in case of longwave emission lasers.

*My input into creating work [**H6**] consisted of proposing of a modification of an active area used in interband cascade laser, in order to cover possibly wide spectral range. I have performed calculation of energies of electrons and holes, energies of fundamental optical transitions, and squared moduli of the overlap intergrals as a function of number of InAs layers. Moreover, I have designed an appropriate construction of active areas, to which external field is applied. I have taken part in analysis and interpretation of results. I estimate my contribution at 35 %.*

The [**H7**] article shows results of the research on energy structure and optical properties of W-shaped AlSb/InAs/GaAsSb/InAs/AlSb quantum wells grown on GaSb substrate. In this work the results of analysis of energetic location of conduction and valence bands in GaAsSb grown on GaSb substrate, in cases: (a) without strain, (b) with strain have been shown. For the first time there has been a proposal of incorporation of tensile-strained GaAsSb into the active area, as a contrast to previously used GaInSb, which is compressively-strained. The consequence of such an action are new possibilities of spatial confinement for hole, and of band structure engineering for such a well (figure 11), including energies of the fundamental optical transition (emission wavelength), or the oscillator strength of such a transition.

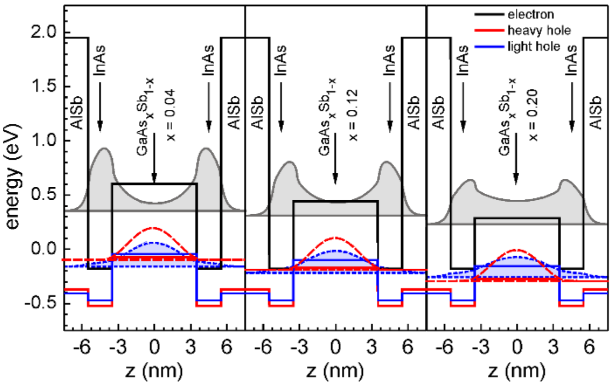


Fig. 11: Confinement potential profile corresponding to the conduction and the valence band edges for the W-design AlSb/InAs/$GaAs_xSb_{1-x}$/InAs/AlSb QW for three different values of As content (black for electrons, red for heavy holes, blue for light holes). In addition, the density probabilities of fundamental electron, heavy hole, and light hole states and their energy levels. The $GaAs_xSb_{1-x}$ layer thickness is 7.0 nm. The width of the InAs layers is equal to 2.0 nm [**H7**].

The research included the impact of InAs layer on the energy of fundamental optical transition In W-shaped AlSb/InAs/$GaAs_xSb_{1-x}$/InAs/AlSb for different values of As molar fraction $GaAs_xSb_{1-x}$ material. The calculations were performed for $GaAs_xSb_{1-x}$ layers of 3 nm and 7 nm in width. Results of these calculations are shown in figure 12. This figure shows, for comparison, energies of optical transitions of W-shaped quantum wells in case when the GaAsSb material is exchanged on typically applied GaInSb. Comparison of these results has led to another important conclusion, namely, that using thicker GaAsSb layers translates to lesser sensitivity of emission wavelength of the fundamental transition on inaccuracies of thicknesses of respective layers of the same structure. Moreover the change of straining conditions, and the possibility of its control by changing the composition of GaAsSb layer, allows to control the degree of subband mixing in the valence band, and in extreme cases, for causing the fundamental transition to be light-hole (the highest subband in the valence band is a light-hole subband).

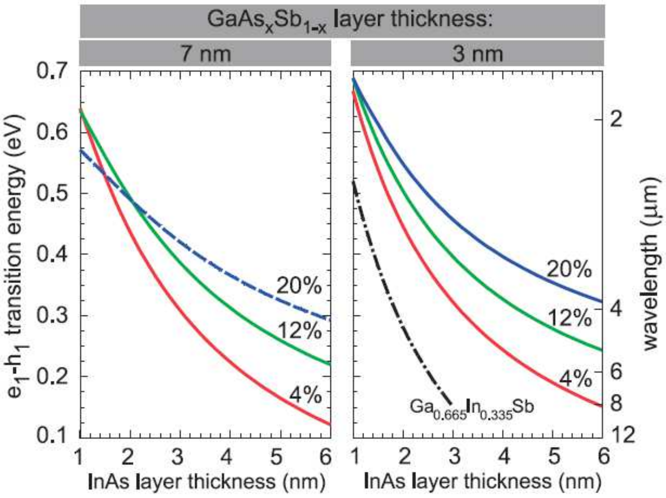


Fig. 12: Dependence of energy of the fundamental optical transition in an AlSb/InAs/GaAs$_x$Sb$_{1-x}$/InAs/AlSb structure as a function of InAs thickness (solid lines). Additionally, results of calculations have been shown for a structure in which GaAs$_x$Sb$_{1-x}$ layer has been replaced by Ga$_{0.665}$In$_{0.335}$Sb layer (dash-dot line) [**H7**].

As a result of conducted calculations, it has occurred that in case of light-hole character of the fundamental optical transition, we are able to achieve important 4-5 µm region, and to have additional advantage with increased value of squared modulus of the overlap integral (figure 13).

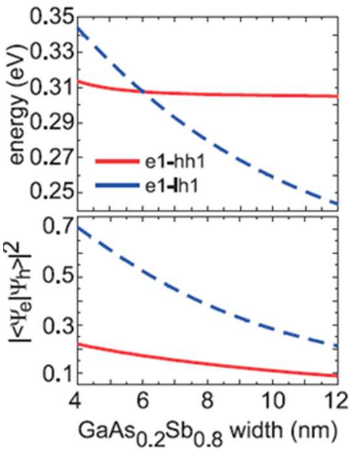


Fig. 13: Transition energy and oscillator strength for heavy holes (red solid line) and light holes (blue dashed line) in the type-II W-design AlSb/InAs/GaAs$_{0.2}$Sb$_{0.8}$/InAs/AlSb QW as functions of the GaAsSb layer thickness. In all cases, the InAs layer thickness is 6.0 nm [**H7**].

Additionally, changes in the structure caused by tensile strain influence also on polarisational selection rules. Work [**H7**] first suggest the possibility of using such a structure as a polarisational independent active material in mid-infrared range, which is an original aspect, since such devices virtually do not exist, and they are desired in many applications (e.g. optical amplifiers).

*My input into work [**H7**] was based on proposing of appropriate material for construction of a novel active area for interband cascade lasers. In order to perform required calculations I have modified software. I have analysed the band structure and the influence of strain for material used in constructing new active area. I have calculated dependencies of energies of electrons and holes, the energy of the fundamental optical transition and the square of modulus of an overlap integral as a function of many parameters of the system, such as molar fraction of arsenic in GaAsSb, InAs well width and GaAsSb width. I have taken part in analysis and* *interpretation of the results, and in preparing the manuscript. I estimate my input at 75 %.*

The [**H8**] publication is another step in research on type II quantum wells with tensile-strained GaAsSb. The goal of this work was to design an active area with polarisational independence in mid-infrared range. The paper shows results of calculations of optical gain in such quantum wells for two light polarisation TE and TM (for optical modes with electric and magnetic vector in the well plane and transversally to the plane, respectively, in a edge-emitting devices geometry). The energetic dispersion of energy levels of charge carriers in W-shaped quantum wells was calculated using 8-band $k{\cdot}p$ model. Achieved values of energy and wavefunctions of electron and hole states in this structure allowed to calculate optical gain. In the calculation the width of InAs layers and arsenic molar fraction of GaAsSb was modified. The results have shown, to what extent the energetic structure, the bandwith, and the optical gain value can be influenced. The calculations have been performed as a function of carriers concentration in such an active area. For large concentrations of carriers, the optical gain in cases of TE and TM polarisation is the same and includes much wider wavelength range. In the same manner there has been shown, how manipulation the carrier concentration can achieve on polarisational properties of such a structure.

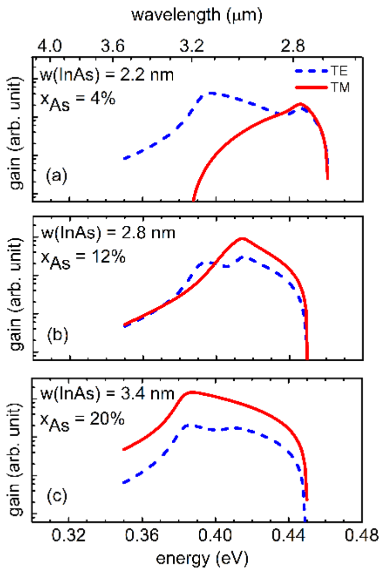


Fig. 14: The gain spectra of different W-design AlSb/InAs(w)/$GaAs_xSb_{1-x}$(7nm)/InAs(w)/AlSb QWs (a) x=4 %, w=2.2 nm, (b) x=12 %, w=2.8 nm, (c) x=20 %, w=3.4 nm at the same carrier density equal 4×10^{18} cm^{-3} and for the electric field equal to 70 kV/cm. The short dash (blue) curves represent results for TE polarization, the solid (red) – TM polarization [**H8**].

Additionally, the influence of an external electric field has been calculated. Calculation of an optical gain for typical value of electric field of W-shaped AlSb/InAs/GaAsSb/InAs/AlSb quantum wells, i.e. 70 kV/cm. Examples of the results are shown in figure 14. The main result of this work is showing the possibility of obtaining polarisational independence as a function of gain for type-II active areas in mid-infrared range by applying appropriate material system and bandgap and strain engineering.

