

## Half of the Century Story of Semiconductors at the Institute of Physics and in Jaszowiec

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Doi: [10.12693/APhysPolA.142.567](https://doi.org/10.12693/APhysPolA.142.567)

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Since the foundation of the Institute of Physics, Polish Academy of Sciences (IF PAN) in 1953, semiconductor physics has been its main research activity. This short paper provides lists of (i) organizational milestones of “Jaszowiec” and (ii) invited talks presented by physicists of IF PAN at the “Jaszowiec” meetings. For a more in-depth discussion covering selected fields of IF PAN’s activity and containing references to original papers, readers are delegated to a recent essay completed by the present author for the 100th anniversary of the Polish Physical Society (T. Dietl, *Acta Phys. Pol. A* **139**, 355 (2021), systematically updated versions at [arXiv:2103.07456](https://arxiv.org/abs/2103.07456)).

topics: semiconductors, magnetic semiconductors, epitaxy, defects

### 1. Introduction

The Institute of Physics, Polish Academy of Sciences (IF PAN) was founded in 1953, and since then semiconductor physics has been its main research activity, which is a not surprising, considering that Professor Leonard Sosnowski [1–3] was the director of IF PAN in the years 1954–1966. IF PAN’s Professor Witold Giriat, after his return from a post-doc stay at the Brown University, initiated the “Jaszowiec” meetings in 1970 [4, 5]. In course of the years, the meeting changed its name from the initial Seminar to School, and finally became the International School & Conference on the Physics of Semiconductors “Jaszowiec 20xx”. Also, its location moved between various Beskidy Mountains holiday resorts in southern Poland, from Jaszowiec to Ustroń, Krynica Zdrój, Wisła, and to the present location in Szczyrk. For different reasons, in 1978, 1981, and 2020, “Jaszowiec” was not organized.

In Sect. 2, some organizational milestones of “Jaszowiec” that led to its present shape will be recalled. The available program and abstract booklets indicate that so far 55 IF PAN researchers have delivered 120 lectures, i.e., over 30% of the invited talks presented by delegates of Polish institutions. The third and final section of this paper contains a list of those lectures, which titles illustrate the evolution of the main interests over the last fifty years. This author’s 20-page long historical essay [6] contains a discussion on IF PAN’s accomplishments with a focus on topics I am familiar with, supported by references to over 200 papers with the IF PAN affiliation.

### 2. A couple of “Jaszowiec” organizational milestones

There is no doubt that the “Jaszowiec” yearly meetings, as well as similar conferences elsewhere, significantly contributed to the development of semiconductor physics in Poland. In addition, to disseminating the recent developments and showing new research directions, the “Jaszowiec”-type of events are productive in many ways. First, the abstract submission deadline acts as a stimulator. Second, a similar role is played by a healthy competition between peers, research groups, and institutions. Third, new collaborations are arranged. Fourth, young participants learn and practice soft skills, such as presenting the obtained results and discussing them with experts and peers. Finally, the social aspects cannot be overvalued as they play a similar role to integration meetings organized by companies. A long break after lunch allows for mountain excursions or naps after more or less wild dancing parties lasting beyond midnight. It is therefore quite right to enable the number of attendees to surpass the number of presentations, in other words, delegating to “Jaszowiec” all, who are scientifically active in semiconductor laboratories across Poland, including master students.

I once heard an opinion that it is easier to open a new series of conferences than to stop those that cease to attract new generations of participants. I am sure that “Jaszowiec” shows no symptoms of deterioration. This healthy situation not only reflects the vitality of semiconductor physics on the globe and in Poland, but also results from several reorganization steps undertaken by numerous

“Jaszowiec” chairs and, hard to identify today, other members of the “Jaszowiec” community. I quote some of the milestones together with the key persons behind them and the year of introduction of the change.

- Involvement of semiconductor groups across Poland (Robert Gałazka; 1977) in organizing the “Jaszowiec”. Later it is organized by the Institute of Physics, Polish Academy of Sciences, the Faculty of Physics, University of Warsaw, and the Institute of High Pressure Physics, Unipress.
- Internationalization (Jerzy Langer; 1981). “Jaszowiec” switches to English, and word-class semiconductor scholars from abroad start to lecture.
- Imposed rotation of the Program Committee (Piotr Bogusławski and others — around 1985). According to the present rules, particular members of the Committee serve no longer than three consecutive years. New members are selected by the Program Committee during the “Jaszowiec” meeting. The newcomers take part in voting for the Chair of the next meeting.

