Leibniz Gemeinschaft

**Der Senat**

15. März 2022

# Stellungnahme zum
# Leibniz-Institut für Plasmaforschung und Technologie e.V., Greifswald (INP)

## Inhaltsverzeichnis

## Vorbemerkung

Die Einrichtungen der Forschung und der wissenschaftlichen Infrastruktur, die sich in der Leibniz-Gemeinschaft zusammengeschlossen haben, werden von Bund und Ländern wegen ihrer überregionalen Bedeutung und eines gesamtstaatlichen wissenschaftspolitischen Interesses gemeinsam gefördert. Turnusmäßig, spätestens alle sieben Jahre, überprüfen Bund und Länder, ob die Voraussetzungen für die gemeinsame Förderung einer Leibniz-Einrichtung noch erfüllt sind.[1]

Die wesentliche Grundlage für die Überprüfung in der Gemeinsamen Wissenschaftskonferenz ist regelmäßig eine unabhängige Evaluierung durch den Senat der Leibniz-Gemeinschaft. Die Stellungnahmen des Senats bereitet der Senatsausschuss Evaluierung vor.

Für die Bewertung einer Einrichtung setzt der Ausschuss Bewertungsgruppen mit unabhängigen, fachlich einschlägigen Sachverständigen ein. Der für das INP zuständigen Gruppe stand eine von der Einrichtung erstellte Evaluierungsunterlage zur Verfügung. Die wesentlichen Aussagen dieser Unterlage sind in der Darstellung (Anlage A dieser Stellungnahme) zusammengefasst.

Wegen der Corona-Pandemie musste der für den 17. und 18. Juni 2021 vorgesehene Evaluierungsbesuch am INP in Greifswald entfallen. Die Bewertung erfolgte im Rahmen eines Ersatzverfahrens, das der Senatsausschuss Evaluierung (SAE) in Umsetzung eines Grundsatzbeschlusses des Senats vom 31. März 2020 eingerichtet hat. Der Senat hält in diesem Grundsatzbeschluss fest, dass das Ersatzverfahren ein Notbehelf ist und ausschließlich auf Einrichtungen angewendet wird, die im Regelturnus von sieben Jahren evaluiert werden. Die Bewertungen, auf deren Grundlage der Senat Stellung nimmt, sind auf zentrale Kernfragen der Entwicklung und Perspektive einer Leibniz-Einrichtung fokussiert. Ausführliche Einschätzungen und Schlussvoten zu Teilbereichen und Planungen für „kleine strategische Sondertatbestände“ müssen regelmäßig entfallen.

Die Bewertungsgruppe erstellte den Bewertungsbericht (Anlage B). Das INP nahm dazu Stellung (Anlage C). Der Senat der Leibniz-Gemeinschaft verabschiedete am 15. März 2022 auf dieser Grundlage die vorliegende Stellungnahme. Der Senat dankt den Mitgliedern der Bewertungsgruppe und des Senatsausschusses Evaluierung für ihre Arbeit.

## 1. Beurteilung und Empfehlungen

Der Senat schließt sich den Beurteilungen und Empfehlungen der Bewertungsgruppe an.

Das Leibniz-Institut für Plasmaforschung und Technologie (INP) betreibt anwendungsorientierte Grundlagenforschung auf dem Gebiet der Niedertemperatur-Plasmaphysik. Sein Schwerpunkt liegt auf der Erforschung der reaktiven Eigenschaften kalter Plasmen mit Blick auf unterschiedliche Anwendungsgebiete, etwa bei der Dekontamination hitzeempfindlicher Objekte oder in der Wundheilung.

Organisatorisch sind die Arbeiten am INP in die beiden Bereiche Materialien und Energie sowie Umwelt und Gesundheit gegliedert, die derzeit jeweils drei Forschungsprogramme

[1] Ausführungsvereinbarung zum GWK-Abkommen über die gemeinsame Förderung der Mitgliedseinrichtungen der Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz e. V.

umfassen. Mit vielversprechenden neuen Anwendungsgebieten wurde das **Forschungsprofil** seit der letzten Evaluierung sehr gut weiterentwickelt, strukturell unterstützt durch die Einführung von Forschungs- und Nachwuchsgruppen als neuen, kleineren Arbeitseinheiten am Institut. Seit 2017 erhält das INP zusätzliche Mittel der institutionellen Förderung für die Forschung im Bereich Plasmamedizin. Durch die strategische Partnerschaft mit dem Klinikum Karlsburg im Rahmen eines gemeinsamen „Kompetenzzentrum Diabetes" hat das Institut zudem den empfohlenen Einstieg in die klinische Forschung erreicht. Als ein weiteres zukunftsträchtiges Forschungsfeld wurde außerdem die Plasma-Agrarkultur am Institut etabliert. Bund und Länder haben vor Kurzem entschieden, die institutionelle Förderung ab 2023 auch hierfür auszuweiten.

Darüber hinaus sehen die zur Evaluierung vorgelegten strategischen **Planungen** vor, im Rahmen der vorhandenen Grundausstattung in weitere neue Bereiche mit großem Potential vorzustoßen, etwa in die Felder Bioökonomie und Industrie 4.0. Diese Vorhaben müssen allerdings noch klarer definiert werden, auch mit Blick auf einzubeziehende fachliche Kompetenzen. Außerdem sollten klassische, inzwischen in die industrielle Anwendung überführte Betätigungsfelder kritisch überprüft und ggf. aufgegeben oder neu ausgerichtet werden.

Mit seinen **Publikationen** erreicht das INP wie empfohlen inzwischen über die Plasmaphysik hinaus das gesamte Fach Physik sehr gut. In den neuen Anwendungsbereichen, etwa der Plasmamedizin und -biologie, sollte nun ebenfalls in höherrangigen Zeitschriften mit interdisziplinärer Ausrichtung publiziert werden. Mit seinem Engagement im Bereich **Forschungsdaten** erbringt das Institut wichtige Serviceleistungen für die Fachgemeinschaft der Plasmaphysik.

Das Institut verfolgt eine ausgesprochen effektive **Transferstrategie**, basierend auf der internen Entwicklung von Konzepten und Prototypen, strategischen Partnerschaften und Verträgen mit Unternehmen. Seit der letzten Evaluierung haben Arbeiten des INP zu zwei erfolgreichen Ausgründungen im medizinischen Bereich geführt.

**Leitung** und **Gremien** des INP erfüllen ihre Aufgaben bei der Steuerung der Institutsentwicklung sehr gut und haben geeignete Maßnahmen zur Qualitätssicherung etabliert.

Junge **Wissenschaftlerinnen und Wissenschaftler** werden am INP sehr gut gefördert. Allerdings sollte die Anzahl der Promovierenden erhöht werden, wie bereits vor sieben Jahren empfohlen. Auch muss das Institut nach wie vor mehr Anstrengungen unternehmen, wissenschaftliches Spitzenpersonal von außerhalb der Region und aus dem Ausland für die Mitarbeit am Institut zu gewinnen. Die sehr guten Bedingungen am INP bieten dafür eine ausgezeichnete Grundlage. Der Anteil von Wissenschaftlerinnen am Institut konnte seit der letzten Evaluierung deutlich erhöht werden. Von den neu eingerichteten Forschungsgruppen werden drei von Frauen geleitet. Diese Entwicklung muss fortgeführt werden, denn insgesamt sind am INP nur vier von 21 Leitungspositionen mit Wissenschaftlerinnen besetzt.

Das INP ist international sehr anerkannt. Auch in das wissenschaftliche Umfeld der Region ist das Institut eng eingebunden. Die **Kooperation** mit der Universität Rostock

wurde weiter vertieft; mittlerweile sind drei Professoren gemeinsam mit dieser Hochschule berufen. Zwei gemeinsame Berufungen bestehen mit der Universität Greifswald.

Die institutionelle **Förderung** des Instituts ist auskömmlich. Es werden regelmäßig Drittmittel in beeindruckender Höhe eingeworben, vor allem bei Bund und Ländern. 2020 erhielt das INP eine umfangreiche EU-Förderung für die Koordination des Horizon 2020-Projekts „HiPowAR“. Das INP sollte an diesen Erfolg anknüpfen und zukünftig regelmäßig Drittmittel auf europäischer Ebene – neben der EU auch beim ERC – einwerben.

Das INP zeichnet sich durch seine Positionierung zwischen Grundlagenforschung und industrieller Anwendung in einem ausgesprochen dynamischen Umfeld aus. Es erfüllt die Anforderungen, die an eine Einrichtung von überregionaler Bedeutung und gesamtstaatlichem wissenschaftspolitischem Interesse zu stellen sind. Die Erfüllung der Aufgaben des INP ist an einer Hochschule nicht in dieser Weise möglich. Eine Eingliederung des INP in eine Hochschule wird daher nicht empfohlen.

## 2. Zur Stellungnahme des INP

Der Senat begrüßt, dass das INP beabsichtigt, die Empfehlungen und Hinweise aus dem Bewertungsbericht bei seiner weiteren Arbeit zu berücksichtigen.

## 3. Förderempfehlung

Der Senat der Leibniz-Gemeinschaft empfiehlt Bund und Ländern, das INP als Einrichtung der Forschung und der wissenschaftlichen Infrastruktur auf der Grundlage der Ausführungsvereinbarung WGL weiter zu fördern.

2 June 2021

# Annex A: Status report

## Leibniz Institute for Plasma Science and Technology, Greifswald (INP)

### Contents

## 1. Key data, structure and tasks

### Key data

| | |
|---|---|
| Year established: | 1992 as Institute for Low Temperature Plasma Physics (until 2007), dating back to the Research Centre for Gas Discharge Physics established in 1946 and hosted by the Academy of Sciences of the GDR |
| Admission to joint funding by Federal and *Länder* Governments: | 1992 |
| Admission to the Leibniz Association: | 1992 |
| Last statement by the Leibniz Senate: | 2015 |
| | |
| Legal form: | registered association |
| Responsible department at *Länder* level: | Ministry of Education, Science and Culture of the State of Mecklenburg-Vorpommern (BM) |
| Responsible department at Federal level: | Federal Ministry of Education and Research (BMBF) |

**Total budget** (2020)

€ 9.7M institutional funding

€ 10.2M revenue from project grants

€ 0.2M revenue from services

**Number of staff** (2020)

99 individuals in "research and scientific services"

33 individuals in "science supporting staff (laboratories, technical support etc.)"

33 individuals in "science supporting staff (administration)"

### Mission and structure

"The **function** of the Association is to conduct application-oriented fundamental research, in particular in the field of low-temperature plasmas, and to promote their use. In doing so, it conducts freely chosen research projects coordinated with the Federal Republic of Germany and the State of Mecklenburg-Vorpommern [...] as well as externally funded and contract research, and promotes the training and continuing education of junior scientists and technicians in the field of low-temperature plasma physics in cooperation with scientific universities and industry." (Quoted from Section 1 of the Articles of Association)

INP's activities are conducted in two research divisions, "Materials & Energy" and "Environment & Health", which are subdivided into three research programmes each (see chapters 4 and 7). Administratively, the institute is **structured** into eight scientific departments, four research groups and three junior research groups, as well as the depart-

ments “Management Support”, “Board Departments” and “Administration & Infrastructure”.

## 2. Overall concept and core results

The Leibniz Institute for Plasma Science and Technology (INP) conducts fundamental research in the field of low-temperature plasma physics as well as application-oriented research for plasma technology. INP sees its core competences in the experimental diagnostics and numerical modelling of low-temperature plasmas coupled with the design of plasma sources and plasma processes for a variety of applications.

The research areas of INP are translational and interdisciplinary, combining plasma physics with chemistry, surface technology, electrical and mechanical engineering, biochemistry, microbiology and cell biology, medicine, hygiene, food chemistry, and plant physiology. INP focuses on topics that advance applications or support actual research demands of already established technologies. Findings are pursued to the level of demonstrating technical feasibility.

The **research division “Materials & Energy”** includes the research programmes “Materials and Surfaces”, “Plasma Chemical Processes”, and “Welding and Switching”. It promotes the development of established applications of e.g. plasma surface technology and electric arc technology. Research concentrates on plasma processes for new materials e.g. electrochemically active materials, on new plasma-assisted chemical processes, and on monitoring systems for plasma processes. The majority of activities of the research division is congruent with topics of the German energy transition programme (Germany’s *Energiewende*) focusing on new materials for hydrogen technology, green ammonia production, Power2X technologies, and batteries.

The **research division “Environment & Health”** comprises the research programmes “Bioactive Surfaces”, “Plasma Medicine”, and “Decontamination”. It concentrates on new plasma applications mostly in biomedicine and environment. The topic spectrum focuses on plasma-based modification and optimisation of surfaces and materials interacting with biological systems including biosensing systems. It further includes both the development and optimisation of plasma-based methods and processes for the inactivation of microorganisms and the degradation of contaminants on surfaces, materials, in water and air. Moreover, the direct application of cold atmospheric plasmas on the human body and cells is intensively investigated including both fundamental research of the mechanisms of interactions of physical plasmas with living cells and tissues and the introduction of new plasma-based methods and devices in medicine.