> *My input into [**H8**] work was proposing how this type of structures polarisational independence can be realised, planning appropriate structures, and developing the software. I have calculated the dependencies of optical gain as a function of InAs well width, molar fraction on As in the GaAsSb layer, carrier concentration, and electric field. I have analysed obtained results. I have taken part in their interpretation, and preparing publication manuscript. I have participated in preparing final conclusion of the work. I estimate my input at 80 %.*

Work [**H9**] shows results of the research on possible constructions of active areas applied for passive mode locking in interband cascade lasers emitting in mid-infrared range. Such a construction is used for generation of ultrashort impulses – in this case in mid-infrared. Passive mod locking is usually achieved by linking in one device the active area, where the gain is achieved, with saturable absorber. Characteristic lifetimes in absorber part τ_a and in gain part of the active are τ_g should satisfy inequation $\tau_a << \tau_g$ [67]. It has been proposed, that in such a device as a interband cascade laser, to apply external voltage and steering with electric fiel, in order to change characteristic time constants (and as a consequence oscillator strengths of optical transitions), which is shown schematically in figure 15.

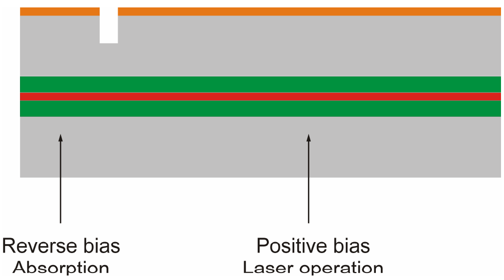


Fig. 15: Schematics of two parts of an interband cascade laser [**H9**].

It has been shown, that a change in a range between -100 kV/cm and +100 kV/cm causes the most relative changes of overlap integral for triple type II AlSb/InAs/$Ga_{0.65}In_{0.35}Sb$/InAs/$Ga_{0.65}In_{0.35}Sb$/InAs/AlSb structure as in fig. 16.

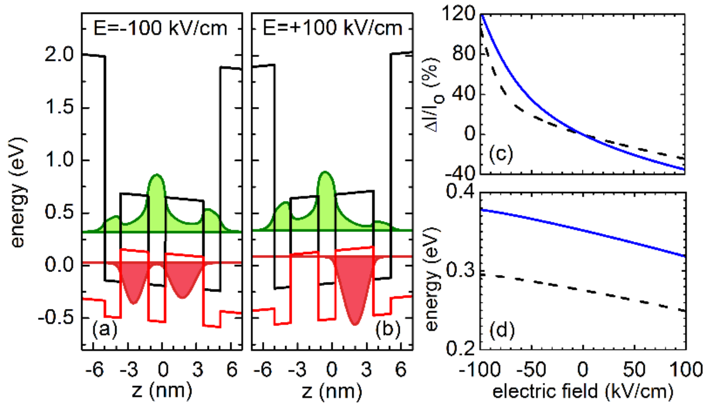


Fig. 16: Confinement potential profile corresponding to the conduction and valence band edges, for the modified triple QW design AlSb/InAs(1.4nm)/$Ga_{0.65}In_{0.35}Sb$(2.4nm)/InAs(1.5nm)/$Ga_{0.65}In_{0.35}Sb$(3.3nm)/InAs(1.5nm)/AlSb structures, for two different values of external electric field: -100 kV/cm (panel (a)) and +100 kV/cm (panel (b)). In addition, probability densities of the fundamental electron and heavy hole states and their energy levels are shown. There is also shown the effect of the external electric field on the relative change of the squared overlap integral (panel (c)) and on the transitions' energy (panel (d)). The black dashed line marks the results of AlSb/InAs(1.4nm)/$Ga_{0.65}In_{0.35}Sb$(2.4nm) /InAs(1.5nm)/$Ga_{0.65}In_{0.35}Sb$(3.3nm)/InAs(1.5nm)/AlSb structure, and the blue continuous line - AlSb/InAs(1.4nm)/$Ga_{0.65}In_{0.35}Sb$(2.4nm) /InAs(1.0nm) /$Ga_{0.65}In_{0.35}Sb$(3.3nm)/InAs(1.0nm)/AlSb [**H9**].

Similar optimistic result has been achieved fot W-shaped AlSb/InAs/$GaAs_{0.2}Sb_{0.8}$/InAs/AlSb quantum wells. In both cases change to oscillator strength is a couple times higher than for a traditional AlSb/InAs/GaInSb/InAs/AlSb area. These results can pave the way for a new class of devices based on interband cascade laser conception and using passive mode locking.

*My input into work [**H9**] consisted of the idea of applying asymmetric, triple type-II structure AlSb/InAs/$Ga_{0.65}In_{0.35}Sb$/InAs/$Ga_{0.65}In_{0.35}Sb$/InAs/AlSb and W-shaped AlSb/InAs/$GaAs_{0.2}Sb_{0.8}$/InAs/AlSb for passive mode-locking, and planning appropriate calculations. I have calculated the dependence of relative change of squared modulus of the overlap integral, and energies of fundamental optical transition as a function of external electric field for three different construction of an active area for interband cascade laser. I have analysed achieved results. I have taken part in the interpretation of the results and preparing the manuscript of the work. I have taken part in preparing final conclusions of the work. I estimate my input at 50 %.*

3.4 Summary

Investigations of selected III-V compound based quantum structures for enhanced working parameters of semiconductor infrared radiation emitters is based on a cycle of 9 articles. Below I show the summary of most important results.

- It has been shown, to what degree objects such as quantum dashes can be treated as independent quantum emitters, which is of important meaning in devices such as lasers or single-photon sources in near infrared – [**H1**].
- It has been shown, that nitride-diluted quantum wells can be more advantageous for application, after placing in optical cavity, in polariton lasers – [**H2**].
- The band discontinuities of conduction and valence band, and effective masses of electrons in GaAsN/GaAs quantum wells have been calculated in cases of small nitrogen contents – [**H3**].
- The band structure of an active area has been proposed and modelled, and the analysis of active areas in interband cascade lasers has been accomplished in order to achieve appropriate emission wavelength and to increase oscillator strength – [**H4-H5**].
- An alternative way of constructing active areas in interband cascade lasers has been achieved by proposing a construction of active areas by proposing an increase of number of quantum wells – [**H6]**.
- It has been proposed a complete new active area of interband cascade lasers with tensile-strained GaAsSb which may lead to lesser sensitivity of manufacturing inaccuracies of such a device, and to increase the value of squared modulus of an overlap integral of the fundamental optical transition in aimed mid-infrared range – [**H7]**.
- For the first time active areas for interband cascade lasers have been designed that show polarisational independence as a function of gain in mid-infrared – [**H8]**.
- New solution of active areas has been shown that may lead to creating new class of impulse devices in mid-infrared based on conception of interband cascade lasers and using passive mode-locking – [**H9]**.

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4. OTHER SCIENTIFIC ACHIEVEMENTS

4.1 Before obtaining Ph.D. degree

I have started my scientific work at fourth year of studies at Applied Physics of specialization Solid State Physics at the Faculty of Fundamental Problems of Technology at Wrocław University of Science and Technology in the Laboratory of Optical Spectroscopy of Nanostructures (LOSN). The issue I addressed was influence of excitons on optical transitions in semiconductors. The inspiration for detailed analysis of this research was experimental results obtained in the LOSN. I have graduated from master studies in 1996. The topic of my master thesis was *Influence of excitons on fundamental optical transition of semiconductors in presence of external electric field.* In 1996 I have begun doctoral studies at Institute of Physics of Faculty of Fundamental Problems of Technology at Wrocław University of Science and Technology. The topic of my scientific work was focused on calculation of energies and wavefunctions of confined states in low-dimensional semiconductor structures. At this time I have developed computer programmes (using the method of binding matrices) for calculations of energies and wavefunctions of electron and hole states in rectangular-shaped quantum wells (using one-band kp model). Next, I have applied my programmes to interpret experimental data from photoreflectance spectroscopy used to: researching on the effect of coupling of states in double quantum wells. Another task was to theoretically describe the band structure and optical properties of $Al_xGa_{1-x}As/GaAs$ heterojunctions selectively doped with acceptors. In my calculations I have included realistic parameters of the structures (accumulative character of charge layer creating at the junction) and multi-body effects of exchange and correlation. The band structure of the holes is described with quite sophisticated mathematically model (Luttinger model), which excludes analytical solutions and leads many researchers to oversimplify the calculations. Using four-band Luttinger model as a basic approximation for the description of hole states from around the top of the valence band of III-V semiconductors wit direct bandgap I have written a computer program, which calculates band structure of hole subbands. Performed calculations was self-consistent. In this work I have proposed a model of quasi-stationary surface exciton. Next, I have calculated energies and lifetimes of such nonstationary quasi-particles in p-type heterojunctions. My doctoral dissertation was titled *Properties of excitons in p-type single $Al_xGa_{1-x}As/GaAs$ heterostructures*. My scientific achievement before the Ph.D. title consists of 8 articles in scientific papers and 3 conference works. They have been included in my publication list. The results of my research were shown during poster session during 3 scientific conferences.