- Kindergarten/School (Perła Kacman; 1991). The main event is preceeded by two days of tutorial sessions for students, initially also from Poland’s neighbouring countries.
- The International Advisory Committee helps to select lecturers (Jan Gaj; 1997).
- The Program Committee consists of colleagues from Polish semiconductor centers not directly involved in “Jaszowiec” organization (Grzegorz Karczewski; 2005).

### 3. Invited talks of IF PAN researchers at the Jaszowiec Conferences

The list of invited talks presented at the “Jaszowiec” meetings by IF PAN researchers appears to provide an unbiased survey of interests and accomplishments during the last 50 years or so. Considering the contents of the lectures and the speaker expertise, the lectures delivered can be divided into nine research domains (Tables I–IX). They are presented together with the corresponding lecture titles in chronological order.

Research domain: narrow-gap and topological semiconductors.

TABLE I

Year	Invited speaker	Title of the lecture
1971	W. Gariat	Optical and photoelectrical properties of mercury chalcogenides
1971	W. Zawadzki	“Relativistic” effects in semiconductors
1972	W. Gariat	A small energy gap semiconductors: IV–VI and II–V group
1972	J. Rauluszkiwicz	Application of electron tunneling to study semiconducting materials
1973	A. Mycielski	On some optical properties of zero- and small-gap semiconductors
1973	W. Szymańska	Anomaly of static dielectric function in symmetry induced zero-gap semiconductors and effect of this anomaly on electron mobility
1974	A. Jędrzejczak	Tunable infrared semiconductor lasers
1974	A. Mycielski	Magneto-optics in zero-gap semiconductors
1974	W. Szymańska	Electron transport phenomena in lead chalcogenides
1975	L. Sosnowski	Pressure studies of semiconductors
1977	L. Sosnowski	Group IV–VI semiconductors
1977	W. Szymańska	Electron scattering and transport phenomena in narrow-gap semiconductors
1979	J. Piotrowski	New applications of $A^{II}B^{VI}$ semiconductor compounds with narrow energy gap
1981	J. Cisowski	II–V narrow-gap semiconducting compounds
1981	W. Zawadzki	Inversion layers in narrow-gap semiconductors
1991	T. Wojtowicz	Far-infrared magneto-optical studies of HgTe–CdTe superlattices in the semimetallic regime
2014	R. Buczko	Surface states of topological crystalline insulators
2016	T. Dietl	Topological materials doped with magnetic impurities
2018	R. Buczko	Dirac cones at topological/trivial semiconductor interface with atomic steps
2019	K. Dybko	Magnetotransport in topological materials replaced by T. Dietl, Point-contact spectroscopy of topological materials

Research domain: quantum transport and localization.

TABLE II

Year	Invited speaker	Title of the lecture
1971	L. Sosnowski	Quantum effects in electron transport in a magnetic field
1971	R.R. Gałazka	Shubnikov-de Hass effect as a tool in studies of semiconductor band structure
1974	P. Byszewski	The magnetophonon resonance in semiconductors
1976	R.R. Gałazka	Magneto-resistance of narrow-gap semiconductors in the quantum regime
1987	T. Dietl	Physics of semiconductors below 1 K
1991	J. Jaroszyński	Metal-insulator transition in doped semiconductors
1993	J. Wróbel	Electronic transport in quantum wires
1996	J. Wróbel	Electron transport in submicron wires of semiconductors
1997	T. Dietl	Fabrication and physics of small resistors and capacitors
1999	J. Jaroszyński	Transport in quantum structures of diluted magnetic semiconductors
1999	W. Zawadzki	Density of states for ballistic electrons in electric and magnetic fields
2003	T. Andrearczyk	Quantum Hall ferromagnet in magnetically-doped quantum wells
2005	J. Wróbel	Spin filtering and Stern–Gerlach effect in one-dimensional structures
2007	G. Grabecki	Quantum ballistic transport in nanostructures of paraelectric PbTe

Research domain: spin resonances and spin qubits.