### Results

INP highlights the following activities and core results:

- Publication of a new concept for the plasma-based synthesis of materials for hydrogen production (i.e. for the synthesis of unsupported, highly porous platinum and iridium catalysts with low surface loading)

- Extension of high-end laser absorption methods from UV to Terahertz resulting in the detection and monitoring of key species in near-industrial plasma processes (e.g. etching, deposition, nitriding, plasma jet treatment)
- Modelling of non-thermal atmospheric-pressure plasmas (dielectric-barrier discharges and atmospheric-pressure plasma jets) and of electric arcs
- Analysis of molecular mechanisms of plasma-supported wound healing together with first steps in research for the use of cold atmospheric plasmas for cancer treatment
- Fabrication of stimuli-responsive hydrogels as "materials on demand" based on plasma polymerisation by a cold atmospheric-pressure plasma jet and mineralisation of pharmaceutical residuals in water by corona discharges

INP's **publication strategy** aims at dissemination and outreach of results among the different scientific communities. Research in plasma physics is mainly published in peer-reviewed journals dedicated to this subject. Work on plasma technologies in engineering applications is mainly directed to journals of applied physics and engineering publishers (i.e. IEEE journals), and is also presented on conferences with distinct participation of industry. With increasing interdisciplinarity, according to INP, publications appear in a broader variety of journals, e.g. related to material science, chemistry, and biomedicine fields. Between 2018 and 2020 scientists from INP published research results in 560 publications, 360 (64%) of which were articles in peer-reviewed journals (see appendix 2).

INP's **knowledge transfer strategy** (see chapter 4) focuses on transfer to industry and on supporting entrepreneurial activities of early career researchers as well as on spinning off start-up companies. Since the last evaluation, two companies were spun off:

- In 2015: ColdPlasmaTech GmbH, a company developing plasma-medical devices for large surface wound healing
- In 2019: Nebula Biocides GmbH, aiming at the development and certification of devices for novel, economic hand disinfection.

This transfer of results is also based on patents owned by INP. During the past three years, 40 patents were applied for and 20 patents were granted.

To meet the need for a more intense exchange of **research data** in the community of plasma technology, e.g. for validation of fundamental results, potential technological approaches, and the wide variety of plasma sources, INP developed the interdisciplinary plasma technology data platform INPTDAT which operates since 2019. Further research and development in the field of open data and research data management is currently conducted in the framework of the project "Qualitätssicherung und Vernetzung von Forschungsdaten in der Plasmatechnologie - QPTDat".

## 3. Changes and planning

### Development since the previous evaluation

INP states that in both research divisions **interdisciplinary and translational research** topics have become more relevant. These topics relate to the modification and processing of surfaces and materials, including bioactive surfaces, catalytic materials, nanomaterials, and liquids, with a strong focus on monitoring and control of plasma chemical processes. The field of plasma-supported degradation and decontamination includes inorganic and organic pollutants in air, water and on surfaces. Plasma applications in biology have evolved beyond plasma medicine to plasma applications in agriculture and food processing as emerging fields. Moreover, INP has initiated research activities in technologies for renewable energy.

This development led to structural changes that were implemented after an internal review process and a discussion with the Scientific Advisory Council. The process resulted in six instead of eight research programmes and the introduction of **(junior) research groups** to the institute. These groups are meant to work in agile teams on new topics and topics that develop dynamically. As INP sees these groups as scientific incubators, they are given a greater degree of freedom in thematic orientation and self-organisation. The respective (junior) research groups are part of a specific research programme and not of a scientific department. All in all, four research groups and three junior research groups have been established.

In 2015, INP secured BMBF funding for a second phase of the **Centre for Innovation Competence (ZIK) *plasmatis***, which had initially been established in December 2009. In ZIK *plasmatis* INP investigates the extent to which cell activity can be influenced by physical cold plasmas and how to use these results to transfer plasma technology into medical application. Two junior research groups were established (see below).

In 2016, the **Competence Centre Diabetes Karlsburg** (KDK), a branch office of INP at the Clinics in Karlsburg (located 23 km from Greifswald) was opened with the aim of integrating competencies in diabetes and plasma technology. There, three laboratories (Microbiology, Cellbiology and Plasma Source Concepts) as well as devices and equipment to analyse patients and volunteers were set up. In 2017, INP and the Plasma Bioscience Research Center (PBRC) at Kwangwoon University jointly opened the **Applied Plasma Medicine Center** (APMC) in **Seoul**/South Korea.

Since 2019, INP coordinates the project **Campfire** which is funded in the WIR! programme for innovation and structural transformation of BMBF. The programme promotes the structural change in economically underdeveloped regions through research and development projects of larger consortia of industry, research and regional stakeholders, each funded with up to € 15 M for five years. Also in the WIR! programme, INP is one of the management institutions of the cluster project **Physics for Food**, which considers innovative physical technologies for agriculture and food processing. Finally, in 2020, INP acquired the EU Horizon 2020 **project HiPowAR** – Highly efficient power production by green ammonia total oxidation in a membrane reactor" (with a total budget of € 4M). This

is a joint project with five partners (two from industry) under coordination of INP to support research for hydrogen technology and the use of ammonia for energy storage.

Major changes in the research division **Materials & Energy**:

- After the former **head of the research division** had left INP in 2015 to pursue a career in industry, one of the department heads took over in 2017 and became jointly appointed W3-professor at University of Rostock.
- In 2015, in order to achieve greater synergies in the areas of catalytic chemistry, plasma chemistry, plasma surface technology, new diagnostic methods, and electrical engineering, the former research programmes “Surface/Thin Films” and “Catalytic Materials” were merged to the research programme **Materials and Surfaces**.
- In 2017, the previous research programme “Process Monitoring” was renamed **Plasma Chemical Processes**. It was established, among other things, to consolidate and strengthen INP’s core competence in monitoring, modelling, and analysis of plasma processes. The new head is jointly appointed W2-profesor at University of Rostock.
- In 2019, INP recruited a new head for the research programme **Welding/Switching**.
- In 2019, the research group **Materials for Energy Technology** was established. The multidisciplinary team covers the fields of plasma technology, materials and chemical engineering. Linked to the research programme “Materials and Surfaces”, the group’s objective is the development of cost-effective and scalable synthesis routes for the production of nanomaterials and thin films.

Major changes in the research division **Environment & Health**:

- After the previous evaluation, because of their high scientific and technological potential, INP decided to expand the topics of the former research programme “Plasma Medicine/Decontamination” further. As a result, the research programme was divided in 2015.
- Since then, the research programme **Plasma Medicine** focuses on all aspects of plasma medicine and its application. It also includes the research activities of ZIK *plasmatis* and of the branch office of INP at Klinikum Karlsburg.
- The research programme **Decontamination** was expanded by integrating the former programmes “Pollutant Degradation” and “Bioelectrics” with the aim of utilising synergies of activities related to clean water, air pollution, and clean food.
- In 2015, the new scientific department **Plasma Life Science** was established in the context of consolidating research in the fields of plasma medicine and decontamination.
- Since 2016, research on direct and indirect interaction of cold plasmas with cells is investigated by the two ZIK *plasmatis* junior research groups **Plasma Redox Effects** and **Plasma Liquid Effects**.

- From 2017 on, plasma medicine and related topics have been strengthened further with **additional institutional funding** *(Sondertatbestand)* that included financial means for eleven permanent positions (eight 100%, three 50% contracts) for scientists and administrative staff. Based on their results and plans for future work, the two ZIK *plasmatis* junior research groups of the first funding phase were developed to research groups and incorporated scientifically into the research programme "Plasma Medicine". The objective of the research group **Plasma Wound Healing** is to deepen and broaden the basis of plasma-based wound healing by identifying differences between skin cells and the microorganisms found in chronic wounds. Under new leadership since 2017, the research group **Plasma Source Concepts** focuses on the development of plasma sources optimally adapted to specific medical applications.
- In 2017, in order to strengthen the fundamentals in the field of bioactive surfaces, the junior research group **Biosensing Surfaces** was established. The group engages in the development and characterisation of novel functional layers for sensors in the life science sector (e.g. medicine, pharmacy and biotechnology). The head of the junior group also serves as head of the research programme "Bioactive Surface".
- In 2018, the research group **Plasma Agriculture** was established. Its major focus is the development and characterisation of innovative plasma processes for crop protection with the aim of improving plant health and increasing plant stress tolerance, while securing growth and yield at the same time.

**Strategic work planning for the coming years**

INP will continue interdisciplinary research related to low-temperature plasmas. According to INP, main issues such as the complexity of non-equilibrium plasma chemistry, the manifold plasma-surface interaction processes, and the interaction of plasma with liquids and biomaterials require more fundamental studies. The understanding of plasmas in liquids needs investigations in view of applications like material synthesis, water, and biomass treatment. INP's strategy is reviewed and adapted in an annually retreat with all leading scientists and confirmed by the Scientific Advisory Council.

Additionally, continuous research activities will be related to diagnostics (e.g. in situ attenuated total reflection spectroscopy, micro-discharge diagnostics, frequency comb THz laser absorption spectroscopy), analytics (surfaces, materials, X-ray photoelectron spectroscopy), simulation and modelling (e.g. multi-physics tools, plasma plus liquid, non-equilibrium plasmas), and production processes.

INP's four main areas of future focus are:

- Technologies for renewable energy use: Materials utilised in fuel cells and batteries as well as switching devices (contributing to the field of electro-mobility); Materials for electrolysis, fuel cells, and hydrogen storage as well as $CO_2$ conversion (as part of future Power2X technologies)
- Bio-economy: Plasma technology for plant health, reduction of chemical protection, sustainable agriculture, and production of food and organic products.

- Health economy and aging society: Plasma medicine (wound healing, cancer treatment); Plasma hygiene (bioactive surfaces, decontamination)
- Industry 4.0: Control concepts for plasma and thermal processes; New and adapted plasma sources with intelligent control and diagnostics as well as automation features; Sensors for key quantities of production processes or product lifetime (biosensors, hot surfaces, high-voltage insulation); Research data management.

In the context of plasma technology in agriculture and bio-economy, based on a positive vote of the Board of Trustees and the Scientific Advisory Council, INP has applied for additional institutional funding (*Sondertatbestand*) for a technical centre **"Plasma in Agriculture and Food Processing"** in January 2021. The planned research activities are aimed at the production of healthier food while reducing the use of chemicals, at the processing of crops with the aid of gentle technologies, and the generation of renewable energy from biogenic residues. Promising results have already been obtained in initial projects like, for example, the cluster project "**Physics for Food"**. For further investigations on an industrial scale and for the extension of interdisciplinary work, appropriate facilities and infrastructure are required as well as the recruitment of additional expertise, including three joint professorships with universities in Mecklenburg-Vorpommern.

## 4. Controlling and quality management

### Facilities, equipment and funding

Funding (see appendix 3)

In 2018-2020, INP's total revenue was € 19.1 M per year on average. Institutional funding amounted to € 9.8 M. Additional funding from third-party sources included € 8.9 M from project grants (corresponding to 47% of revenues) and € 0.2 M from services (1%). The revenue from services derived mainly from license fees for intellectual property rights. Since 2013, INP's **institutional funding** has increased by € 2.8 M based on the framework for research and innovation (*Pakt für Forschung und Innovation*), and, from 2017 on, by receiving additional funding to steady the activities in the research programme "Plasma Medicine" (*Sondertatbestand*).

INP's most important **third-party funding** sources are Federal and *Länder* governments (average share of third-party funding per year: 69%), industry (10%), the German Research Foundation (DFG; 7%), and the EU (6%). The revenue from the Federal government grants consists of about 82% project funding from BMBF, 15% from BMWi, and 3% from BMEL[1]. The revenue from the State of Mecklenburg-Vorpommern stems mainly from the European Regional Development Fund.

[1] BMBF: Federal Ministry of Education and Research; BMWi: Federal Ministry for Economic Affairs and Energy; BMEL: Federal Ministry of Food and Agriculture.

Facilities and equipment

INP maintains laboratories and offices at three locations. In recent years, the institute's main building in **Greifswald** has been extended to about 5000 $m^2$ of floor space to include an annex mainly for interdisciplinary work and for the Centre for Innovation Competence (ZIK) *plasmatis*. With a current average of about 200 employees, the institute states that it has reached its capacity limits again (in both laboratory space and offices). Therefore, from 2022 on, it plans to occupy an additional area of 1200 $m^2$ in a new building (Centre for Life Science and Plasma Technology) built by the city of Greifswald, adjunct to INP's main building.