4.2 After obtaining the Ph.D. title

After obtaining the Ph.D. title in year 2000 I was employed at the Institute of Physics at Wrocław University of Science and Technology, initially as a scientific-didactic assistant. Then, since 2001 I have been employed as an assistant professor. After obtaining doctoral degree I have been developing my workshop, which I could verify directly thanks to experimental data obtained at LOSN. I have developed methods and programmes used to:

(1) calculating energies and wavefunctions of holes in AlGaAs-GaAs heterostructures in magnetic field set parallel to growth direction of a structure;
(2) calculating g-factor in quantum wells in different orientation of growth direction in a magnetic field parallel to growth direction;
(3) calculating exciton binding energy is single and double quantum wells;
(4) calculating energies and wavefunctions of electrons and holes in structures made direct band III-V semiconductors wih nitrogen;
(5) calculating energy structure of charge carriers in wetting layer.

Thanks to that it became possible to analyse properties of low-dimensional semiconductor structures:

- *heterostructures and quantum wells AlGaAs/GaAs – two-dimensional hole gas*

In AlGaAs/GaAs structures it is possible to achieve highest mobilities of both electrons and holes which indicates their high quality. Holes confined in low-dimensional system show interesting properties, which comes from the fact, that effective spin of a hole is 3/2 (heavy and light holes) and – much stronger than in case of a conduction band – spin orbit interaction. Additionally, band structure of holes in the valence band is much more complicated than of electrons in the conduction band. The valence band structure is described by quite sophisticated mathematically model (Luttinger model), which excludes analytical solutions and leads many researchers to oversimplify the calculations. One the more important results of my research was identifying in photoluminescene lines the H line as a result of recombination of light excited electron with two-dimensional holes existing near a junction[1]. The analysis of optical transitions of H band, split in a magnetic field parallel to a vector of electromagnetic wave propagation (Faraday configuration), allowed to reveal energetic structure of states in the valence band. The relative intensity of optical transitions has been explained according with selection rules, which have been derived for interband transitions in a magnetic field for both circular polarisations. The important result[2] of research on this type of structures was showing, that generally ignored in calculation subband anisotropy, impacting the Luttinger hamiltonian in magnetic field, has an important impact on optical properties of hole both qualitatively and quantitatively. It has been shown[3], that the spin split-off, of the top hole subband in all examined growth directions i.e. [001], [110] and [113] depend on value ant direction of the wavevector and is strongly anisotropic as related to relative orientation of wavevector and the induction of magnetic field, and a simple scientific tool for observing the change of spin orientation of carriers have been

[1] M. Kubisa, L. Bryja, K. Ryczko, J. Misiewicz, C. Bardot, M. Potemski, G. Ortner, M. Bayer, A. Forchel, C. Sorensen, Physical Review B 67, 035305 (2003).
[2] K. Ryczko, M. Kubisa, L. Bryja, J. Misiewicz, R. Stępniewski, M. Byszewski, M. Potemski, Physica B: Condensed Matter 346, 451 (2004).
[3] M. Kubisa, K. Ryczko, J. Misiewicz, Physical Review B 83, 195324 (2011).

shown. The another result of my theoretical research was showing an explanation of nonlinear spin split-off as a function of magnetic field[4] for unilaterally p-doped quantum wells, which results from mixing of states in the valence band. Moreover, it has been shown, that in strong magnetic fields, properties of heavy-hole excitons are described by excited landau states, which have light-hole character. The result of this work was 20 articles. During the research I have collaborated with many known scientific centres, such as Experimentelle Physik 2 Technische Universität Dortmund in Germany, Ioffe Physical-Technical Institute, Russian Academy of Sciences in Russia, Cavendish Laboratory, University of Cambridge in Great Britain, Laboratoire National des Champs Magnétiques Intenses, Grenoble in France, Instytut Fizyki PAN w Warszawie in Poland, Technische Physik, Universität Würzburg in Germany, The Niels Bohr Institute, University of Copenhagen in Denmark.

- *other heterostructures and quantum wells*

Main results in this are: (1) showing that adding a little amount of nitrogen (up to 5%) significantly changes the binding energy of the heavy-hole fundamental excitonic state in GaAs-InGaAsN-GaAs quantum well[5]; (2) determining the values of discontinuities of conduction band in this structure in the GaNAsSb-GaAs material system[6] (3) determining the discontinuities of the conduction band in this structure in the GaInAsSb-AlGaAsSb material system[7]. The research was conducted with institutions such as Solid State and Photonics Laboratory, Stanford University from the USA, Université Montpellier 2-CNRS from France. The effect of this work was 38 publications.

- *quantum dots*

The research regarding quantum dots aimed at: (1) examining tunneling of carriers between the quantum wells and quantum dots[8]; (2) analysis of the influence of realistic potential confining carriers in the wetting layers on the value of energy of the fundamental optical transition[9]; (3) analysis of energy structure of a system of coupled quantum dots[10]. It is worth mentioning, that this research was conducted with institutions such as: CNR-Institute of Photonics and Nanotechnology, Roma in Italy, Ecole Polytechnique Fédérale de Lausanne, Institute of Quantum Electronics and Photonics, Lausanne in Switzerland. There is 13 publications covering this topic.

[4] J. Jadczak, M. Kubisa, K. Ryczko, L. Bryja, M. Potemski, Physical Review B 86, 245401 (2012).
[5] K. Ryczko, G. Sęk, J. Misiewicz, Solid State Communications 122, 323 (2002).
[6] R. Kudrawiec, K. Ryczko, J. Misiewicz, H. Yuen, S. Bank, M. Wistey, H. Bae, J. Harris, Applied Physics Letters 86, 141908 (2005).
[7] M. Motyka, G. Sęk, K. Ryczko, J. Misiewicz, S. Belahsene, G. Boissier, Y. Rouillard, Journal of Applied Physics 106, 066104 (2009).
[8] W. Rudno-Rudziński, K. Ryczko, G. Sęk, J. Misiewicz, E. Semenova, A. Lemaitre, A. Ramdane, Semiconductor Science and Technology 26, 085004 (2011).
[9] G. Sęk, K. Ryczko, M. Motyka, J. Andrzejewski, K. Wysocka, J. Misiewicz, L. Li, A. Fiore, G. Patriarche, Journal of Applied Physics 101, 063539 (2007).
[10] G. Sęk, K. Ryczko, J. Misiewicz, M. Bayer, F. Klopf, J. Reithmaier, A. Forchel, Solid State Communications 117, 401 (2001).

5. SCIENTIFIC ACTIVITY

5.1 List of publications from the JCR database

5.1.1 After obtaining the PhD

Ministry of Science points (as of 2016)	Impact Factor	Authors of the publication, title of the publication, name of journal, vol., no.(page), year, description of input into work	Percent input to work
		2016	
20	1,29	M. Dyksik, M. Motyka, M. Kurka, **K. Ryczko**, M. Dallner, S. Höfling, M. Kamp, G. Sęk, J. Misiewicz, *Photoluminescence quenching mechanisms in type II InAs/GaInSb QWs on InAs substrates,* **Optical and Quantum Electronics** 48, 401 (2016). *Contribution to work: theoretical modelling and numerical calculations.*	25%
35	3,736	L. Bryja, J. Jadczak, **K. Ryczko**, M. Kubisa, J. Misiewicz, A. Wójs, F. Liu, D. R. Yakovlev, M. Bayer, C. A. Nicoll, I. Farrer, D. A. Ritchie, *Thermal dissociation of free and acceptor-bound positive trions from magnetophotoluminescence studies of high quality GaAs/Al$_x$Ga$_{1-x}$As quantum wells*, **Physical Review B** 93, 165303 (2016). *Contribution to work: preparing theoretical model and performing calculations.*	15%
40	3,142	M. Motyka, M. Dyksik, **K. Ryczko**, R. Weih, M. Dallner, S. Höfling, M. Kamp, G. Sęk, J. Misiewicz, *Type-II quantum wells with tensile-strained GaAsSb layers for interband cascade lasers with tailored valence band mixing*, **Applied Physics Letters** 108, 101905 (2016). *Contribution to work: theoretical modelling and numerical calculations, discussion and interpretation of the results.*	25%
15	0,525	M. Syperek, **K. Ryczko**, M. Dallner, M. Dyksik, M. Motyka, M. Kamp, S. Höfling, J. Misiewicz, G. Sęk, *Room Temperature Carrier Kinetics in the W-type GaInAsSb/InAs/AlSb Quantum Well Structure Emitting in Mid-Infrared Spectral Range*, **Acta Physica Polonica A** 130, 1224 (2016). *Contribution to work: performing calculations and discussion of the results.*	15%
		2015	
35	3,736	M. Kubisa, **K. Ryczko**, I. Bisotto, C. Chaubet, A. Raymond, W. Zawadzki, *Conduction electrons localized by charged magnetoacceptors A^{2-} in GaAs/GaAlAs quantum wells*, **Physical Review B** 92, 035409 (2015). *Contribution to work: performing calculations.*	20%
20	1,29	F. Janiak, M. Dyksik, M. Motyka, **K. Ryczko**, J. Misiewicz, K. Kosiel, and M. Bugajski, *Advanced optical characterization of AlGaAs/GaAs superlattices for active regions in quantum cascade lasers*, **Optical and Quantum Electronics** 47, 945 (2015). *Contribution to work: performing calculations and discussion of the results.*	15%
30	2,584	M. Motyka, G. Sęk, **K. Ryczko**, M. Dyksik, R. Weih, G. Patriarche, J. Misiewicz, M. Kamp, S. Höfling, *Interface Intermixing in Type II InAs/GaInAsSb Quantum Wells Designed for Active Regions of Mid-Infrared-Emitting Interband Cascade Lasers*, **Nanoscale Research Letters** 10:471 (2015).	15%