TABLE III

Year	Invited speaker	Title of the lecture
1971	K. Leibler	Electron paramagnetic resonance of Iron-group ions in AII–BVI compounds
1975	K. Leibler	Nuclear magnetic resonance in semiconducting compounds
1985	Z. Wilamowski	Magnetic resonance studies of ion and electron dynamics
2010	Ł. Cywiński	Dephasing of electron spin qubits due to their interaction with nuclei in quantum dots

Research domain: magnetic and semimagnetic semiconductors.

TABLE IV

Year	Invited speaker	Title of the lecture
1972	J.M. Langer	Magnetic semiconductors
1977	R.R. Gałazka	Semimagnetic semiconductors
1979	L. Sosnowski	Semimagnetic semiconductors
1981	R.R. Gałazka	Magnetic properties of semimagnetic semiconductors
1983	T. Dietl	Bound magnetic polarons in semimagnetic semiconductor
1987	A. Mycielski	Fe-based semimagnetic semiconductors
1988	R.R. Gałazka	Semimagnetic semiconductors — selected problems
1989	Z. Wilamowski	HgFeSe — A system with mixed valence
1989	T. Story	IV–VI semimagnetic semiconductors with rare earth ions
1992	A. Mycielski	Fe and Co in semimagnetic alloys with two anions
1992	T. Story	Correlations between magnetic properties and carriers concentration in semimagnetic semiconductors (replacing M.J.W de Jonge)
1998	T. Story	IV–VI semimagnetic semiconductors: Recent Developments
1998	T. Dietl	From magnetic polarons to ferromagnetism
2000	T. Story	Semiconductor ferromagnetic structures
2004	M. Sawicki	Magnetic anisotropy in GaMnAs
2006	P. Sankowski	Spin related phenomena in semiconductor heterostructures
2009	M. Sawicki	Controlling magnetism in metal-insulator-semiconductor structures of diluted ferromagnetic semiconductors
2011	T. Dietl	Understanding and exploiting magnetism of semiconductors
2015	C. Śliwa	The physics of ferromagnetic semiconductors: from symmetry to micromagnetic properties

Research domain: epitaxy and low-dimensional structures.

TABLE V

Year	Invited speaker	Title of the lecture
1981	T. Bryskiewicz	Electroepitaxy of semiconductor compounds
1984	W. Zawadzki	Magnetic and thermal properties of 2-dimensional electron gas
1985	T. Dietl	Introduction to the physics of two-dimensional electron gas
1987	J. Kossut	Diluted magnetic semiconductor quantum wells and superlattices
1995	T. Wojtowicz	Weakly diluted magnetic CdTe/Cd <sub>1-x</sub> Mn <sub>x</sub> Te semiconductor structures grown by MBE
1996	G. Karczewski	Doping and characterization of wide-gap II–VI epilayers
1998	T. Wojtowicz	Graded quantum well structures made of diluted magnetic semiconductors
1998	Z.R. Żytkiewicz	Epitaxial lateral overgrowth — a tool for dislocation blockade in multilayer systems
2001	J. Kossut	Low dimensional structures of diluted magnetic semiconductors
2002	J. Kossut	Physics of low dimensional structures made of diluted magnetic (semimagnetic) semiconductors
2005	T. Wojtowicz	Peculiarities of the MBE growth and properties of ferromagnetic III–Mn–V alloys
2009	E. Guziewicz	ZnO by ALD — advantages of the material grown at low temperature
2009	W. Zaleszczyk	ZnTe- and ZnO-based nanowires: building blocks of nanosensors
2011	D. Elbaum	ZnO biosensing
2011	L. Kłopotowski	Charging effects in self-assembled CdTe quantum dots
2012	P. Kacman	Modelling III–V nanowires
2013	T. Wojtowicz	(Cd,Mn)Te-based quantum structures with ultra-high mobility 2D electron gas: from technology to basic and applied research
2017	P. Wojnar	Optically active heterostructures in II–VI nanowires

Research domain: structure and defects.