In cooperation with the University of **Rostock**, INP operates a 300$m^2$ electric technology facility with two laboratories (a high-current laboratory and a high-voltage laboratory for joint research on electrical insulation systems). In 2017, INP established the Competence Centre Diabetes **Karlsburg** (see chapter 3) with laboratories and office space of around 250$m^2$.

INP has several application **laboratories** at its disposal, which are also available for external cooperation, e.g.:

- PVD Processing and Coatings (inter alia multi-target co-deposition, high power impulse magnetron sputtering, ion-assisted electron beam evaporation, chemical vapour deposition)
- PiL Materials Laboratory (batch- and flow-through reactors with pulsed high voltage for rapid synthesis of nanoparticle suspensions)
- Plasma Diagnostics Laboratory (LAS, cavity-enhanced spectroscopy, LIF, OES, MW interferometry, MS, sub-ns diagnostics)
- Laboratory for Surface Diagnostics (inter alia SEM, AFM, XPS, in-situ XPS, EDX, FTIR for e.g. nanostructured materials)
- Laboratory for Materials Characterisation (analytical facilities for crystallographic properties, gas-permeation rate determination in materials)
- Laboratory for High-Frequency Engineering (control and development of microwave sources)
- Arc Research Laboratory (high pulse current and high-voltage sources, vacuum chamber and optical diagnostics for analysis of switching arcs)
- Welding Arc Laboratory (welding machines and optical diagnostics)
- High-Current/High-Voltage Laboratories (high current and high-voltage sources, micro-Ohm and partial discharge diagnostics for power and insulation systems)
- Microbiological laboratory (safety level 2 laboratory inter alia for human pathogenic microorganisms of risk groups 1 and 2)
- Laboratory for Plasma Decontamination (plasma process development for disinfection and sterilisation of medical products and hygienisation of food products)

- Life Science Laboratory (safety level 2 laboratory inter alia for cultivation of cell lines, fluorescence, luminescence, and hyperspectral imaging; flow cytometers, mass spectrometry, chromatography, and omics technologies)

In addition to the basic technical infrastructure of a physics research institute, INP operates various workshops equipped with modern devices (e.g. a mechanical workshop and a glassblowing facility).

INP's **IT concept** is based on the principle of operating as few software structures as possible for communication, management, and administration. About 400 PCs and workstations are in use at the institute and connected to various servers. A cluster for server virtualisation is operated at INP to provide IT services. The scientific department “Plasma Modelling” uses a high-performance computing cluster with eleven nodes and around 180 cores as well as other computing servers with a total of 120 cores.

The **IT security** measures are based on an IT security concept, which is supplemented by a series of guidelines. A central storage system is used to ensure data security. It is designed redundantly over several fire protection zones. The data is backed up using an external retrieval process. An offline backup of the IT core components of INP for emergency recovery is being implemented.

### Organisational and operational structure

INP is a registered association. Its constituent bodies are the General Assembly, the Board of Trustees, the Scientific Advisory Council, and the Board of Directors. The institute is led by a scientific-administrative dual leadership (see annex 1).

The scientific director is chairman of the **Board of Directors**, represents INP in public, and is responsible for the science strategy development and its implementation. The administrative board member assumes the position of the Chief Financial Officer, manages the day-to-day administrative and infrastructure business and is responsible for personnel administration and the budget. Two further members, scientists at present, support and advise on operative business and strategic considerations. The Board of Directors meets regularly every two weeks.

The institute is **structured administratively** into the Board of Directors, scientific departments, research groups and junior research groups, as well as the departments “Management Support”, “Board Departments”, and “Administration & Infrastructure”. The eight scientific departments are “Plasma Bioengineering”, “Plasma Diagnostics”, “Plasma Life Science”, “Plasma Modelling”, “Plasma Surface Technology”, “Plasma Process Technology”, “Plasma Sources”, and “Plasma Radiation Techniques”. **Scientifically**, INP is organised into the two research divisions "Materials & Energy" and "Environment & Health", which are subdivided into three research programmes each (see chapters 2 and 7).

Such **matrix structure**, in view of INP, stands for a project-centric organisation that ensures the development and maintenance of competencies, while, at the same time, providing flexibility in reacting on novel demands from the scientific community and the public.

**Quality Management**

The **internal quality management** of INP is the responsibility of the Board of Directors as well as of the heads of the research divisions and departments. The institute's work is reviewed annually in a retreat of the senior staff and at strategy workshops held by the research divisions. All ongoing projects at the institute are assessed in monthly project reviews. The project managers report on deadlines, finances, resources, publication activities, and the overall course of the project. In the case of deviations from the plan, corrective measures are discussed during monthly research division meetings.

The **cost and performance accounting** (CPA) is based on designated indicators that include the number of publications and patents, the amount of external funding, the number of conference papers and (invited) lectures, activities in education and teaching, expert reviews, participation in scientific committees, and the organisation of national and international conferences. Institutional funding is by 30% evenly spread across the research programmes and by 70% awarded based on the CPA of the previous year.

Annual targets and soft goals for all employees are part of the appraisal interview. The achievement of the set goals is rewarded with a **performance-based funding allocation** (LOM, *Leistungsorientierte Mittelvergabe*) for outstanding employees. This is governed by an in-house agreement of the Board of Directors and INP's works council.

The institute operates according to the principles of **good laboratory practice** (GLP). Safety officers are designated for different areas (hazardous materials, fire protection, etc.). INP has an **ombudsman**. The institute's scientific work and project realisation comply with the **rules of good scientific practice** of the Leibniz Association and the German Research Foundation (DFG). Methods and results of experimental studies are documented in laboratory notebooks.

Following the **research data management** guidelines and policies of the Leibniz Association and DFG, INP is committed to further promoting the widest possible accessibility and reuse of research data. The database INPTDAT supports the handling of open data in accordance with the FAIR (Findable, Accessible, Interoperable, Re-usable) data principles (see chapter 2). Results are published preferably in recognised scientific journals, which provide a peer-review process (for **publication strategy** see chapter 2). INP states that publication in open-access or hybrid journals is strongly supported.

INP's **transfer strategy** is based on three pillars according to the principle "From idea to prototype". The first pillar comprises application-oriented research until the in-house development of concepts and laboratory prototypes of new plasma devices and processes. Joint projects with industry e.g. funded by EU, German federal government (BMBF, BMEL, and BMWI) and the state of Mecklenburg-Vorpommern constitute the second pillar and by far the largest part of INP's third-party funding. The third pillar is based on bilateral contracts with industry partners. INP aims to acquire around 10% of the annual third-party funds from these bilateral contracts and to enter into strategic partnerships in order to facilitate medium- to long-term research plans.

### Quality management by advisory board and supervisory board

The **Scientific Advisory Council** (SAC) consists of at least six members. They are appointed by the Board of Trustees for a four-year term, as a rule reappointment is permitted once. Among the members, science and industry should be equally represented. SAC advises the Board of Trustees and the Board of Directors on all important scientific and organisational matters, in particular regarding long-term research and development planning. It convenes at least once a year. Every year, it evaluates the research efforts and work planning of INP in a written report and all three years with an audit report.

The **Board of Trustees** has at least four and up to six members with voting rights. One member each is delegated by the Federation and the State. Additional members are elected by the General Assembly for a term of four years, at least one of them from a cooperating university and at least one from industry. Re-election is possible. The Board of Trustees decides on all significant scientific, economic and organisational matters of INP, such as appointing the members of the Board of Directors. It convenes at least twice a year. The Board of Directors and the Chair of the Scientific Advisory Council attend the sessions in an advisory capacity.

## 5. Human resources

As of June 30th, 2020, INP had 165 employees, thereof 99 in research and scientific services, 33 in services, and 33 in administration. These persons are supported by 29 student assistants and one trainee (see appendix 4).

INP sees well qualified, highly motivated, and efficient employees as essential for the institute's success. Challenges are the shortage of skilled professionals, the necessity for global networking, and international competition. In order to prepare scientific and science supporting staff for current and future requirements, INP has introduced a personnel development concept in 2013 which was updated in 2020. It includes different fields of action, such as staff recruitment and selection, advancement of professional and soft skills, promotion of junior staff in the scientific and science-supporting area, management development, and gender equality measures. In 2021, INP received the **HR Excellence in Research Award** of the European Commission and thus committed to creating a suitable working environment for excellent research.

The annual appraisal interview is the central instrument of **career planning and development** for all staff members of INP. Besides discussing and monitoring target agreements, it aims to determine career goal and career path based on potential analyses. INP follows the **Leibniz Guidelines on Career Development**. Many scientists of INP develop towards academia, a larger number of scientists orients towards industry or non-scientific area and few scientists progress towards spin-off.

### Leading scientific and administrative positions

INP follows the staffing standards of the Leibniz Association, foremost when filling scientific and administrative leadership positions. According to INP, these positions are always

advertised internally and externally, e.g. in paid employment web portals and using contacts to academic and industrial research groups all over the world. If appropriate, head hunters are included in the search for top positions.

For leadership positions, INP aims at joint professorships with universities ("Jülich model" and "Thuringian model"). Five professors in leadership positions at INP were appointed in accordance with rules of the Universities of Greifswald (two) and Rostock (three). The decision is proposed by an appointment committee with equal participation of representatives of INP and university, and is confirmed by the faculty board.

For (junior) research see chapter 3.

**Staff with a doctoral degree**

All positions are generally advertised internally and externally. Permanent positions in the scientific field are offered depending on the strategic focus and availability of position and funding.

Postdoctoral researchers of INP are given the opportunity to take on responsibility for mentoring young scientists, to acquire third-party funding as well as to gain experience in research transfer. They are encouraged to develop management and leadership skills by taking part in internal and external mentoring programmes and by taking over the management of a third-party funded project. Also, INP supports postdoctoral researchers who aim for a professorship. A long-term career plan is developed, with special consideration of habilitation-related work phases. There are currently three candidates at INP aiming for a habilitation.

An average of 18 postdocs are working at INP (i.e. scientists who completed their doctoral degree in the last six years).

In the past few years, two scientists received professorships, one at the University of Applied Sciences in Zwickau, Germany and one at Polytechnique Montréal, Canada. More than 15 scientists moved to industry and took on different positions there. One former leading scientist became head of a management position at ABB.

**Doctoral Candidates**

As of June 30th, 2020, 20 doctoral candidates (including scholarship recipients) worked at INP. Most doctoral candidates work in third-party projects, usually funded for three years. If necessary, INP extends funding, e.g. to ensure the completion of project work and publications in parallel to the dissertation. In 2018-2020, 28 doctorates were completed. The average duration currently amounts to four years.

Further details on the supervision and employment of doctoral candidates are part of the internal **guideline** "Regulation on the Employment of Doctoral Candidates". This guideline exists since 2016 and was updated in 2020. The included INP **supervision agreement** aims at providing equal and transparent conditions for all doctoral candidates and an impetus for the personnel development planning. It includes details e.g. regarding mentoring, involvement in research projects, participation in conferences, secondment to

other research institutions, in-house training and courses. PhD students have the possibility to participate in **structured programmes** such as the International Helmholtz Graduate School for Plasma Physics, the Greifswald Graduate School in Science, and the Greifswald's Graduate Academy.

### Science supporting staff

INP established a vocational training programme in 2015 for the profession of industrial mechanic. Since then, one training has been successfully completed. Currently, one person is being trained.

INP facilitates special professional training courses. All employees have access to personalised support for their professional and social skills. Internal and external seminars and workshops are offered as the most common training measures.

### Equal opportunities and work-life balance

As of June 30th, 2020, 35 of the 99 employees in Research and scientific services were women (35%), i.e. in terms of individual scientific status groups, 9 of the 19 doctoral students and 4 of 21 leadership personnel. INP intends to increase the share of women on the first and second levels of scientific leadership positions to 25% (Board of Directors 2020: 0%, heads of research programmes and scientific departments 2020: 17%) and to 50% on the third level (heads of research groups and junior research groups 2020: 33%). According to internal statistics of 2020, applications by women account for only about 20% in natural sciences and for 35% in biology/medicine. Therefore, the institute intends to pay more strategic attention to the targeted and direct addressing of potential female candidates. INP staff take part in mentoring programmes and special trainings. A gender equality plan was implemented in 2020 and a career programme for female scientists will commence in 2021.

Every four years, female staff elect a **gender equality officer** and a deputy. Both officers are exempt for gender equality tasks for at least 50% of their working hours. In 2014, the institute was certified with the *Total E-quality* certificate, with two successful re-certifications in 2017 and 2020.

INP supports **work-life balance** with a series of measures (e.g. core working time, mobile working). Individual solutions are made possible for special family reasons (e.g. for employees returning to work after longer absences).