		Contribution to work: performing calculations and interpretation of the results.	
25	2,117	**K. Ryczko**, T. Liszka, *Tailoring the effect of electric field in type II W-design InAs/GaInSb quantum well structures for emission up to 12 μm,* **Superlattices and Microstructures** 78, 144 (2015). *Contribution to work: proposing a construction of an active area for interband cascade lasers, writing appropriate software, performing calculations, analysis and discussion of the results and writing the manuscript.*	85%
2014			
40	3,302	J. Jadczak, L. Bryja, **K. Ryczko**, M. Kubisa, A. Wójs, M. Potemski, F. Liu, D. Yakovlev, M. Bayer, C. Nicoll, I. Farrer, D. Ritchie, *High magnetic field studies of charged exciton localization in GaAs/Al$_x$Ga$_{1-x}$As quantum wells*, **Applied Physics Letters** 105, 112104 (2014). *Contribution to work: planning and performing calculations and discussion of the results.*	18%
15	0,53	**K.Ryczko**, *Crystal orientation dependence of the fundamental optical transition in type-II W-design quantum well structures*, **Acta Physica Polonica A** 126, 1149 (2014). *Contribution to work: proposing a new approach to constructing an active area for interband cascade laser planning appropriate calculations, analysis and interpretation of the results and writing a manuscript..*	100%
2013			
30	2,185	F. Janiak, M. Motyka, G. Sęk, M. Dyksik, **K. Ryczko**, J. Misiewicz, R. Weih, S. Höfling, M. Kamp, G. Patriarche, *Effect of arsenic on the optical properties of GaSb-based type II quantum wells with quaternary GaInAsSb layers*, **Journal of Applied Physics** 114, 223510 (2013). *Contribution to work: theoretical modelling, analysis of the outcome and discussion of the results, analiza wyników i dyskusja rezultatów.*	12%
15	0,604	**K. Ryczko**, G. Sęk, J. Misiewicz, *Lateral Coupling within the Ensemble of InAs/InGaAlAs/InP Quantum Dashes*, **Acta Physica Polonica A** 124, 805 (2013). *Contribution to work: proposition of a model, performing calculations, discussion of the results and partial preparing of the manuscript.*	75%
15	0,604	M. Pieczarka, P. Podemski, A. Musiał, **K. Ryczko**, G. Sęk, J. Misiewicz, F. Langer, S. Höfling, M. Kamp, A. Forchel, *GaAs-Based Quantum Well Exciton-Polaritons beyond 1 μm*, **Acta Physica Polonica A** 124, 817 (2013). *Contribution to work: theoretical modelling and analysis of the results.*	8%
15	0,643	A. Mika, G. Sęk, **K. Ryczko**, M. Kozub, A. Musiał, A. Maryński, J. Misiewicz, F. Langer, S. Höfling, T. Appel, M. Kamp, A. Forchel, *Oscillator strength of optical transitions in InGaAsN/GaAsN/GaAs quantum wells*, **Optica Applicata** 43, 53 (2013). *Contribution to work: performing calculations.*	22%
2012			
35	3,767	J. Jadczak, M. Kubisa, **K. Ryczko**, L. Bryja, M. Potemski, *High magnetic field spin splitting of excitons in asymmetric GaAs quantum wells*, **Physical Review B** 86, 245401 (2012). *Contribution to work: opracowanie podstaw teoretycznych analizowanego modelu, wykonanie obliczeń, analiza rezultatów, opracowaniu wniosków końcowych pracy.*	24%
40	3,794	F. Janiak, G. Sęk, M. Motyka, **K. Ryczko**, J. Misiewicz, A. Bauer, S. Höfling, M. Kamp, A. Forchel, *Increasing the optical transition oscillator strength in GaSb-based type II quantum wells*, **Applied Physics Letters** 100, 231908 (2012).	18%

		Contribution to work: theoretical modelling, discussion of the results.	
		2011	
35	3,691	M. Kubisa, **K. Ryczko**, J. Misiewicz, *Nonlinear Zeeman Splitting of Holes in Doped GaAs Heterostructures*, **Physical Review B** 83, 195324 (2011) *Contribution to work: working on theoretical basis of analysed model performing calculations, and analysis of the results.*	40%
15	0,444	P. Sitarek, **K. Ryczko**, J. Misiewicz, D. Reuter, A. Wieck, *Optical Transitions between Confined and Unconfined States in p-Type Asymmetric GaAs/InGaAs/AlGaAs QW Structures,* **Acta Physica Polonica A** 120, 849 (2011) *Contribution to work: performing calculations and discussion of the results.*	20%
30	2,023	G. Sęk, F. Janiak, M. Motyka, **K. Ryczko**, J. Misiewicz, A. Bauer, S. Höfling, A. Forchel, *Carrier loss mechanisms in type II quantum wells for the active region of GaSb-based mid-infrared interband cascade lasers*, **Optical Materials** 33, 1817 (2011) *Contribution to work: performing calculations.*	15%
20	0,966	M. Motyka, F. Janiak, **K. Ryczko**, G. Sęk, J. Misiewicz, A. Bauer, R. Weih, S. Höfling, M. Kamp, A. Forchel, *Above GaSb barrier in type II quantum well structures for mid-infrared emission detected by Fourier-transformed modulated reflectivity*, **Opto-electronics Review** 19, 137 (2011) *Contribution to work: performing calculations.*	15%
15	0,444	M. Kubisa, **K. Ryczko**, J. Jadczak, L. Bryja, J. Misiewicz, M. Potemski, *Nonlinear Zeeman Splitting of Holes in Doped GaAs Heterostructures*, **Acta Physica Polonica A** 119, 609 (2011) *Contribution to work: performing calculations and interpretation of the results.*	20%
20	1,058	**K. Ryczko**, G. Sek, M. Motyka, F. Janiak, M. Kubisa, J. Misiewicz, S. Belahsene, G. Boissier, Y. Rouillard, *Effect of Annealing-Induced Interdiffusion on the Electronic Structure of Mid Infrared Emitting GaInAsSb/AlGaInAsSb Quantum Wells*, **Japanese Journal of Applied Physics** 50, 031202 (2011) *Contribution to work: proposition of theoretical model, performinf calculations, discussion of the results and participation in a redaction of manuscript.*	30%
30	1,723	W. Rudno-Rudziński, **K. Ryczko**, G. Sęk, J. Misiewicz, E. Semenova, A. Lemaitre, A. Ramdane, *Carrier wavefunction control in a dilute nitride-based quantum well-a quantum dot tunnel injection system for 1.3 μm emission*, **Semiconductor Science and Technology** 26, 085004 (2011) *Contribution to work: theoretical modelling, performing of the calculations, discussion of the results.*	20%
		2010	
20	1,018	G. Sęk, M. Motyka, **K. Ryczko**, F. Janiak, J. Misiewicz, S. Belahsene, G. Boissier, Y. Rouillard, *Band offsets and photoluminescence thermal quenching in mid-infrared emitting GaInAsSb quantum wells with quinary AlGaInAsSb barriers*, **Japanese Journal of Applied Physics** 49, 031202 (2010). *Contribution to work: performing calculations and discussion of the results.*	
		2009	
30	2,072	M. Motyka, G. Sęk, **K. Ryczko**, J. Misiewicz, S. Belahsene, G. Boissier, Y. Rouillard, *Optical transitions and band gap discontinuities of GaInAsSb/AlGaAsSb quantum wells emitting in the 3 μm range determined by modulation spectroscopy*, **Journal of Applied Physics** 106, 066104 (2009).	35%