TABLE VI

Year	Invited speaker	Title of the lecture
1975	A. Zaręba	Non-crystalline semiconductors
1975	J. Aulytner	Real structure of semiconducting mercury compounds in the light of X-ray and electron microscopy studies
1976	J. Łagowski	Surface states in semiconductor compounds
1976	N. Kwietniak	Radiative and non-radiative transitions in semiconductor compounds
1979	J.M. Langer	CdF <sub>2</sub> : From physics to applications
1979	T. Dietl	Selected topics of the amorphous phase physics
1980	J.M. Langer	Multiphonon effects in localized defects
1980	T. Figielski	Dislocations and electronic processes in semiconductors
1980	W. Wardzyński	Photochromic materials
1983	T. Warmiński	Structural studies of semiconductors — possibilities and limitations
1985	P. Bogusławski	Electronic and crystal structure of semiconductors in pseudopotential theory
1986	M. Godlewski	Nonradiative recombination processes induced by deep impurities in semiconductors
1987	J.A. Majewski	Cohesive properties and structural phase transitions in non-metallic solids
1988	T. Figielski	Imperfections in nearly perfect GaAs crystals
1988	W. Szkielko	Grain boundaries in tetrahedrally bonded semiconductors
1989	P. Bogusławski	Ordered phase of III–V alloys
2001	R. Buczko	Bonding arrangements at the Si/SiO <sub>2</sub> interface
1992	J. M. Langer	Defects and semiconductor junctions
1992	P. Bogusławski	Atomic-scale morphology of semiconductors heterointerfaces
1995	P. Bogusławski	Native defects in GaN

Research domain: excitons and optics.

TABLE VII

Year	Invited speaker	Title of the lecture
1972	M. Suffczyński	Biexcitons
1975	M. Suffczyński	Exchange splitting in excitons
1975	W. Zawadzki	Physics of spin-flip Raman laser
1975	M. Suffczyński	Exchange splitting in excitons
1976	W. Wardzyński	Polaritons
1977	M. Suffczyński	Excitons bound to neutral impurities
1980	W. Walukiewicz	Resonant Raman effect
1991	A. Suchocki	Four- and two-wave mixing studies in solids
2016	M. Matuszewski	Theory of polariton condensates
2021	A. Kamińska	Instantaneous decay rate analysis of time resolved photoluminescence (TRPL): application to nitrides and nitride structures

Research domain: impurities.

TABLE VIII

Year	Invited speaker	Title of the lecture
1973	L. Sosnowski	Resonance states of impurity atoms in semiconductors
1976	L. Sosnowski	Role of short-range impurity potentials in radiative recombination
1977	J. Chroboczek	Percolation theory and semiconductors
1977	M. Miąsek	Deep impurity states in semiconductors
1981	J. Chroboczek	Impurity wave functions and their verification in impurity conduction phenomena
1989	L. Dobaczewski	DX enigma
1990	J. Kossut	Spatial correlations of donor-electrons in semiconductors
1993	M. Godlewski	Electroluminescence from rare earth activated materials — new concepts
1996	L. Dobaczewski	Iron-Boron pair in Silicon: Old problem anew
1997	A. Suchocki	Use of bistable centers in semiconductors for holographic recording
2000	L. Dobaczewski	Hydrogen and its complexes in Silicon

Research domain: miscellaneous.

TABLE IX

Year	Invited speaker	Title of the lecture
1988	A. Wittlin	Is there energy gap in high- $T_c$ superconductors?

And what about the international impact, was there any? The criterion could constitute invitations to the main biannual conference of the IUPAP Semiconductor Commission. At the International Conference on the Physics of Semiconductors, invited talks were given by representative IF PAN's physicists: L. Sosnowski (1964, 1968); W. Zawadzki (1972 — plenary); R.R. Gałazka (1978, 1986); J.M. Langer (1980, 1998); T. Dietl (1988, 2004 — plenary, 2016); A. Mycielski (1988); J. Kossut (1990); P. Bogusławski (1992); G. Grabecki (2006); E. Guziewicz (2008); M. Sawicki (2010); T. Story (2014); T. Wojtowicz (2018). Additionally, invited presentations on magnetic

and semimagnetic semiconductors were delivered at the main conferences of other IUPAP commissions: the International Conference on Magnetism by R.R. Gałazka (1994); T. Dietl (2003, 2015 — semi-plenary) and at the International Conference on Low-Temperature Physics, by T. Dietl (1987).

Of course, all that would not be possible without the extensive and friendly international and national collaborations, often arranged during “Jaszowiec” meetings, particularly with our colleagues from the University of Warsaw, the Institute of Electron Technology, and the Institute of High Pressure Physics Unipress.

### **Acknowledgments**

The author thanks Ms. Beata Imińska for collecting information displayed in the Tables. The International Research Centre MagTop is funded by the Foundation for Polish Science through the IRA Programme financed by EU within SG OP Programme.

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