## 6. Cooperation and environment

INP has a long-lasting partnership with **University of Greifswald** which is one of the institute's founding members. Since 2003, the scientific director is a jointly appointed professor in Experimental Physics. As a result of the cooperation between the University Medicine Greifswald and INP, a joint professorship for "Plasma Medicine" was established in 2011. From 2005-2017, INP, the Institute for Physics at the University of Greifswald and researchers from Kiel University worked together in the Collaborative Research Centre Transregio 24 "Fundamentals of Complex Plasmas".

Since the last evaluation, INP has expanded its cooperation with the **University of Rostock**. Then, there were two joint professorships, one in "Applied physics – Bioelectrics" and one in "High Voltage and High Current Technologies". After the latter terminated his joint professorship and left INP in 2015, there are two further joint professorships now:

- In early 2017, the head of the research division "Materials & Energy" was appointed joint professor for "High Voltage and High Current Technologies"
- In September 2017, the head of INP's research programme "Plasma Chemical Processes" was appointed joint professor for "Plasmas for Surfaces"

In the framework of joint research projects, partnerships with many other universities, technical universities, and universities of applied sciences in Germany are maintained. The **teaching activities** of staff members of INP comprise a variety of fields at different levels. This includes supervisions of bachelor, master and PhD theses.

Within **Leibniz Association**, INP is involved in two Research Alliances (Energy transition, Health technologies) and the Research Network "Immune-Mediated Diseases". INP also collaborates with several institutes of the Fraunhofer Society, the Centre for Material and Coastal Research in Geesthacht (HZG) and the Centre in Dresden-Rossendorf (HZDR) of the Helmholtz Association, as well as the Max Planck Institute for Plasma Physics, Greifswald branch.

INP's **international collaborations** mainly concern scientific research and education in the field of low-temperature plasmas for applications. The strategic partnerships with the Universities of Bari, Brno, Cambridge, Oxford, Riga, and Tomsk are emphasised by agreements of collaboration. These include joint training agreements, guest lectures, and internships for junior scientists. Collaborations have been initiated with partners in South Korea (see chapter 3) and Taiwan as these countries have developed plasma-technology through large government funded programmes.

Within the **European Union**'s 7th Framework Programme (FP7), the major project "PlasmaShape" (plasma applications) was funded and conducted at INP. In Horizon 2020, the project "HiPowAR" is coordinated by INP. There, INP and partners from Czech Republic, Germany, Italy, and Sweden aim to develop technology in the direct conversion of ammonia into energy.

INP cooperates closely with five local **companies** spun off by the institute since its foundation. These spin-offs are neoplas GmbH, neoplas control GmbH, neoplas med GmbH, ColdPlasmaTech GmbH, and Nebula Biocides GmbH.

### Institution's status in the specialist environment

According to INP, low-temperature plasmas are being studied at various locations in Germany. Among all these institutions, INP considers the Fraunhofer Institute for Surface Engineering and Thin Films (IST) in Braunschweig and the Fraunhofer Institute for Electron Beam and Plasma Technology (FEP) in Dresden as the largest and leading institutions in the field of applied research. Besides INP, the Ruhr University Bochum (RUB) is perceived to be the most developed and leading institution in the field of fundamental research.

The majority of institutions in international plasma research are larger than INP. With regard to the range of topics and INP's fields of activity, according to INP, internationally leading institutions include Eindhoven University of Technology (The Netherlands), LAPLACE at the Paul Sabatier University, Toulouse (France), and Drexel University in Philadelphia (USA).

## 7. Subdivisions of INP

**Research division "Materials & Energy"**

### 7.1 Research programme “Materials and Surfaces”

[19.2 FTE, thereof 11.8 FTE Research and scientific services, 2.4 FTE Doctoral candidates, and 5.0 FTE Science supporting staff]

The research programme “Materials and Surfaces” focuses on the study of innovative plasma processes and the application of technical plasmas for thin film deposition and material synthesis. The concept aims at the experimental characterisation and modelling of the basic plasma properties underlying these technical processes. Research further explores the correlation with the resulting microscopic structure and composition of the synthesised thin film materials as well as its technical properties. Knowledge of this correlation may result in better controlled manufacturing processes, which in turn leads to superior products.

Regarding application areas, the research programme has mainly dealt with three topics: 1. coatings and materials for electro-catalysis and hydrogen technology, for battery and fuel cell technology, noted in short as “Materials for Renewable Energies”; 2. “Functional Coatings” e.g. for adhesion promotion; and 3. “Photonics” for optical precision coatings and synthesis of optical fibres including aspects of plasma based process control to promote Industry 4.0 standards within plasma surface processing.

In recent years, a strong strategic focus has been placed on topic 1 which, in the transfer sector, resulted in the major initiative “Campfire” coordinated by INP (see chapter 3). The initiative, devoted to fuel and energy storage using ammonia in particular, is intended to form the backbone of research for years to come. INP states that research on this topic has already led to new and promising concepts for the synthesis of nanostructured materials including correlations between plasma parameters and surface microstructure. Significant progress was also achieved in disclosing the fundamental mechanisms of atmospheric-pressure plasmas for film deposition (topic 2) and on in-situ monitoring of coating processes (topic 3).

Over the period 2018-2020, the programme published on average 19.3 articles in peer-reviewed journals and 4.7 articles in peer-reviewed proceedings per year. Average yearly project grants amounted to € 2M over the same period and were obtained mostly from Federal and *Länder* governments (€ 850k), the EU (€ 640k), and the Leibniz Association (€ 430k). In 2018-2020, in total, 1 patent, 2 other industrial property rights and 6 exploitation rights/licences were granted and 1 doctoral degree was completed.

### 7.2 Research programme “Plasma Chemical Processes”

[17.1 FTE, thereof 13.5 FTE Research and scientific services, 1.3 FTE Doctoral candidates, and 2.3 FTE Science supporting staff]

The overall goal of the research programme “Plasma Chemical Processes” is to link breakdown and formation processes in reactive, molecular plasmas with induced chemical processes. Based on the core competences in plasma diagnostics and modelling, it aims to improve the understanding of industrial processes, to develop new approaches for the control and optimisation of plasma processes, and to design new chemical processes and reactors working at elevated pressures. One focus is on the detection and monitoring of key species (charged and neutral plasma species). Further investigations examine the kinetics of transient molecular species in plasma processes, like etching, nitriding/nitrocarburising, and deposition in particular in nitrogen-carbon-hydrogen plasmas at low pressure. Within the last few years, the spectrum of high-end laser absorption methods has been extended beyond the mid-infrared spectral region spanning a spectral range from ultraviolet to terahertz.

The research programme continues the activities of the former research programme “Process Monitoring”. However, it emphasizes more on the fundamental understanding and improvement of plasma-chemical processes. Moreover, it has begun to include reactive plasmas at atmospheric pressure because of their increasing interest in industry. Important plasma species in plasma jets, e.g. radicals, were identified and quantified. Several fundamental results for dielectric barrier discharges, in particular discharge regimes, elementary processes of plasma generation and instabilities, are the basis for dedicated plasma reactor concepts. These results were achieved by using high-resolution measurements in combination with multidimensional and reaction kinetics modelling.

Over the period 2018-2020, the programme published on average 16.3 articles in peer-reviewed journals and 7.7 articles in peer-reviewed proceedings per year. Average yearly project grants amounted to € 1.1M over the same period and were obtained mostly from Federal and *Länder* governments (€ 390k), the DFG (€ 370k), and industry (€ 230k). In 2018-2020, in total, 21 exploitation rights/licences were granted and 3 doctoral degrees were completed.

### 7.3 Research programme “Welding and Switching”

[11.5 FTE, thereof 9.5 FTE Research and scientific services, 2.0 FTE Science supporting staff]

The research programme “Welding and Switching” focuses on the physics, diagnostics and mathematical simulation of thermal plasmas and their interactions with bordering regions (electrodes, walls). In particular, electric arcs in technological applications and discharge phenomena in electric systems and devices during switching or owing insulation failures are considered. Along with fundamentals on arc plasmas, current research aims at timely topics like extending industry digitalisation (Industry 4.0), growing use of renewable electric energy sources and the search for environment-neutral technologies. These comprise optical sensors, process control, switching phenomena in DC grids, as well

as decentral power generation and its integration, among others. Related areas of the application of thermal plasmas, such as high-temperature waste treatment and chemical conversion (Power2X), are also explored.

In order to meet the scientific challenges, the research programme relies on in-house expertise. Experimental work with high-performance devices and power sources using state-of-the-art diagnostic methods in spectroscopy and imaging systems is combined with multi-physics mathematical modelling and simulation of arc discharges.

According to INP, important achievements over the past years include the discovery of a new arc-attachment mode in vacuum arcs as well as the progress in non-equilibrium arc modelling and in optical sensors for arc welding monitoring. Intense cooperation with industry permitted the direct application of methods and infrastructure on projects to improve welding processes and for switching performance optimisation of low and high voltage switchgear. The work is located mainly in Greifswald as well as in Rostock.

Over the period 2018-2020, the programme published on average 14.7 articles in peer-reviewed journals and 11.3 articles in peer-reviewed proceedings per year. Average yearly project grants amounted to € 600k over the same period and were obtained mostly from industry (€ 220k), Federal and *Länder* governments (€ 190k), and the DFG (€ 160k). In 2018-2020, in total, 1 patent and 1 exploitation right /licence were granted and 1 doctoral degree was completed.

## Research division "Environment & Health"

### 7.4 Research programme “Bioactive Surfaces”

[7.2 FTE, thereof 5.0 FTE Research and scientific services, 1.7 Doctoral candidates, and 0.5 FTE Science supporting staff]

The research programme “Bioactive Surfaces” focuses on the development of plasma-based modification processes to engineer surfaces and materials interacting with biological systems. Modern life science research, biotechnology, and medical technology require specific physico-chemical surface properties, which can be realised by the generation of different functional groups on a broad range of 2D/3D materials. The approaches rely on advanced surface modification technologies based on low-pressure as well as atmospheric-pressure plasma processes, such as PECVD, HiPIMS, and plasma electrolytic polishing, and also include laser technology and wet-chemical processes. Plasma-based processes are developed and investigated for creating antimicrobial, biocompatible and/or biomimetic surfaces as well as methods for cleaning and deburring of medical devices (e.g. scaffolds). The focus of the research programme is on the modification of surfaces for the immobilisation of enzymes, bacteria or cells for medical devices (e.g. implants), and on bio-catalytic systems. With the implementation of the junior research group “Biosensing Surfaces”, research activities on atmospheric-pressure plasma processes for the generation of functional coatings on biosensing platforms were intensified and strengthened.

The research programme follows a multidisciplinary approach combining plasma physics/chemistry, materials engineering, polymer chemistry, and expertise from biosciences. In-depth characterisation of material surfaces is conducted by a multitude of analytical

tools. Furthermore, interfacial phenomena are investigated in correlation with biological and environmental surface interactions. The research programme pursues application-oriented and industry-driven research with focus on upscaling and transfer of processes and technology, i.e. from fundamental research to its application.

Over the period 2018-2020, the programme published on average 10.7 articles in peer-reviewed journals and 0.7 articles in peer-reviewed proceedings per year. Average yearly project grants amounted to € 540k and were obtained mostly from Federal and *Länder* governments (€ 380k) and industry (€ 150k). In 2018-2020, a total of 1 patent and 2 exploitation rights/licences were granted.

### 7.5 Research programme "Plasma Medicine"

[30.0 FTE, thereof 17.6 FTE Research and scientific services, 5.4 Doctoral candidates, and 7.0 FTE Science supporting staff]

Plasma medicine is an innovative research area at the interface between physics and life sciences, which is focused on the medical use of cold atmospheric-pressure plasmas (CAP). Besides its antimicrobial activities, exposure of mammalian cells to physical plasma can lead to either stimulation or inhibition of cellular function. Key research areas are engineering and plasma physical investigation of CAP sources. The aim is to exploit a differentiated interaction of specific plasma components with specific structural as well as functional elements or functionalities of living cells to effectuate therapeutic effects.

In recent years, the research programme "Plasma Medicine" has pursued the strategy of focusing its research on molecular mechanisms of plasma-cell and plasma-tissue interaction. The results scientifically substantiate clinical CAP application in wound healing and cancer treatment and further foster CAP technology transfer to industry. A research highlight was a substantial deciphering of molecular mechanisms of direct stimulation of wound healing by CAP independent on antiseptic effects, which was proven in a clinical trial in 2020. The research programme uses a wide range of methods and techniques of plasma diagnostics and plasma source engineering on the one hand and microbiological as well as cell- and molecular-biological methods on the other hand. The work is located in Greifswald and Karlsburg.