		Contribution to work: selection of an appropriate model of calculations, writing appropriate software, performing calculations, discussion of the results, developing final conclusions, participation in manuscript preparation.	
30	1,253	G. Sęk, J. Andrzejewski, **K. Ryczko**, P. Poloczek, J. Misiewicz, E. Semenova, A. Lemaitre, G. Patriarche, A. Ramdane, *Electronic structure properties of the In(Ga)As/GaAs quantum dot-quantum well tunnel-injection system*, **Semiconductor Science and Technology** 24, 085011 (2009) *Contribution to work: performing calculations oraz analysis of the results.*	15%
40	3,554	M. Motyka, G. Sęk, **K. Ryczko**, J. Misiewicz, T. Lehnhardt, S. Höfling, A. Forchel, *Optical properties of GaSb-based type II quantum wells as the active region of midinfrared interband cascade lasers for gas sensing applications*, **Applied Physics Letters** 95, 251901 (2009) *Contribution to work: proposing of a model performing calculations, discussion of the results.*	20%
15	0,358	W. Rudno-Rudziński, **K. Ryczko**, G. Sęk, M. Syperek, J. Misiewicz, E.-M. Pavelescu, C. Gilfert, J. Reithmaier, *Optical methods used to optimise semiconductor laser structures with tunnel injection from quantum well to InGaAs/GaAs quantum dots*, **Optica Applicata** 39, 923 (2009) *Contribution to work: performing calculations, discussion of the results.*	20%
40	3,554	A. Bauer, F. Langer, M. Dallner, M. Kamp, M. Motyka, G. Sęk, **K. Ryczko**, J. Misiewicz, S. Höfling, A. Forchel, *Emission wavelength tuning of interband cascade lasers in the 3-4 μm spectral range*, **Applied Physics Letters** 95, 251103 (2009) *Contribution to work: performing calculations.*	10%
15	0,358	M. Motyka, G. Sęk, F. Janiak, **K. Ryczko**, J. Misiewicz, K. Kosiel, M. Bugajski, *Photoreflectance study of $Al_{0.45}Ga_{0.55}As$/GaAs superlattice: optical transitions at the miniband Γ and Π points*, **Optica Applicata** 39, 897 (2009) *Contribution to work: performing calculations.*	15%
40	3,554	W. Rudno-Rudziński, G. Sęk, **K. Ryczko**, M. Syperek, J. Misiewicz, E. Semenova, A. Lemaitre, A. Ramdane, *Room temperature free carrier tunneling in dilute nitride based quantum well - quantum dot tunnel injection system for 1.3 μm*, **Applied Physics Letters** 94, 171906 (2009) *Contribution to work: proposing of a model, performing calculations, discussion of the results.*	15%
25	1,228	W. Rudno-Rudziński, G. Sęk, **K. Ryczko**, M. Syperek, J. Misiewicz, E. Semenova, A. Lemaitre, A. Ramdane, *Optical properties and energy transfer in InGaAsN quantum well - InAs quantum dots tunnel injection structures for 1.3 μm emission*, **Physica Status Solidi (A)** 206, 826 (2009) *Contribution to work: proposing of a model, performing calculations, discussion of the results.*	15%
2008			
40	3,726	P. Podemski, G. Sęk, **K. Ryczko**, J. Misiewicz, S. Hein, S. Höfling, A. Forchel, G. Patriarche, *Columnar quantum dashes for an active region in polarization independent semiconductor optical amplifiers at 1.55 μm*, **Applied Physics Letters** 93, 171910 (2008) *Contribution to work: wykonanie obliczeń oraz analiza rezultatów.*	12%
2007			
35	3,172	W. Zawadzki, S. Bonifacie, S. Juillaguet, C. Chaubet, A. Raymond, Y. Meziani, M. Kubisa, **K. Ryczko**, *Nonlinear dependence of the magnetophotoluminescence energies of asymmetric $GaAs/Ga_{0.67}Al_{0.33}As$ quantum wells on an external magnetic field*, **Physical Review B** 75, 245319 (2007)	10%

		Contribution to work: performing calculations.	
40	3,596	M. Motyka, G. Sęk, **K. Ryczko**, J. Andrzejewski, J. Misiewicz, L. Li, A. Fiore, G. Patriarche, *Optical and electronic properties of GaAs-based structures with columnar quantum dots*, **Applied Physics Letters** 90, 181933 (2007) *Contribution to work: performing calculations.*	15%
15	0,647	L. Bryja, A. Wójs, **K. Ryczko**, K. Wójcik, J. Misiewicz, M. Potemski, D. Reuter, A. Wieck, *Anderson-Fano transitions in photoluminescence of a two dimensional electron gas*, **International Journal of Modern Physics B** 21, 1429 (2007) *Contribution to work: theoretical modelling, performing calculations, discussion of the results.*	15%
30	2,171	G. Sęk, **K. Ryczko**, M. Motyka, J. Andrzejewski, K. Wysocka, J. Misiewicz, L. Li, A. Fiore, G. Patriarche, *Wetting layer states of InAs/GaAs self-assembled quantum dot structures: Effect of intermixing and capping layer*, **Journal of Applied Physics** 101, 063539 (2007) *Contribution to work: theoretical modelling, performing calculations, discussion of the results.*	20%
2006			
30	2,316	G. Sęk, P. Poloczek, **K. Ryczko**, J. Misiewicz, A. Löfter, J. Reithmaier, A. Forchel, *Photoreflectance determination of the wetting layer thickness in the $In_xGa_{1-x}As/GaAs$ quantum dot system for a broad indium content range of 0.3-1*, **Journal of Applied Physics** 100, 103529 (2006) *Contribution to work: performing calculations, discussion of the results.*	15%
15	0,371	L. Bryja, **K. Ryczko**, A. Wójs, J. Misiewicz, M. Potemski, *Skyrmions in a hole gas with large spin gap and strong disorder*, **Acta Physica Polonica A** 110, 163 (2006) *Contribution to work: theoretical modelling, performing calculations, discussion of the results.*	20%
2005			
25	1,489	W. Rudno-Rudziński, **K. Ryczko**, G. Sęk, J. Misiewicz, M. Da Silva, and A. Quivy, *Photoreflectance study of energy level structure of self-assembled InAs/GaAs quantum dots emitting at 1.3 μm*, **Solid State Communications** 135, 232 (2005) *Contribution to work: proposal of a model, performing calculations, discussion of the results.*	25%
30	2,498	R. Kudrawiec, H. Yuen, **K. Ryczko**, J. Misiewicz, S. Bank, M. Wistey, H. Bae, J. Harris, *Photoreflectance and photoluminescence investigations of a step-like GaInNAsSb/GaAsN/GaAs quantum well tailored at 1.5 μm: The energy level structure and the Stokes shift*, **Journal of Applied Physics** 97, 053515 (2005) *Contribution to work: theoretical modelling, performing calculations, discussion of the results.*	15%
40	4,127	R. Kudrawiec, **K. Ryczko**, J. Misiewicz, H. Yuen, S. Bank, M. Wistey, H. Bae, J. Harris, *Band-gap discontinuity in $GaN_{0.02}As_{0.87}Sb_{0.11}/GaAs$ single-quantum wells investigated by photoreflectance spectroscopy*, **Applied Physics Letters** 86, 141908 (2005) *Contribution to work: theoretical modelling, performing calculations, discussion of the results.*	20%
25	0,702	**K. Ryczko**, G. Sęk, J. Misiewicz, *The influence of interdiffusion on the binding energy of excitons in $In_xGa_{1-x}N_yAs_{1-y}/GaAs$ quantum wells*, **Superlattices and Microstructures** 37, 273 (2005) *Contribution to work: theoretical modelling, performing calculations, discussion of the results, developing final conclusions, participation in writing the manuscript.*	60%
2004			

30	2,049	J. Misiewicz, R. Kudrawiec, **K. Ryczko**, G. Sęk, A. Forchel, J. Harmand, M. Hammar, *Photoreflectance investigations of the energy level structure in GaInNAs-based quantum wells*, **Journal of Physics Condensed Matter** 16, 31 (2004) *Contribution to work: theoretical modelling, performing calculations, discussion of the results.*	20%
40	4,308	R. Kudrawiec, G. Sęk, **K. Ryczko**, J. Misiewicz, J. Harmand, *Photoreflectance investigations of oscillator strength and broadening of optical transitions for GaAsSb-GaInAs/GaAs bilayer quantum wells*, **Applied Physics Letters** 84, 3453 (2004) *Contribution to work:theoretical modelling, performing calculations, discussion of the results, developing final conclusions of the work.*	20%
20	0,679	**K. Ryczko**, M. Kubisa, L. Bryja, J. Misiewicz, R. Stępniewski, M. Byszewski, M. Potemski, *Hole subbands and Landau levels in p-type single $Al_xGa_{1-x}As/GaAs$ heterostructures*, **Physica B: Condensed Matter** 346, 451 (2004) *Contribution to work: selecting appropriate theoretical model, writng appropriate software, performinf calculations, discussion of the results, developing final conclusions and participation in preparing the manuscript.*	60%
20	0,679	L. Bryja, M. Kubisa, **K. Ryczko**, J. Misiewicz, R. Stępniewski, M. Byszewski, M. Potemski, D. Reuter, A. Wieck, *Magnetic-field-induced excitons in photoluminescence from heavily doped p-type $Ga_{1-x}Al_xAs/GaAs$ single heterojunction*, **Physica B: Condensed Matter** 346, 442 (2004) *Contribution to work: performing calculation, discussion of the results.*	15%
30	1,647	R. Kudrawiec, G. Sęk, P. Sitarek, **K. Ryczko**, J. Misiewicz, T. Wang, A. Forchel, *Three beam photoreflectance as a powerful method to investigate semiconductor heterostructures*, **Thin Solid Films** 450, 71 (2004) *Contribution to work: performing calculations.*	10%
2003			
30	1,117	J. Misiewicz, G. Sęk, **K. Ryczko**, *Photoreflectance spectroscopy of quantum dots*, **Current Applied Physics** 3, 417 (2003) *Contribution to work: performing calculations.*	10%
30	1,715	R. Kudrawiec, G. Sek, **K. Ryczko**, J. Misiewicz, A. Forchel, *Infrared photoreflectance spectroscopy of AlGaAsSb-, InGaSb-based quantum wells*, **Materials Science and Engineering B: Solid-State Materials for Advanced Technology** 102, 331 (2003) *Contribution to work: performing calculations.*	15%
25	1,602	R. Kudrawiec, G. Sęk, **K. Ryczko**, J. Misiewicz, P. Sundgren, C. Asplund, M. Hammar, *The nature of optical transitions in $Ga_{0.64}In_{0.36}As_{1-x}N_x/GaAs$ single quantum wells with low nitrogen content ($x <= 0.008$)*, **Solid State Communications** 127, 613 (2003) *Contribution to work: theoretical modelling, performing calculations, discussion of the reuslts.*	10%
30	2,171	J. Derluyn, I. Moerman, M. Leys, G. Patriarche, G. Sęk, R. Kudrawiec, W. Rudno-Rudziński, **K. Ryczko**, J. Misiewicz, *Control of nitrogen incorporation in Ga(In)NAs grown by metalorganic vapor phase epitaxy*, **Journal of Applied Physics** 94, 2752 (2003) *Contribution to work: performing calculations and discussing the results.*	10%
20	0,652	R. Kudrawiec, L. Bryja, G. Sęk, **K. Ryczko**, J. Misiewicz, A. Forchel, *Optical properties of an $In_{0.22}Ga_{0.78}Sb/GaSb$ single quantum well*, **Crystal Research and Technology** 38, 399 (2003) *Contribution to work: performing calculations.*	10%
20	0,565	J. Misiewicz, G. Sęk, R. Kudrawiec, **K. Ryczko**, D. Gollub, J. Reithmaier, A. Forchel, *Photomodulation spectroscopy applied to low-dimensional semiconductor structures*, **Microelectronics Journal** 34, 351 (2003) *Contribution to work: performing calculations and discussing the results.*	15%