Over the period 2018-2020, the programme published on average 51 articles in peer-reviewed journals and 2 articles in peer-reviewed proceedings per year. Average yearly project grants amounted to € 3.7M and were obtained mostly from Federal and *Länder* governments (€ 3.5M), industry (€ 120k), and DFG (€ 110k). In 2018-2020, in total, 11 patents, 7 other industrial property rights and 2 exploitation rights/licences were granted and 17 doctoral degrees were completed.

### 7.6 Research programme "Decontamination"

[25.9 FTE, thereof 17.3 FTE Research and scientific services, 2.5 Doctoral candidates, and 6.1 FTE Science supporting staff]

The research programme "Decontamination" focuses on the development, analysis, and optimisation of plasma-based methods and processes for the inactivation of microorganisms and the degradation of contaminants by plasma technologies. Approaches are investigated for environmental protection (especially for the biological and chemical decontamination of air and water), food security and preservation, occupational and personal safety, and the reduction of germs in medical and healthcare facilities. In addition, the support of germination, growth and metabolisms of crops by plasma treatments resulted in the establishment of the research group "Plasma Agriculture". At the same time, the continuous applied research on decontamination means for personal hygiene has culminated in the spin-off of the commercial enterprise Nebula Biocides GmbH.

Achievements of the research programme are based on state-of-the-art methods for the generation and study of electrical discharges, which include pulsed discharges, dielectric barrier discharges, and microwave driven discharges in different configurations. Different mechanisms, such as the generation of radicals and reactive species, charged particles, ultra-violet emission, and electric fields, can be emphasised and exploited either directly or indirectly, e.g. for the subsequent application of plasma-treated water as disinfectant. In order to address interdisciplinary questions, the research programme strongly relies on in-house expertise in microbiology, environmental science, food technology, and plant biology in addition to core competencies in plasma physics, engineering, and modelling.

Over the period 2018-2020, the programme published an average of 26 articles in peer-reviewed journals and 2 articles in peer-reviewed proceedings per year. Average yearly project grants amounted to € 850k and were obtained mostly from Federal and Länder governments (€ 800k) and industry (€ 50k). In 2018-2020, in total, 6 patents, 1 other industrial property right and 4 exploitation rights/licences were granted and 6 doctoral degrees were completed.

## 8. Handling of recommendations from the previous evaluation

INP responded as follows to the 10 recommendations of the last external evaluation (highlighted in italics, see also statement of the Senate of the Leibniz Association issued on 23 March 2015, pages B-3/B-4):

1) *"The expertise available in the Plasma Diagnostics Department, to which process monitoring is assigned, should be exploited more fully by both Research Divisions. It is suggested that the important topic of process monitoring should be included in the title of the Research Division (e.g. Plasma Processes for Materials and Energy) and thus highlight the division's particular strength in this field."*

   Since the last evaluation, a main activity of the department "Plasma Diagnostics" has been the extension of high-end laser absorption methods from UV to terahertz for atomic and molecular species detection. The department continues to develop and

apply novel diagnostics in close connection to the research fields investigated at INP, e.g., plasma surface coating processes and plasma sources for biomedical applications. In 2019, a new application laboratory for plasma diagnostics of atmospheric-pressure plasma sources was established. With this laboratory, laser-based plasma diagnostics will become available for internal as well as external partners in the coming years. However, the label "Plasma Processes for Materials and Energy" for the research division would be misleading because of the limitation to processes and to just this research division. All major topics "Materials", "Energy", "Environment", and "Health" deal with plasma processes in both fundamental and applied research. Therefore, this is seen as a cross-programme core competence, similar to modelling/simulation, plasma source development, or data management.

2) *"Worldwide, INP is one of the most appropriate places, if not the most appropriate, for driving research in the new field of plasma medicine and plasma biology in the coming years. The institute is aware that, in scientific terms, this internationally still young research area is, in the best sense of the word, high-risk. Against this backdrop, INP is firstly recommended to intensify existing contacts with the medical sector and include clinical trials at an early stage. Secondly, contacts should be sought to companies to alert them to the potential for medical and biological applications and awaken industrial interest early on."*

   This recommendation fits well with INP's strategy to strengthen contacts to the medical sector and to international companies including device manufacturers for a sustainable development of the research fields of plasma medicine and biology and to support the transfer of research results into the medical practice. Complementary, INP has aimed to expand and to strengthen the topic of plasma decontamination and to intensify contacts to the hygiene sector, the food industry and the agricultural sector. Here, synergies to other research programmes have been used to a larger extent.

   In order to pool competencies in the fields of diabetes and plasma technology and to achieve a closer collaboration with medical partners in wound-healing issues, the Competence Centre Diabetes Karlsburg was established (see chapter 3). For clinical trials the lead of clinicians is needed. INP contributed to a clinical randomized controlled trial (RCT) study on patients with diabetic foot ulcers performed by clinical cooperation partners, which was published in July 2020.

   Project-based cooperations with new industrial partners have been initiated. INP sees the lack of availability of industrial partners (number, financial power) and their limited readiness to assume risk (regulations on medical devices, German reimbursement system) as main challenges in this field of transfer.

3) *"The Federal Government and the Land Mecklenburg-Vorpommern are recommended to continue providing their important third-party funding for research in plasma medicine and plasma biology. Starting second respective funding phases would be greatly welcomed; access to bridging funding, if required, should also be facilitated to ensure the continuation of these activities at the institute. Furthermore, based on the success of this support, the Federal Government and the Land should work together with INP leadership to put the new research direction at the institute on a permanent footing."*

Based on this recommendation, INP applied successfully for research funding in plasma medicine and plasma biology which led to the two junior research groups "Plasma Redox Effects" and "Plasma Liquid Effects" (funded by BMBF). Furthermore, strategic investments for the Centre for Innovation Competence (ZIK) *plasmatis* were granted.

In addition, INP applied for an increase in institutional funding (*Sondertatbestand*, see chapter 3) at the end of 2014 to put the research directions plasma medicine and biology on solid ground. Following the granting of this additional budget, eleven permanent positions for scientists in the field of plasma medicine and related topics were realised and have enabled the long-term preservation of know-how in this specific field.

4) *"Following on from the pleasing increase in the publication record, it is now time to pursue a yet more targeted publication policy. Outcomes that are of relevance to applications or are of interest to companies should be published differently from fundamental scientific findings. To a much greater extent than has been the case so far, fundamental results should reach the entire physics community, i.e. beyond plasma physics, via high-impact journals. Above all, however, it is important to reach other disciplines that have now become of major potential interest to INP's work, particularly medicine and biology."*

   With respect to this recommendation, INP claims to have adapted its publication policy (see chapter 2): on the one hand, it is now more targeted on fundamental scientific findings and, on the other hand, on results with high relevance to applications. The institute has further supported the publication of fundamental findings in journals reaching the entire physics community as well as the publication of interdisciplinary work in high-impact journals e.g. in the biomedical field. The more than 350 articles in peer-reviewed journals during 2018 and 2020 were published in about 160 different journals.

5) *"In addition to the appointments made since 2011, INP envisages that every head of a Research Programme should hold a W2 professorship. This plan is welcomed. Due to the age-structure amongst senior scientists it will only be possible to implement this plan in the long term."*

   This recommendation has encouraged INP to pursue its strategy for staff development, where the appointment of professorships is a joint responsibility of INP and the cooperating universities. In the long term, every head of a research programme should hold a W2 professorship or a comparable position. At present, three out of six research programmes are managed by W2 professors.

6) *"The path embarked upon to invite a larger number of scientists from abroad and increase the number of visits abroad by INP researchers should be consolidated. The institute is recommended, in particular, to utilize the EU's Marie Curie Programme."*

   According to INP, since the last evaluation, the number of guest scientist from abroad could be consolidated and has ranged between 30 and 60 per year. The number of visits abroad by INP researchers with stays longer than a week could also be

consolidated on the level of the last evaluation, with most of the stays lasting less than a week. In the last few years, INP activities within EU's Horizon 2020 section "Marie Skłodowska Curie Actions" have been increased and resulted in an ITN grant starting eventually from 1 March 2021.

7) *"A comparatively large number of INP's leading scientists have spent a significant part of their academic careers in Greifswald. It can be seen that INP's new topics are leading to a greater number of appointments of both male and female researchers from other parts of Germany and abroad. When recruiting doctoral candidates and other scientists the institute must, however, pursue a policy of more comprehensive internationalization."*

   This recommendation, according to the institute, is consistent with the staff development strategy. Now, about 30 % of scientists at INP come from abroad.

8) *"There is an urgent need to improve the situation in gender equality, especially with respect to leading positions. INP must take this into account in case of new appointments. Given that there is unlikely to be significant fluctuation amongst the 12 leading scientists in higher income groups in the immediate future, INP has to find other ways to attract female scientists, e.g. by mid-term or long-term exchange programmes with other institutes. The number of women amongst the scientists in non-executive positions must also be increased."*

   INP points to activities regarding gender equality and equal opportunities with the aim to increase the share of women in leading positions and at the institute in general (see chapter 5).

9) *"The number of doctoral candidates should be increased even further."*

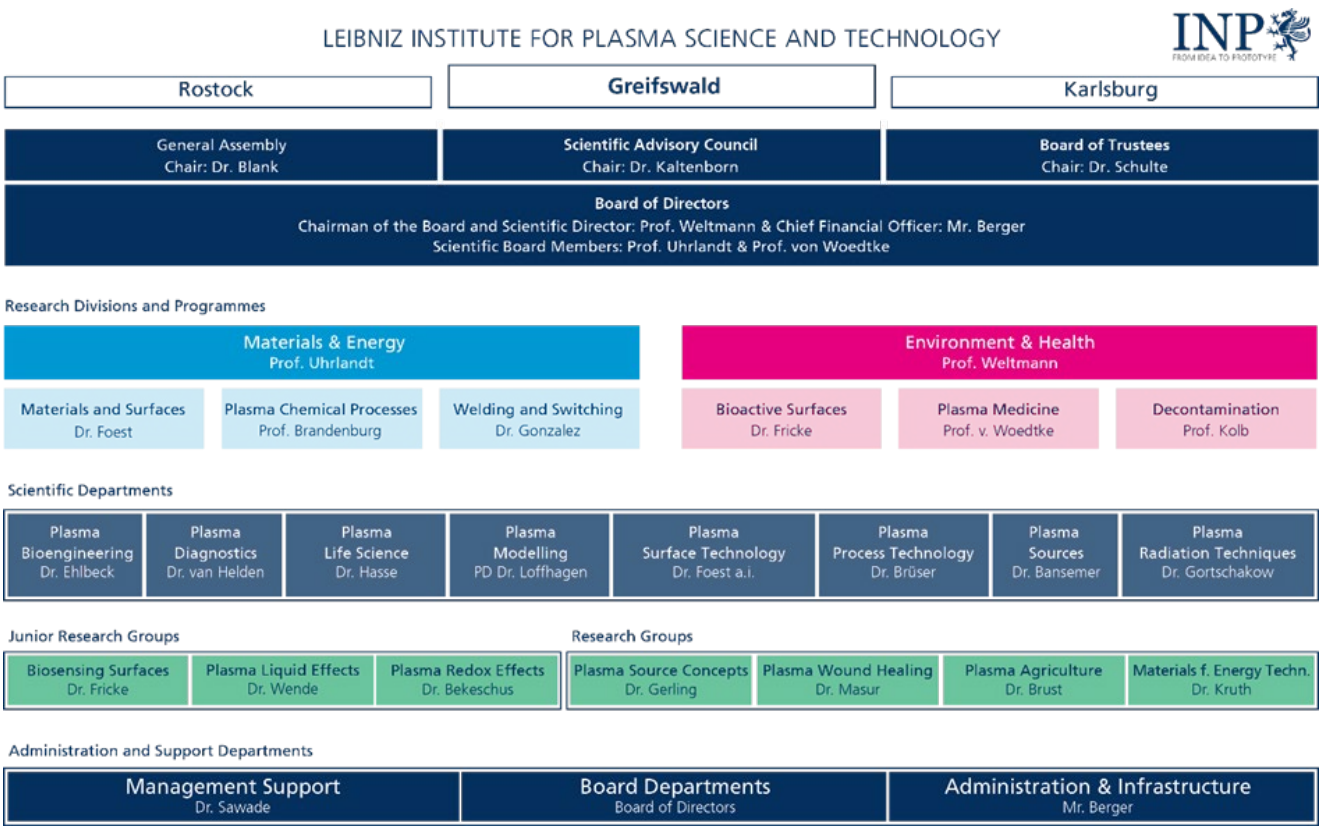
   The recommendation of an increase of the number of doctoral candidates has been clearly recognized by INP as an ongoing task. Since the last evaluation, the number of doctoral candidates employed at INP varied between 20 and 25. A further increase is still being sought.

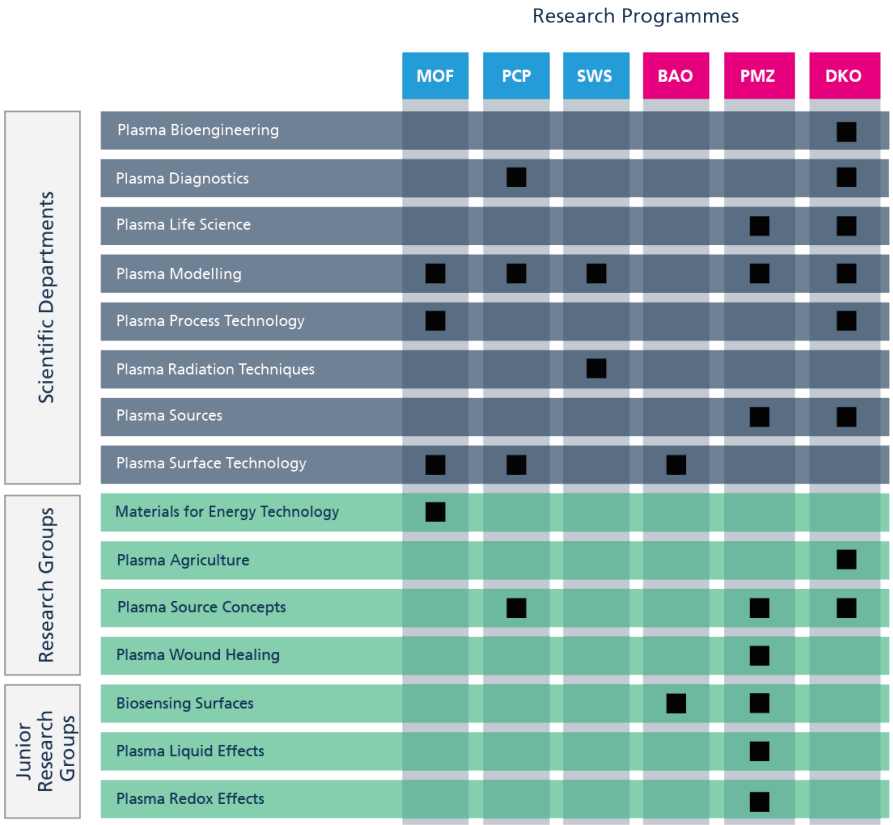
10) *"The staff appointment plan is still, unfortunately, binding. This and other restrictions to flexible resource management occurring in practice should be aligned with the relevant agreements between the Federal Government and the Länder without further delay."*

    INP highly welcomed this recommendation and the request for agreements between Federal Government and *Land* to remove restrictions to a flexible resource management without further delay.

# Appendix 1

## Organisational chart and matrix structure



## Appendix 2

### Publications and patents

| | Period | | |
|---|---|---|---|
| | **2018** | **2019** | **2020** |
| **Total number of publications** | 200 | 170 | 190 |
| Monographs | 0 | 0 | 0 |
| Individual contributions to edited volumes | 12 | 4 | 6 |
| Articles in peer-reviewed journals | 116 | 109 | 135 |
| Articles in peer-reviewed proceedings | 41 | 21 | 13 |
| Articles in other journals | 6 | 9 | 18 |
| Working and discussion papers (final project reports) | 23 | 26 | 18 |
| Editorship of edited volumes | 2 | 1 | 0 |

| **Industrial property rights** | **2018** | **2019** | **2020** |
|---|---|---|---|
| Patents (granted/applied) | 5/16 | 10/10 | 5/14 |
| Other industrial property rights (granted/applied) | 7/0 | 1/1 | 2/1 |
| Exploitation rights/licences (number) | 11 | 13 | 12 |

# Appendix 3 Revenue and expenditure

| Revenue | | 2018 | | | 2019 | | | 2020[1)] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | k€ | % | % | k€ | % | % | k€ | % | % |
| **Total revenue (sum of I., II. and III.; excluding DFG fees)** | | **17.516,9** | | | **19.575,9** | | | **20.065,7** | | |
| **I.** | **Revenue (sum of I.1., I.2. and I.3)** | **17.209,5** | **100 %** | | **19.380,6** | **100 %** | | **20.018,6** | **100 %** | |
| 1. | INSTITUTIONAL FUNDING (EXCLUDING CONSTRUCTION PROJECTS AND ACQUISITION OF PROPERTY) | 10.213,7 | 59,3 % | | 9.594,6 | 49,5 % | | 9.684,6 | 48,4 % | |
| 1.1 | Institutional funding (excluding construction projects and acquisition of property) by Federal and *Länder* governments according to AV-WGL | 10.213,7 | | | 9.594,6 | | | 9.684,6 | | |
| 1.2 | Institutional funding (excluding construction projects and acquisition of property) not received in accordance with AV-WGL | 0,0 | | | 0,0 | | | 0,0 | | |
| 2. | REVENUE FROM PROJECT GRANTS | 6.863,2 | 39,9 % | 100 % | 9.605,4 | 49,6 % | 100 % | 10.176,6 | 50,8 % | 100 % |
| 2.1 | DFG | 439,2 | | 6,40 % | 709,7 | | 7,4 % | 776,5 | | 7,6 % |
| 2.2 | Leibniz Association (competitive procedure) | 815,0 | | 11,87 % | 644,8 | | 6,7 % | 231,0 | | 2,3 % |
| 2.3 | Federal, *Länder* governments | 4.589,0 | | 66,86 % | 7.297,0 | | 76,0 % | 6.440,2 | | 63,3 % |
| 2.4 | EU | 0,0 | | 0,0 % | 0,0 | | 0,0 % | 1.933,3 | | 19,0 % |
| 2.5 | Industry | 989,0 | | 14,41 % | 942,9 | | 9,8 % | 753,7 | | 7,4 % |
| 2.6 | Foundations (DBU) | 25,1 | | 0,37 % | 0,0 | | 0,0 % | 0,0 | | 0,0 % |
| 2.7 | Other sponsors (DAAD) | 5,9 | | 0,09 % | 11,0 | | 0,1 % | 41,9 | | 0,4 % |
| 3. | REVENUE FROM SERVICES | 132,6 | 0,8 % | | 180,6 | 0,9 % | | 160,2 | 0,8 % | |
| 3.1 | Revenue from commissioned work | 62,9 | | | 49,8 | | | 45,7 | | |
| 3.2 | Revenue from publications | 0,0 | | | 0,0 | | | 0,0 | | |
| 3.3 | Revenue from exploitation of intellectual property for which the institution holds industrial property rights (patents, utility models etc.) | 68,0 | | | 129,0 | | | 109,2 | | |
| 3.4 | Revenue from exploitation of intellectual property without industrial property rights | 1,7 | | | 1,8 | | | 2,5 | | |
| 3.5 | Revenue from other services | 0,0 | | | 0,0 | | | 0,0 | | |
| **II.** | **Miscellaneous revenue** (e.g. membership fees, donations, rental income, funds drawn from reserves) | **307,4** | | | **195,3** | | | **47,1** | | |
| **III.** | **Revenue for construction projects** (institutional funding by Federal and *Länder* governments, EU structural funds, etc.) | **0,0** | | | **0,0** | | | **0,0** | | |

| Expenditures | | k€ | k€ | k€ |
|---|---|---|---|---|
| **Expenditures (excluding DFG fees)** | | **17.634,1** | **19.567,9** | **19.625,4** |
| 1. | Personnel | 10.624,3 | 10.634,7 | 11.398,1 |
| 2. | Material expenses | 2.164,5 | 2.047,9 | 2.297,9 |
| 2.1 | *Proportion of these expenditures used for registering industrial property rights (patents, utility models etc.)* | *206,5* | *167,5* | *238,5* |
| 3. | Equipment investments | 2.933,7 | 4.971,6 | 2.773,1 |
| 4. | Construction projects, acquisition of property | 0,0 | 0,0 | 0,0 |
| 5. | Other operating expenses | 1.911,6 | 1.913,7 | 3.156,3 |

| | | | |
|---|---|---|---|
| DFG fees (if paid for the institution – 2.5% of revenue from institutional funding) | 246,3 | 249,0 | 254,3 |

*[1] Preliminary data: yes*

# Appendix 4

## Staff

(Basic financing and third-party funding / proportion of women (as of: 30 June 2020)

| | Full time equivalents | | Employees | | Female employees | | Foreigners |
|---|---|---|---|---|---|---|---|
| | Total | on third-party funding | Total | on temporary contracts | Total | on temporary contracts | Total |
| | Number | Percent | Number | Percent | Number | Percent | Number |
| **Research and scientific services** | **87,8** | 65,3 | **99** | 73,7 | **35** | 88,6 | **27** |
| 1st level (scientific directors) | 3,0 | 0,0 | 3 | 0,0 | 0 | 0,0 | 0 |
| 2nd level (department and research programme leaders) | 12,0 | 8,3 | 12 | 8,3 | 2 | 0,0 | 1 |
| 3rd level (research and junior research group leaders) | 6,0 | 83,3 | 6 | 66,7 | 2 | 100,0 | 0 |
| Scientists in non-executive positions (A13, A14, E13, E14 or equivalent) | 53,6 | 80,5 | 59 | 83,0 | 22 | 90,9 | 19 |
| Doctoral candidates (A13, E13, E13/2 or equi.) | 13,2 | 62,0 | 19 | 100,0 | 9 | 100,0 | 7 |
| **Service positions** | **32,7** | **27,4** | **33** | | | | |
| Laboratory (E9 to E12, upper-mid-level service) | 18,7 | 42,5 | 19 | | | | |
| Laboratory (E5 to E8, mid-level service) | 4,0 | 25,0 | 4 | | | | |
| Workshops (E9 to E12, upper-mid-level service) | 2,0 | 0,0 | 2 | | | | |
| Workshops (E5 to E8, mid-level service) | 3,0 | 0,0 | 3 | | | | |
| Information technology - IT (E9 to E12, upper-mid-level service) | 4,0 | 0,0 | 4 | | | | |
| Technical (large equipment, service; E5 to E8, mid-level service) | 1,0 | 0,0 | 1 | | | | |
| **Administration**[1] | **30,8** | 14,2 | **33** | | | | |
| Head of the administration | 1,0 | 0,0 | 1 | | | | |
| Staff positions (from E13, senior service) | 10,9 | 30,9 | 12 | | | | |
| Staff positions (E9 to E12, upper-mid-level service) | 5,0 | 20,0 | 5 | | | | |
| Internal administration (financial administration, personnel, etc., E9 to E12, upper-mid-level service) | 10,6 | 0,0 | 11 | | | | |
| Internal administration (financial administration, personnel, etc., E5 to E8, mid-level service) | 2,3 | 0,0 | 3 | | | | |
| Building service (E1 to E4) | 1,0 | 0,0 | 1 | | | | |
| **Student assistants** | **7,1** | 68,2 | **29** | | | | |
| **Trainees** | **1,0** | 0,0 | **1** | | | | |
| **Scholarship recipients at the institution** | **1,0** | 100,0 | **1** | | **0** | | **1** |
| Doctoral candidates | 1,0 | 100,0 | 1 | | 0 | | 1 |
| Post-doctoral researchers | 0,0 | 0,0 | 0 | | 0 | | 0 |

[1] Includes staff of the INP-units „Administration & Infrastructure“, „Management Support“ and “Board Departments” (s. Appendix 1)

2 December 2021

# Annex B: Evaluation Report

# Leibniz Institute for Plasma Science and Technology, Greifswald (INP)

## Contents

## 1. Summary and main recommendations

The INP conducts fundamental research in the field of low-temperature plasma physics as well as application-oriented research on plasma technology. It specialises in research into cold plasmas. These have reactive properties that can be used, for example, in the decontamination of heat-sensitive objects or in wound healing. The institute successfully conducts research into these and other fields of application and develops low-temperature plasma technologies. INP is internationally visible as a major player in its academic fields.

The institute has developed very well since the last evaluation. As recommended at that time, research in the fields of plasma medicine and plasma biology has been strengthened. A new Plasma Life Science department has been set up and, in recent years, the INP has established another emerging field, plasma agriculture, that ties in very well with the existing expertise. The introduction of (junior) research groups is particularly welcomed, because they allow the INP to respond to new trends at short notice. Moreover, the INP has effectively strengthened its access to clinical research through strategic partnerships. Now is the time to also consider areas where the institute's activities can be reduced in order to balance out recent expansions (see recommendation 2).

The increased interdisciplinarity of the INP's research profile is reflected in many publications in a broad spectrum of journals (see recommendation 1). The institute's successful transfer strategy is based on in-house development of concepts and prototypes, strategic partnerships with industry and bilateral contracts with industrial partners. It is remarkably active in the area of spin-offs. Two new companies have been set up since the last evaluation. The impressively high level of third-party funding secured by the INP has been maintained since the last evaluation, representing an average of 47% of the institute's total revenue (2018–2020). The institute is encouraged to keep up its very successful strategy for acquiring project funds, especially DFG and EU funding, and to place a particular focus on competitive funding.