20	0,565	J. Misiewicz, P. Sitarek, **K. Ryczko**, R. Kudrawiec, M. Fischer, M. Reinhardt, A. Forchel, *Influence of nitrogen on carrier localization in InGaAsN/GaAs single quantum wells*, **Microelectronics Journal** 34, 737 (2003) *Contribution to work: performing calculations and discussing the results.*	20%
25	0,930	R. Kudrawiec, G. Sęk, **K. Ryczko**, W. Rudno-Rudziński, J. Misiewicz, J. Wójcik, B. Robinson, D. Thompson, P. Mascher, *Photoreflectance study of the interdiffusion effects in the InGaAsP-based quantum well laser structures*, **Physica E: Low-Dimensional Systems and Nanostructures** 17, 602 (2003) *Contribution to work: proposing a model, performing calculaions, discussion of the results.*	20%
25	0,930	L. Bryja, **K. Ryczko**, M. Kubisa, J. Misiewicz, G. Ortner, A. Kress, M. Bayer, A. Forchel, C. Sorensen, *Magneto-optical studies of 2D hole Landau levels and screening of donor states in p-type modulation doped $Ga_{0.5}Al_{0.5}As/GaAs$ interfaces*, **Physica E: Low-Dimensional Systems and Nanostructures** 17, 260 (2003) *Contribution to work: theoretical modelling, performing calculations, discussion of the results.*	30%
25	1,008	P. Sitarek, K. Ryczko, G. Sęk, J. Misiewicz, M. Fischer, M. Reinhardt, A. Forchel, *Optical investigations of InGaAsN/GaAs single quantum well structures*, **Solid-State Electronics** 47, 489 (2003) *Contribution to work: theoretical modelling, performing calculations, discussion of the results.*	25%
35	2,962	M. Kubisa, L. Bryja, **K. Ryczko**, J. Misiewicz, C. Bardot, M. Potemski, G. Ortner, M. Bayer, A. Forchel, C. Sorensen, *Photoluminescence investigations of two-dimensional hole Landau levels in p-type single $Al_xGa_{1-x}As/GaAs$ heterostructures*, **Physical Review B** 67, 035305 (2003) *Contribution to work: wykonanie obliczeń, dyskusja wyników.*	25%
2002			
25	0,876	**K. Ryczko**, G. Sęk, J. Misiewicz, *Exciton binding energy in a double quantum well: effect of the barrier shift*, **Superlattices and Microstructures** 32, 73 (2002) *Contribution to work: theoretical modelling, performing calculations, discussion of the results, developing final conclusions, participation in writing the manuscript.*	70%
25	0,876	R. Kudrawiec, G. Sęk, **K. Ryczko**, J. Misiewicz, A. Forchel, *Infrared photomodulation spectroscopy of an $In_{0.22}Ga_{0.78}Sb/GaSb$ single quantum well*, **Superlattices and Microstructures** 32, 19 (2002) *Contribution to work: performing calculations, discussion of the results.*	20%
25	1,671	K. Ryczko, G. Sęk, J. Misiewicz, *Effect of nitrogen on the exciton binding energy in $Ga_xIn_{1-x}N_yAs_{1-y}/GaAs$ quantum well*, **Solid State Communications** 122, 323 (2002) *Contribution to work: theoretical modelling, performing calculations, discussion of the results, developing final conclusions, participation in writing the manuscript.*	70%
25	2,180	M. Utko, G. Sęk, **K. Ryczko**, L. Bryja, J. Misiewicz, M. Bayer, J. Koeth, and A. Forchel, *Optical investigations of the above barrier state transitions in $GaAs/Al_{0.3}Ga_{0.7}As$ double quantum wells*, **Materials Science and Engineering C** 19, 167 (2002) *Contribution to work: performing calculations.*	15%
25	1,671	L. Bryja, M. Kubisa, **K. Ryczko**, J. Misiewicz, A. Larionov, M. Bayer, A. Forchel, C. Sorensen, *Impurity-related emission in the photoluminescence from p-type modulation doped $Al_{1-x}Ga_xAs/GaAs$ heterostructures*, **Solid State Communications** 122, 379 (2002) *Contribution to work: performing calculations, discussion of the results.*	15%
2001			

15	0,475	G. Sęk, **K. Ryczko**, J. Misiewicz, M. Bayer, T. Wang, A. Forchel, *Influence of built-in electric field on forbidden transitions in $In_xGa_{1-x}As/GaAs$ double quantum well by three-beam photoreflectance*, **Acta Physica Polonica A** 100, 417 (2001) *Contribution to work: theoretical modelling, performing calculations, discussion of the results*.	20%
30	1,266	G. Sęk, **K. Ryczko**, J. Misiewicz, M. Fischer, M. Reinhardt, A. Forchel, *Photoreflectance spectroscopy of InGaAsN/GaAs quantum wells grown by MBE*, **Thin Solid Films** 392, 150 (2001) *Contribution to work: theoretical modelling, performing calculations, discussion of the results, participation in preparing the manuscript*.	30%
25	1,381	G. Sęk, **K. Ryczko**, J. Misiewicz, M. Bayer, F. Klopf, J. Reithmaier, A. Forchel, *Photoreflectance spectroscopy of vertically coupled InGaAs/GaAs double quantum dots*, **Solid State Communications** 117, 401 (2001) *Contribution to work: theoretical modelling, performing calculations, discussion of the results*.	30%

5.1.2 Before obtaining the PhD

Ministry of Science points (as of 2016)	Impact Factor	Authors of the publication, title of the publication, name of journal, vol., no.(page), year, description of input into work	Percent input to work
		2000	
30	1,160	G. Sęk, **K. Ryczko**, J. Misiewicz, M. Fischer, M. Reinhardt, A. Forchel, *Photoreflectance spectroscopy of InGaAsN/GaAs quantum wells grown by MB*, **Thin Solid Films** 380, 240 (2000) *Contribution to work: theoretical modelling, performing calculations, discussion of the results*.	30%
30	1,160	L. Bryja, O. Stern, M. Kubisa, **K. Ryczko**, M. Bayer, J. Misiewicz, A. Forchel, O. Hansen, *Excited states of two-dimensional hole gas at the $Al_{0.5}Ga_{0.5}As/GaAs$ interface*, **Thin Solid Films** 380, 142 (2000) *Contribution to work: performing calculations, discussion of the results.*	12%
25	0,544	M. Ciorga, M. Kubisa, **K. Ryczko**, L. Bryja, J. Misiewicz, O. Hansen, *Observation of excitons formed by the holes confined at the $Al_{0.5}Ga_{0.5}As/GaAs$ interface*, **Microelectronic Engineering** 51, 235 (2000) *Contribution to work: performing calculations, analysis of the results.*	15%
		1999	
20	1,611	G. Sęk, **K. Ryczko**, M. Kubisa, J. Misiewicz, J. Koeth, A. Forchel, *Photoreflectance study of coupling effects in double quantum wells*, **Opto-electronics Review** 7, 117 (1999) *Contribution to work: theoretical modelling, performing calculations, discussion of the results*.	35%
15	0,351	W. Salejda, M. Tyc, J. Andrzejewski, M. Kubisa, J. Misiewicz, M. Just, **K. Ryczko**, *New numerical matrix methods of solving the quasi-one-dimensional effective-mass equation*, **Acta Physica Polonica A** 95, 881 (1999) *Contribution to work: performing calculations.*	10%

25	1,428	G. Sęk, J. Misiewicz, **K. Ryczko**, M. Kubisa, F. Heinrichsdorff, O. Stier, D. Bimberg, *Room temperature photoreflectance of MOCVD-grown InAs GaAs quantum dots*, **Solid State Communications** 110, 657 (1999) Contribution to work: performing calculations.	15%
1998			
15	0,344	W. Salejda, M. Kubisa, J. Misiewicz, **K. Ryczko**, M. Tyc, *Landauer conductance of generalized Fibonacci-type semiconductor superlattices*, **Acta Physica Polonica A** 94, 514 (1998) Contribution to work: performing calculations.	20%

5.2 Scientific publications from outside of the JCR base

5.2.1 After obtaining the PhD

Authors of the publication, title of the publication, name of journal, vol., no.(page), year, description of input into work	Percent input to work
F. Janiak, M. Motyka, G. Sęk, **K. Ryczko**, M. Dyksik, J. Misiewicz, R. Weih, S. Höfling, M. Kamp, *Optical characterization of type II quantum wells for long-wavelength mid-infrared interband cascade lasers*, **Proceedings of SPIE - The International Society for Optical Engineering** 9134, 91340V (2014) Contribution to work: performing calculations, discussion of the results.	10%
G. Sęk, M. Motyka, F. Janiak, **K. Ryczko**, J. Misiewicz, A. Bauer, M. Dallner, R. Weih, S. Höfling, A. Forchel, S. Belahsene, G. Boissier, Y. Rouillard, *Recent advances in GaSb-based structures for mid-infrared emitting lasers: spectroscopic study*, **Proceedings of SPIE – The International Society for Optical Engineering** 8631, 86312O (2013) Contribution to work: performing calculations, discussion of the results.	10%
F. Janiak, M. Motyka, G. Sęk, **K. Ryczko**, J. Misiewicz, K. Kosiel, M. Bugajski, *Optyczne właściwości supersieci GaAs/AlGaAs badane za pomocą spektroskopii modulacyjnej*, **Elektronika** 10, 46 (2011) Contribution to work: performin calculations.	8%
A. Bauer, M. Dallner, M. Kamp, S. Höfling, L. Worschech, A. Forchel, L. Nähle, P. Fuchs, M. Fischer, J. Koeth, M. Motyka, G. Sęk, **K. Ryczko**, J. Misiewicz, *Interband Cascade Lasers for Wavelength Specific Applications in the 3-4 μm Spectral Range*, **Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference: 2010 Laser Science to Photonic Applications, CLEO/QELS 2010**, 5500589 (2010) Contribution to work: performing calculations and analysis of the results.	5%
A. Bauer, F. Langer, S. Höfling, A. Forchel, M. Motyka, G. Sęk, **K. Ryczko**, J. Misiewicz, *Emission Wavelength Tuning in Interband Cascade Laser Devices in the 3-4 μm Wavelength Range*, **Conference Proceedings - Lasers and Electro-Optics Society Annual Meeting-LEOS** 666 (2009) Contribution to work: performing calculations.	5%
L. Bryja, **K. Ryczko**, A. Wójs, J. Misiewicz, M. Potemski, *Quantum Hall skyrmions in a hole gas with large spin gap and strong disorder*, **AIP Conference Proceedings** 893, 671 (2007) Contribution to work: performing calculations and discussion of the results.	25%
G. Sęk, M. Motyka, **K. Ryczko**, J. Andrzejewski, R. Kudrawiec, J. Misiewicz, F. Lelarge, B. Rousseau, G. Patriarche, *Modulation spectroscopy characterization of InAs/GaInAsP/InP quantum dash laser structures*, **Proceedings of SPIE - The International Society for Optical Engineering** 6481, 64810D (2007) Udział w pracy: wykonanie obliczeń.	20%
H. Yuen, R. Kudrawiec, **K. Ryczko**, S. Bank, M. Wistey, H. Bae, J. Misiewicz, J. Harris Jr., *Investigation of GaNAsSb/GaAs and GaInNAsSb/GaNAs/GaAs band offsets*, **Materials Research Society Symposium Proceedings** 864, 105 (2005) Contribution to work: performing calculations.	15%
L. Bryja, M. Kubisa, **K. Ryczko**, J. Misiewicz, M. Kneip, M. Bayer, R. Stępniewski, M. Byszewski, M. Potemski, D. Reuter, A. Wieck, *Investigations of interface excitons at p-type GaAlAs/GaAs single*	20%

heterojunctions in continues wave and time resolved magneto photoluminescence experiments, **AIP Conference Proceedings** 772, 1158 (2005) *Contribution to work: performing calculations and discussion of the results.*	
G. Sęk, **K. Ryczko**, J. Misiewicz, M. Bayer, F. Klopf, J. Reithmaier, A. Forchel, *Coupled $In_{0.6}Ga_{0.4}As/GaAs$ quantum dots: a photoreflectance study*, **Proceedings of SPIE-The International Society for Optical Engineering** 4413, 139 (2001) *Contribution to work: performing calculations.*	15%
L. Bryja, **K. Ryczko**, M. Kubisa, J. Misiewicz, O. Stern, M. Bayer, A. Forchel, C. Sorensen, *Excitons at the p-type modulation doped $Al_{0.5}Ga_{0.5}As/GaAs$ interface*, **Proceedings of SPIE - The International Society for Optical Engineering** 4413, 16 (2001) *Contribution to work: performing calculations, discussion of the results.*	15%
G. Sęk, M. Nowaczyk, L. Bryja, **K. Ryczko**, J. Misiewicz, M. Bayer, F. Koeth, A. Forchel, *Magneto-photo reflectance of the above barrier state transitions in $GaAs/Al_{0.3}Ga_{0.7}As$ double quantum wells,* **Proceedings of the 25th International Conference on the Physics of Semiconductors PTS I and II** 87, 569 (2001) *Contribution to work: performing calculations, discussion of the results.*	10%

5.2.2 Before obtaining the PhD

Authors of the publication, title of the publication, name of journal, vol., no.(page), year, description of input into work	Percent input to work
G. Sęk, **K. Ryczko**, M. Ciorga, L. Bryja, M. Kubisa, J. Misiewicz, M. Bayer, J. Koeth, A. Forchel, *Optical investigation of coupled $GaAs/Al_{0.3}Ga_{0.7}As$ double quantum wells separated by AlAs barriers*, **Optical Properties of Semiconductor Nanostructures Book Series: Nato Science Series, Partnership Sub-Series 3: High Technology** 81, 91 (2000) *Contribution to work: performing calculations, discussion of the results.*	20%
M. Ciorga, **K. Ryczko**, M. Kubisa, L. Bryja, J. Misiewicz, O. Hansen, *Excitons in the two-dimensional hole gas at the $Al_{0.5}Ga_{0.5}As/GaAs$ interface,* **Optical Properties of Semiconductor Nanostructures Book Series: Nato Science Series, Partnership Sub-Series 3: High Technology** 81, 173 (2000) *Contribution to work: performing calculations.*	35%
G. Sęk, **K. Ryczko**, M. Kubisa, J. Misiewicz, J. Koeth, A. Forchel, *Photoreflectance study of coupling effects in double quantum wells*, **Proceedings of SPIE - The International Society for Optical Engineering** 3725, 201 (1999) *Contribution to work: performing calculations and analysis of the results.*	35%

5.3 Participation in research projects

Title of the project, period of employment, number of the project	Character of works
UE Project Horizon 2020 „***iCspec – In-line Cascade Laser Spectrometer for Process Control***", 01.04.2015 - 31.03.2018, H2020-SPIRE-2014	Principal investigator
NCN Research Project (Opus8) „***Zbadanie struktury energetycznej oraz dynamiki nośników ładunków półprzewodnikowych typu drugiego promieniowania z zakresu 3-10 mikrometrów***", 01.11.2015-30.09.2017, Nr NO0364: UMO-2014/15/B/ST7/04663	Investigator
7th FP UE „***WideLase – Monolithic Widely Tunable Interband Cascade Lasers for Safety and Security***", 01.09.2012-31.08.2015, Nr 318798	Principal investigator
DFG Project „***Emitery promieniowania podczerwonego wykorzystujęce efekt polarytonowy przeznaczone do zastosowań w telekomunikacji światłowodowej***", 01.11.2013-27.08.2014, 15.07.2014-27.08.2014, Nr 390154	Investigator

7th FP UE „***SensHy – Photonic sensing of hydrocarbons based on innovative mid infrared lasers”***, 01.03.2008-31.08.2011, Nr 223998	Principal investigator
Grant MNiSW „***Badania własności optycznych struktur tunelowych typu studnia – kropka kwantowa pod kątem zastosowań w laserach telekomunikacyjnych***”, 2010-2012, Nr N N515 518338	Investigator
6th FP UE „***ZODIAC – Zero order dimension based industrial components applied to telecommunications”***, 2005-2008, Nr FP6/017140	Investigator
Grant KBN „***Badania optyczne półprzewodnikowych kropek kwantowych przy użyciu metod modulacyjnych i technik wysokiej rozdzielczości przestrzennej***”, 2005-2007, Nr PB Nr 1 P03 B04829	Investigator
5th FP UE „***GIFT – GaAs-based emitters for fibre-optical data and telecommunications”***, 01.01.2000 - 30.04.2003, Nr IST-1999-12700	Investigator

5.4 Invited talks

- *Designing the active region in interband cascade lasers* – XVI Krajowa Konferencja Elektroniki, Darłówko Wschodnie, 2017.
- *Imporoved performance interband cascade lasers* – Seminarium Fizyki Politechniki Wrocławskiej, Wrocław, 2017.
- *On the way to imporoved performance interband cascade lasers: theoretical considerations* – XIII Seminarium Powierzchnia i Struktury Cienkowarstwowe SemPiSC, Szklarska Poręba, 2015.
- *On modified type II quantum well systems for improved performance interband cascade lasers,* 7 Krajowa Konferencja Nanotechnologii, Poznań, 2015.
- *Novel design of type-II „W” quantum wells for mid-IR emission with tensile – strained GaAsSb layer for confinement of hole,* The 3rd International workshop on opportunities and challenges in mid-infrared laser-based gas sensing (MIRSENS3), Würzburg, 2015.