The institute is managed very well by its Board of Directors. The INP's convincing scientific developments since the last evaluation were comprehensively orchestrated by an internal review process and in close consultation with the Scientific Advisory Board. INP offers attractive working conditions and has an appropriate set of career planning schemes in place. As increased attention to attracting postdoctoral researchers is necessary in terms of nationwide and international staff acquisition, this should be made more visible when advertising open positions.

The INP has further strengthened its links to local universities over the past few years, ensuring continued close interaction within the region's academic landscape. Joint appointments exist with the University of Greifswald and the University of Rostock.

Special consideration should be given to the following main recommendations in the evaluation report (highlighted in **bold face** in the text):

<u>Overall concept, activities and results</u> (chapter 2)

1. The INP's research activities in the field of low-temperature plasmas are internationally visible, as documented by numerous publications. As recommended in the last evaluation, the institute is now reaching the entire physics community beyond plasma physics very

well. At the same time, the favourable expansion of the research to new fields of application, particularly medicine and biology, has led to a broadened research profile. This is reflected in publications in these disciplines that have now become of major potential interest to INPs work. Here, too, the publication strategy should now focus on high-impact journals with an interdisciplinary readership.

Changes and planning (chapter 3)

2. The INP has developed very positively since the last evaluation, successfully introducing new research areas, setting up independent research groups and refocusing research programmes. Now the institute needs to reconsider which of the activities in the more traditional fields have the potential for cutting-edge research in future. Some topics that have been covered by the institute for a long time (e.g. welding and switching) are losing scientific potential, either because they are now well established in industry or because industry is already using other solutions (e.g. semiconductors). These areas should be realigned in the coming years.
3. The INP has named four areas on which it wants to focus its research and development activities in future: technologies for renewable energy use, health economy and aging society, bio-economy, and Industry 4.0. These fields of research certainly have great potential, not only for basic research but also for applications. However, the plans are currently formulated in very general terms and are correspondingly broad. Before it takes on new topics, the INP should develop its long-term strategy further and set out its research and development aims in more detail taking into account the abovementioned realignment required in some areas. Strategic collaboration with strong partners should be part of this strategy, especially in the new fields of bio-economy and Industry 4.0.

   Given the wide range of research fields now pursued at the INP, the strong emphasis on physics among the researchers should be reconsidered. Investment in broader professional diversity is recommended, including other professional fields and interdisciplinary hiring. In particular, the INP needs to build up in-house expertise in chemistry. To overcome this limitation in the short term, the institute should consider to establish strategic collaborations with suitable research institutes in the fields of catalysis and chemistry.

Controlling and quality management (chapter 4)

4. The proportion of women on the INP boards should be increased. Of the 10 members of the Scientific Advisory Board, only three are female. There is only one woman on the Board of Trustees.

Human resources (chapter 5)

5. Recruiting promising young scientists and supporting their development until they fit the profile of INP leadership positions appears to be a valid strategy. However, efforts to attract top scientists from outside the region and internationally should be significantly increased, for example through the further development of an appropriate advertising campaign. The INP should seek to clearly and pointedly promote the appeal of both the region and the working conditions at the institute, while at the same time actively approaching suitable candidates.

6. While the mentoring and support for PhD students is very good, their numbers vary widely between the different units and the total number of 19 individuals is far too low, at only 19% of the current scientific staff. The INP was advised during the last evaluation to increase the number of PhD students. This recommendation is now even more valid than before.
7. The share of female employees in research and scientific services has successfully been raised to 37% on the lower scientific levels (compared to 19% in 2013). There is a balanced gender ratio among doctoral candidates. The INP should continue on this path and pull the progress through to the top levels, appointing more women to 1st and 2nd level leadership positions as well.

## 2. Overall concept, activities and results

The INP conducts fundamental research in the field of low-temperature plasma physics as well as application-oriented research on plasma technology. It specialises in research into cold plasmas. These have reactive properties that can be used, for example, in the decontamination of heat-sensitive objects or in wound healing. The institute successfully conducts research into these and other fields of application of low-temperature plasmas and develops technologies to produce them. INP is internationally visible as a major player in its academic fields.

A particular strength and unique feature of the INP is the way it connects applied, industry-oriented research with basic research. In consequence, the institute operates in a very dynamic research environment, where research topics are constantly being adopted by industry, which reduces their relevance in an academic research environment. This means that the research portfolio has to be reassessed frequently (see recommendation 2).

The institute's research activities are organized into two research divisions: Materials & Energy, and Environment & Health, each consisting of three research programmes (see chapter 7). The research programmes' scientific competencies are grouped by topic into a matrix structure of eight scientific departments, research groups and junior research groups.

### Research

**The INP's research activities in the field of low-temperature plasmas are internationally visible, as documented by numerous publications. As recommended in the last evaluation, the institute is now reaching the entire physics community beyond plasma physics very well. At the same time, the favourable expansion of the research to new fields of application, particularly medicine and biology, has led to a broadened research profile. This is reflected in publications in these disciplines that have now become of major potential interest to INPs work. Here, too, the publication strategy should now focus on high-impact journals with an interdisciplinary readership.**

The INP's engagement in terms of open access publication is laudable.

### Transfer activities/translation

The INP's transfer strategy is based on in-house development of concepts and prototypes, strategic partnerships with industry and bilateral contracts with industrial partners. The INP uses this strategy very effectively to translate its research results into practical applications. In the years from 2018 to 2020, the institute applied for 40 patents and 20 were granted. The average annual revenue from intellectual property in this period was €102,000.

The INP is remarkably active in setting up spin-offs. Two new companies have been established since the last evaluation: ColdPlasmaTech GmbH in 2015, a company developing plasma-medical devices for large-surface wound healing, and Nebula Biocides GmbH in 2019, which aims to develop and certify devices for novel, economic hand disinfection.

### Research data

It is good to see that the INP is playing an important role in developing standards for research data infrastructure and is taking the lead on relevant projects. Since 2019, the INP has been operating the INPTDAT interdisciplinary plasma technology data platform, one of the first research data infrastructures for plasma technology and plasma medicine in Europe.

## 3. Changes and planning

### Development since the previous evaluation

The INP's convincing scientific developments since the last evaluation were comprehensively orchestrated by an internal review process and in close consultation with the Scientific Advisory Board. In this process, the number of research programmes was reduced from eight to six, and one new department as well as seven independent (junior) research groups were established. The introduction of these groups is a particularly welcome development because they allow the INP to respond to new trends at short notice. This is particularly important in the very fast-moving research field in which the institute operates.

A particular strength of the INP is its unique combination of plasma modelling and diagnostics. This is why it was important that the institute combined the areas of monitoring, modelling and analysis of plasma processes in 2017 to strengthen them (thereby changing the name of the Process Monitoring research programme to Plasma Chemical Processes). It is very good to see that the head of this area has been appointed to a W2 professorship in a joint appointment procedure with the University of Rostock. While the strengthening of the plasma diagnostics area is already leading to innovative research results, such as the development of a mid-infrared (MIR) frequency comb (see chapter 7.2), the plasma modelling area now needs specific further strengthening if the INP is to remain internationally competitive in this very important field.

The recommendation, made during the last evaluation, to strengthen research in the fields of plasma medicine and plasma biology, has also been implemented in a strategically sensible way. This process has been supported with additional institutional funding (minor extraordinary item of expenditure of a strategic nature, *Sondertatbestand*). A new Plasma Life Science department has been set up to establish these important, innovative research fields at the institute. In addition, in recent years, the INP has established another emerging field,

plasma agriculture, that offers excellent synergies with the field of plasma medicine and ties in very well with the existing expertise at the INP. Further strengthening, as planned, is very welcome.

As recommended in the last evaluation, the INP has strengthened its access to clinical research through strategic partnerships. And it has set up a branch office, the Diabetes Competence Centre, at the nearby Klinikum Karlsburg. Some of the work of the Plasma Medicine research programme takes place in the laboratories there, maximising contact with (and interactions within) actual clinical settings. Engaging in this kind of clinical collaboration holds enormous potential for this field. The INP aims to cover everything from basic research to patient – a laudable aim that should be pursued further.

**The INP has developed very positively since the last evaluation, successfully introducing new research areas, setting up independent research groups and refocusing research programmes. Now the institute needs to reconsider which of the activities in the more traditional fields have the potential for cutting-edge research in future (see chapter 7). Some topics that have been covered by the institute for a long time (e.g. welding and switching) are losing scientific potential, either because they are now well established in industry or because industry is already using other solutions (e.g. semiconductors). These areas should be realigned in the coming years.**

### Strategic work planning for the coming years

**The INP has named four areas on which it wants to focus its research and development activities in future: technologies for renewable energy use, health economy and aging society, bio-economy, and Industry 4.0.** The first two topics are already represented at the institute and should be expanded. The bio-economy and Industry 4.0 fields are completely new topics, which tie in well with the work on plasma agriculture, plasma diagnostics and the activities in the area of research data management. **These fields of research certainly have great potential, not only for basic research but also for applications. However, the plans are currently formulated in very general terms and are correspondingly broad. Before it takes on new topics, the INP should develop its long-term strategy further and set out its research and development aims in more detail taking into account the abovementioned realignment that is required in some areas. Strategic collaboration with strong partners should be part of this strategy, especially in the new fields of bio-economy and Industry 4.0.**

**Given the wide range of research fields now pursued at the INP, the strong emphasis on physics among the researchers should be reconsidered. Investment in broader professional diversity is recommended, including other professional fields and interdisciplinary hiring. In particular, the INP needs to build up in-house expertise in chemistry. To overcome this limitation in the short term, the institute should consider to establish strategic collaborations with suitable research institutes in the fields of catalysis and chemistry.**

## 4. Controlling and quality management

### Facilities, equipment and funding

Since the previous evaluation, the INP's core budget has increased from €7.5m in 2013 to €9.7m in 2020. In addition to the annual increases, the institute has received permanent additional funding (*Sondertatbestand*) from the federal and *Länder* governments since 2017 to support activities in the Plasma Medicine research programme.

The impressively high level of third-party funding secured by the INP has been maintained successfully since the last evaluation, representing an average of 47% of the institute's total revenue (2018–2020). In addition to steady high funding levels through project grants from several federal ministries (comprising on average 69% of the project grant revenues in the past three years), as of 2020, 19% of project grant revenue comes from EU funding for the HiPowAR Horizon 2020 project being coordinated by the INP. The INP is also successful in securing funding from DFG projects and through the Leibniz Association's competitive procedure. Around 10% of the INP's third-party funding regularly comes from industry. Overall, the institute is encouraged to keep up its very successful strategy for acquiring project funds, especially DFG and EU funding, and to place a particular focus on competitive funding in the future.

The INP operates laboratories and offices at its main facilities in Greifswald as well as at Rostock University and, since 2017, at the Diabetes Competence Centre in Karlsburg.

The institute possesses a broad range of state-of-the-art devices in its laboratories and aims to keep modernising the equipment. In recent years, increasing attention has been paid to data security and digitalization. The INP should continue to pursue these promising developments in the future.

### Organisational and operational structure

The INP is managed very well by its Board of Directors under the leadership of its Scientific Director, who has been in charge since 2003.

The matrix structure that governs the interaction between various units has been updated since the previous evaluation, and its administrative structure now includes eight scientific departments, four research groups and three junior research groups. The scientific structure currently consists of two research divisions, each with three research programmes. While this setup has proved effective in enabling innovative research within individual units and cooperation between them, the changes in the administrative structure come with an increased overall complexity of decision-making processes. It is important to ensure the continued transparency of these processes, including from an outside perspective. At the same time, the INP should make sure to maintain the flexibility of its scientific structure in order to continue to be able to adapt dynamically to new developments in the future.

### Quality management

The Board of Directors is responsible for the internal quality management at the INP, together with the heads of the research divisions and departments. On top of monthly project

reviews and research division meetings, the institute's overarching work is reviewed annually during a retreat of the senior staff, and annual strategy workshops are held within the research divisions.

A comprehensive set of quality assurance measures and structures keeps the INP in line with good laboratory practice, as well as with the guidelines for good scientific practice promoted by the Leibniz Association and the DFG. An ombudsman monitors compliance with these frameworks.

In its assessments, the INP makes use of a performance-based allocation system (LOM) based on cost and performance accounting, which in turn considers a broad range of indicators – ranging from the number of publications and patents to acquired funding, conference and teaching activities and participation in scientific committees.

The INP adheres to the guidelines on the handling of research data within the Leibniz Association and the DFG, and is committed to the FAIR principles (findable, accessible, interoperable and reusable) – especially through its INPTDAT database.