5.5 Participation in conferences

- 46th International School and Conference on the Physics of Semiconductors “Jaszowiec 2017”, Szczyrk, Poland, June 17th-23th, 2017,
  Towards polarization-independent interband cascade lasers in the mid-infrared.
- 45th “Jaszowiec” International School and Conference on the Physics of Semiconductors, Szczyrk, Poland, June 18th-24th, 2016,
  D*esigning the active region of mode-locked interband cascade lasers.*
- 44th “Jaszowiec” International School and Conference on the Physics of Semiconductors, Wisła, Poland, June 20th-25th, 2015,
  Type-II “W” quantum wells for mid-IR emission with tensile – strained GaAsSb layer for confinement of hole.
- 43th “Jaszowiec” International School and Conference on the Physics of Semiconductors, Wisła, Poland, June 7th-12th, 2014,
  Crystal orientation dependence of the e1-hh1 fundamental transitionin type II W-design quantum well structures.

- 42th “Jaszowiec” International School and Conference on the Physics of Semiconductors, Wisła, Poland, June 22th-17th, 2013,
  GaSb-based W-shaped type II quantum wells for a broad range of mid infrared emission in interband cascade lasers,
  Lateral coupling within the ensemble of InAs/InGaAlAs/InP quantum dashes.
- 20th International Conference on Electronic Properties of Two-Dimensional Systems (EP2DS-20) and 16th International Conference on Modulated Semiconductor Structures(MSS-16), Wrocław, 1.07-5.07.2013,
  Engineering of type II quantum wells for a broad range of mid infrared emission in interband cascade lasers,
  On the importance of in plane coupling within the ensemble of InAs/InGaAlAs/InP quantum dashes.
- 39th “Jaszowiec” International School and Conference on the Physics of Semiconductors, Krynica Zdrój, Poland, June 19th-July 24th, 2010,
  Strong enhancement of hole g-factor in doped two dimensional GaAs structures.
- EMRS – Fall Meeting, Warszawa, Poland, September 17-21, 2007,
  The nature of carrier confinement in quantum dashes of different shapes cross-section.
- International Conference EP2DS-MSS, Genova, 15-20 July 2007,
  The nature of carrier confinement in InAs quantum dashes grown on InP of shapes like triangular cross-section.
- 28th International Conference on the Physics of Semiconductors - ICPS 2006 (Vienna, Austria, 24-28 July 2006),
  Quantum Hall skyrmions in a hole gas with large spin gap and strong disorder.
- Research in High Magnetic Fields, Tuluza (Francja, 2003),
  Hole subbands and Landau levels in p-type single $Al_xGa_{1-x}As/GaAs$ heterostructures.
- XXXII International School on the Physics of Semiconducting Compounds "Jaszowiec 2003" May 30 - June 6, 2003,
  Magnetic field induced excitons and positively charged excitons in photoluminescence from heavily modulation doped p-type $Ga_{1-x}Al_xAs/GaAs$ single heterojunction,
  Photoluminescence and photoreflectance of GaInAsN/GaAs quantum wells with step-like barriers.
- XXXI International School on the Physics of Semiconducting Compounds "Jaszowiec 2002" June 7-14, 2002,
  Observation of 2D Hole Landau Level Dispersion and Screened Magnetodonor States in the Photoluminescence from p-Type Modulation Doped GaAlAs/GaAs Interfaces.
- XXX International School on the Physics of Semiconducting Compounds "Jaszowiec 2001" June 1-8, 2000,
  Investigations of the Above Barrier State Transitions in $GaAs/Al_{0.3}Ga_{0.7}As$ Double Quantum Wells by Photoluminescence Excitation and Photoreflectance Spectroscopies in Magnetic Field.
- XXIX International School on the Physics of Semiconducting Compounds "Jaszowiec 2000", June 2-9, 2000, Ustron-Jaszowiec, Poland,
  The Study of Quasistationary Surface Excitons at the $Al_{0.5}Ga_{0.5}As/GaAs$ Interface,
  Spectroscopic Studies of Above Barrier State Transitions in $GaAs/Al_xGa_{1-x}As$ Double Quantum Wells.

6. INTERNATIONAL AND NATIONAL COLLABORATION

- Technische Physik, University of Würzburg & Wilhelm-Conrad-Röntgen-Research Center for Complex Material Systems, Am Hubland, D-97074 Würzburg, Niemcy
- Firma Nanoplus, Würzburg, Niemcy
- Institut d'Electronique du Sud, Université Montpellier 2-CNRS, UMR 5214, Place Eugene Bataillon, F- 34095 Montpellier Cedex 5, France
- Experimentelle Physik 2, Technische Universität Dortmund, Niemcy
- Ioffe Physical-Technical Institute, Russian Academy of Sciences, 194021 St. Petersburg, Rosja
- Laboratoire National des Champs Magnétiques Intenses, CNRS-UJF-UPS-INSA, Grenoble we Francji
- Cavendish Laboratory, University of Cambridge, Madingley Road, Cambridge, CB3 OHE w Wielkiej Brytanii
- The Niels Bohr Institute, University of Copenhagen, Universitetsparken 5, DK-2100 Copenhagen, Dania
- Department of Microelectronics and Information Technology, Royal Institute of Technology (KTH) Electrum 229, S-16440 Kista, Szwecja
- Airoptic, Poznań, Poland
- Institute of Physics, Polish Academy of Science, Warsaw, Poland

7. DIDACTIC ACTIVITY

7.1 Student classes

Classes for students:

- preparation and conduction tri-semestral course Physics F1, F2, F3 for students of *Technical Physics* and *Optics* at Faculty of Fundamental Problems of Technology – lecture and exercises
- *Physics* for students of Faculties of Civil Engineering and Mechanics of Wrocław University of Science and Technology – lecture, exercises, and laboratories
- *Physics* for students of Faculties (Mechanical-Energetics, Information Technology and Management, Electronics, Electronics, Photonics and Microsystem, and Electrical Engineering) Wrocław University of Science and Technology – exercises and laboratories
- *Quantum mechanics* – exercises
- *Solid State Physics* – exercises
- *Basics of numerical data analysis - Origin* – computer laboratory
- *Physics course for foreigners* – lecture and exercises.

7.2 Scientific supervision of students

- Supervisor of 3 master theses and 1 engineer project

7.3 Participation in studies' programmes committees

- Member of a programme committee for discipline of studies Technical Physics at I and II level of studies – 2012-2016
- Member of a programme committee for discipline of studies Technical Physics at I and II level of studies – 2016-2020

7.4 Popularization of science

- Lectures on physics for high school students from Lower Silesia, Greater Poland and Opole Voivodeships as a part STUDIUM TALENT in academic years 2014/15 and 2016/17.
- Numerous laboratory classes with junior high school' and high school students.
- Participation in Lower Silesia Festival of Science (2013).

7.5 Authorship of student textbooks

Coauthor of a textbook: *MATTER – RADIATION INTERACTION Theory of Condensed Matter II* for students of Faculties of Fundamental Problems of Technology and of Electronics, Microsystems, and Photonics.

8. ORGANIZATIONAL ACTIVITY

8.1 Participation in organising committees of scientific conferences

- *GaAs based lasers for the 1.3-1.5µm wavelength range,* 24.04-26.04.2003 – a member of organizing committee
- *Canadian-Polish Symposium on Nanospintronics*, 13.10.2005 – a member of organizing committee
- *The International Workshop on Quantum Dots and Laser Applications (IWQDLA 2007)*, 12.10-14.07.2007, a member of organizing committee
- *International workshop on opportunities and challenges in mid-infrared laser-based gas sensing*, 06.05-08.05.2010 – a member of organizing committee
- *International workshop on high speed semiconductor lasers*, 07.10-08.10.2010, a member of organizing committee
- *International workshop on opportunities and challenges in mid-infrared laser-based gas sensing*, 07.10-08.10.2010, a member of organizing committee
- *20th International Conference on Electronic Properties of Two-Dimensional Systems (EP2DS-20) and 16th International Conference on Modulated Semiconductor Structures(MSS-16)*, 01.07-05.07.2013 – a member of organizing committee
- *The 3rd International workshop on opportunities and challenges in mid-infrared laser-based gas sensing (mirsens3),* 05.03-07.03.2015 – a member of organizing committee
- *The 4rd International workshop on opportunities and challenges in mid-infrared laser-based gas sensing (mirsens4),* 15.05-17.05.2017 – a member of organizing committee

8.2 Membership in collegial bodies

- Member of the Council of Institute of Physics of Wrocław University of Science and Technology –2008-2012
- Member of the Faculty Collegium of Electors of the Faculty of Fundamental Problems of Technology – 2016.
- Member of the Council of the Faculty of Fundamental Problems of Technology – 2012-2016 i 2016-2020
- Plenipotentiary of the Dean for didactics of physics at Faculty of Fundamental Problems of Technology from 2016

8.3 Membership of organisations and scientific societies

- Member of the Polish Physical Society

8.4 Reviewing publications in international and national scientific journals

Reviews over 20 publications in scientific journals:

(a) Applied Physics Letters
(b) Journal of Applied Physics

(c) Physica Status Solidi B
(d) Superlattices and Microstructures
(e) Solid State Communications
(f) Optica Applicata
(g) Materials Chemistry and Physics

8.5 Other activity

- Secretary of the Seminar the Institute of Physics of Wrocław University of Science and Technology – 2000-2002 oraz 2008-2014
- Secretary of the Seminar Physics of Wrocław University of Science and Technology – 2014-2016
- Secretary of the Seminar Advanced Methods Semiconductor Research – 2008-2016
- Supervision of website www.osn.if.pwr.edu.pl

9. AWARDS

- Award of the Rector – 2016
- Award of the Rector – 2015
- Award of the Rector – 2013
- Award of the Rector – 2003
- Brown Medal 2013

Krzysztof Rychlewski