**Quality management by advisory board and supervisory board**

The Board of Trustees and the Scientific Advisory Council (SAC) monitor and evaluate the overall performance of the INP on a regular basis. The SAC performs its tasks as an external advisory board adequately. It convenes annually and additionally evaluates the INP's research efforts and work planning in a written report at least every three years. The most recent of these audits was performed in 2020.

**The proportion of women on the INP boards should be increased. Of the 10 members of the Scientific Advisory Board, only three are female. There is only one woman on the Board of Trustees.**

## 5. Human resources

As of 30 June 2020, the INP employed 99 people (87.8 FTE) in research and scientific services. The number of employees at the time of the last evaluation in 2013 was 77 (66.8 FTE). This significant increase is partly due to the intensified engagement in the medical sector, for example through additional institutional funding (minor extraordinary item of expenditure of a strategic nature, *Sondertatbestand*) in the area of plasma medicine (see chapters 4 and 7.5).

**Recruiting promising young scientists and supporting their development until they fit the profile of INP leadership positions appears to be a valid strategy. However, efforts to attract top scientists from outside the region and internationally should be significantly increased, for example through the further development of an appropriate advertising campaign. The INP should seek to clearly and pointedly promote the appeal of both the region and the working conditions at the institute, while at the same time actively approaching suitable candidates.**

### Leading scientific and administrative positions

The INP incorporates an impressive wealth of expertise in several key fields under a strong leadership. However, in view of the age structure among the top managers at the INP, several upcoming retirements can be foreseen in the intermediate future and need to be addressed in good time. Early measures should be taken as soon as possible to develop a reliable strategy for the imminent transition process.

### Postdocs and doctoral candidates

INP offers comprehensive career support measures for young scientists. Their professional development is also actively encouraged through the opportunity to gain first-hand management experience in one of the recently implemented (junior) research groups. In view of this, increased attention to attracting postdoctoral researchers may prove a rewarding strategy in terms of nationwide and international staff acquisition. Moreover, the implementation of W1 positions with tenure track would help strengthen the location while at the same time serving staff development.

**While the mentoring and support for PhD students is very good, their numbers vary widely between the different units and the total number of 19 individuals is far too low, at only 19% of the current scientific staff** (29% at the time of the previous evaluation in 2013). **The INP was advised during the last evaluation to aim to increase the number of PhD students. This recommendation is now even more valid than before**. It is noticeable, that hardly any doctoral researchers are employed in the areas with less scientific innovation potential. The refocusing of these areas should also lead to them becoming more attractive again for graduate students from various parts of the world.

### Equal opportunities and work-life balance

The INP offers attractive working conditions and has an appropriate set of career planning schemes in place. This should be made more visible when advertising open positions nationally and internationally.

**The share of female employees in research and scientific services has successfully been raised to 37% on the lower scientific levels (compared to 19% in 2013). There is a balanced gender ratio among doctoral candidates** – as there was at the time of the last evaluation. **The INP should continue on this path and pull the progress through to the top levels, appointing more women to 1st and 2nd level leadership positions as well.** Increased efforts to implement tenure track W1 appointments may be a way to encourage more young female scientists onto a career path.

## 6. Cooperation and environment

The INP has further strengthened its links to local universities over the past few years, ensuring continued close interaction within the region's academic landscape. Two jointly appointed professorships exist with the University of Greifswald, among them the one held by the current director of the INP. At the University of Rostock, in 2017, two more such positions were introduced, in addition to one existing joint professorship. Scientists employed at the

INP also make regular contributions to teaching at these universities as well as at the University of Applied Sciences in Stralsund.

A further strong regional tie has now been created between the INP and the Klinikum Karlsburg, where the jointly established Diabetes Competence Centre Karlsburg started work in 2017, effectively intensifying the INP's contacts with the medical sector as recommended in the previous evaluation (see chapter 3).

On top of the INP's noteworthy local cooperation activities, the institute also interacts closely with a substantial number of German and international universities, through an impressive number of joint projects as well as strategic cooperative partnerships. Such partnerships encompass scientific research as well as, for example, guest professorships, joint training agreements and guest lectures.

Within the Leibniz Association, the INP is involved in two Leibniz Research Alliances, dealing with energy transition and health technologies respectively, and it is part of the Research Network on Immune-Mediated Diseases. Furthermore, it has a stable cooperation track record as well as ongoing projects with a number of Leibniz Institutes. Additional strategic partnerships within the Leibniz Association should be considered to make use of synergies and existing specialist competences in the various institutes (for example in agriculture with the Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), in diabetes research with the German Diabetes Center (DDZ) and the German Institute of Human Nutrition Potsdam-Rehbruecke (DIfE) and in ammonium and catalysts research with the Leibniz Institute for Catalysis (LIKAT Rostock)). Especially in the fields of bio-economy and Industry 4.0, INP would reach a further strategic benefit by collaborating with strong partners also beyond the Leibniz network.

The INP successfully cultivates its close contacts with industry while at the same time maintaining its academic independence. Technology transfer plays an important role, and this is realised through the INP's five spin-off companies, two of which have been set up since the last evaluation, as well as through its joint projects and bilateral contracts with industrial partners.

## 7. Subdivisions of the INP

**Materials & Energy research division**

### 7.1 Research programme: Materials and Surfaces

[19.2 FTE, of whom 11.8 FTE research and scientific services staff, 2.4 FTE doctoral candidates, and 5.0 FTE science support staff]

The Materials and Surfaces research programme focuses on the study of plasma processes and the application of technical plasmas for thin film deposition and material synthesis. The aim of the concept is the experimental characterisation and modelling of the basic plasma properties underlying these technical processes.

The focus of the research programme recently shifted to plasma methods for materials for hydrogen technologies. This is a very timely development because materials for renewable energies are a very promising and topical research area. These activities have led to the INP

being entrusted with the coordination of big consortia such as the Campfire project with 30 regional and national partners. It also acquired HiPowAR – Highly Efficient Power Production by Green Ammonia Total Oxidation in a Membrane Reactor, a Horizon 2020 project. It is good to see that modelling activities on film growth or surface modifications will be addressed in the future. Some other research fields within the programme, like the manufacturing of optical fibres and optical coatings, have been transferred to industry or replaced by other technologies. The INP should take advantage of the introduction of the new, promising research topics to close down activities that are no longer topical.

The research programme has access to impressive infrastructure, which enables very good diagnostics. Its level of third-party funding is high, consisting mainly of funds from the federal government and the EU, while funding from industry could be increased. The scientific output is published adequately. Given the size of the research programme, the number of PhD students – and, in particular, the number of completed PhD theses (one between 2018 and 2020) – is far too low.

### 7.2 Research programme: Plasma Chemical Processes

[17.1 FTE, of whom 13.5 FTE research and scientific services staff, 1.3 FTE doctoral candidates, and 2.3 FTE science support staff]

The Plasma Chemical Processes research programme was developed from the former Process Monitoring programme (see chapter 3).

The expertise and results in the area of plasma diagnostics deserve a special mention. This topic is one of the INP's core topics and the results are outstanding. They include high-end and novel diagnostics, such as the recording of optical spectra in the UV-Vis range with a time resolution as low as 5 ps and a new spectrometer based on a MIR frequency comb. It is good to see that the programme is pursuing new directions, like research on atmospheric-pressure plasma that has high industrial relevance. A new application laboratory for plasma diagnostics of atmospheric-pressure plasmas was founded in 2019. This is an important step, as it will strengthen the theoretical and mechanistic base at the INP. The INP also plans to address surface diagnostics in the future – a welcome development, but one that will necessitate incorporating more chemist's expertise. The programme would also benefit from a stronger link to research programme 7.1 (Materials and Surfaces) and from strengthening the plasma modelling area, as recommended in chapter 3.

The research programme is very visible internationally, as demonstrated by a very good publication record in well-chosen journals. The transfer activities are very good, in particular in gas trace sensing. In 2020, a spin-off company (neoplas control GmbH, founded in 2006) started manufacturing driver electronics for laser sources that were developed by INP. It is good to see that the programme is active in the further expansion of the interdisciplinary INPTDAT data platform. The research programme is successful in the acquisition of third-party funds. However, EU grant funding should be increased. The number of PhD students is low. Given the joint appointment of the programme head to a professorship in collaboration with the University of Rostock in 2017, it is expected that this situation will improve in the near future (see chapter 5).

### 7.3 Research programme: Welding and Switching

[11.5 FTE, of whom 9.5 FTE research and scientific services staff and 2.0 FTE science support staff]

The Welding and Switching research programme focuses on the physics, diagnostics and mathematical simulation of electrical arcs and discharge phenomena in electrical systems and devices during switching. It also explores thermal plasma for waste treatment or chemical conversion.

The programme has recognised experimental and modelling expertise in its scientific domain and strong links with industry. The focus is on multiphysics modelling of arcs. However, many of the areas where the programme has been successful in the past, have now been adopted by industry, while, in other areas, alternative solutions have been found, e.g. in semiconductor physics. The institute should therefore close down these activities and develop its more promising research topics.

In this context, it is good to see future plans that include industry digitalisation (Industry 4.0) and renewable electric energy sources. The plans for the next years have strong links and partly an overlap to the research programmes 7.2 (Plasma Chemical Processes) and 7.1 (Materials and Surfaces). Insofar, the INP should consider how to combine or even to merge the expertise of research programme 7.3 with the other two programmes. This could, for example, lead to strengthening the institute's position in the field of thermal and atmospheric plasmas for different applications.

The research programme publishes well and is successful in the acquisition of third-party funds, mainly from industry. There is close collaboration with the University of Rostock. With a new thematic focus, it should therefore be perfectly possible to attract PhD students. There are currently no doctoral researchers working on the programme.

## Environment & Health research division

### 7.4 Research programme: Bioactive Surfaces

[7.2 FTE, of whom 5.0 FTE research and scientific services staff, 1.7 FTE doctoral candidates, and 0.5 FTE science support staff]

The Bioactive Surfaces research programme develops plasma-based modification processes to engineer surfaces and materials interacting with biological systems. The focus is on the modification of surfaces for the immobilisation of enzymes, bacteria or cells for medical devices (e.g. implants), and on bio-catalytic systems.

With the establishment of a junior research group on Biosensing Surfaces, the research activities on atmospheric-pressure plasma processes for the generation of functional coatings on biosensing platforms have been intensified and strengthened. The scientific results, for example in the field of plasma-based functionalisation of microparticles, are promising. A number of processes have been successfully established, including HiPIMS (high power impulse magnetron sputtering), plasma electrolytic polishing and atmospheric-pressure plasma spraying.

In the future, the research programme plans to address plasma-based functionalisation of microparticles, the synthesis of functionalised microparticles and of plasma-polymerised coatings as 3D support structures for cell growth. As there are already several successful groups in those fields of research, possible synergies with internal and external partners should be explored. The research division would benefit from employing more scientists with expertise in organic and polymer chemistry.

The programme's third-party funding consists mainly of industry and federal government funding. Funding from competitive procedures, like those run by the DFG and EU, should therefore be increased not least with the aim to raise the number of PhD candidates. The publication output has developed very well, considering the small number of scientific personnel in this research programme.

### 7.5 Research programme: Plasma Medicine

[30.0 FTE, of whom 17.6 FTE research and scientific services staff, 5.4 FTE doctoral candidates, and 7.0 FTE science support staff]

The Plasma Medicine research programme focuses on the medical use of cold atmospheric-pressure plasmas (CAP). Key research areas within the programme are engineering and plasma physical investigation of CAP sources. The aim is to exploit a differentiated interaction of specific plasma components with specific structural as well as functional elements or functionalities of living cells to effectuate therapeutic effects.

The programme has been significantly strengthened since the last evaluation, in line with recommendations (see chapter 3). It is well established internationally. The emphasis on wound healing makes a lot of sense and is promising. For example, the team successfully identified the role of the reactive oxygen and nitrogen species (RONS) not only as the species responsible for wound decontamination, but also for tissue regeneration. Particularly noteworthy is that it validated the direct stimulation of plasma-induced wound healing, independent of antiseptic effects, in a clinical trial. The strong collaboration with the clinics, which led to the cooperation with Karlsburg (see chapter 3), is appreciated.

The research program is also very successful in the field of technology transfer. A spin-off company was founded (ColdPlasmaTech), and numerous patents have been filed. Publication output is very good. The programme acquires a high amount of third-party funding. However, EU funding should be increased. Compared to other INP research programmes, Plasma Medicine employs a high number of PhD students. It is good to see that many theses were completed in the past three years.

### 7.6 Research programme: Decontamination

[25.9 FTE, of whom 17.3 FTE research and scientific services staff, 2.5 FTE doctoral candidates, and 6.1 FTE science support staff]

The Decontamination research programme focuses on the development, analysis, and optimisation of plasma-based methods and processes for the inactivation of microorganisms and the degradation of contaminants by plasma technologies. Approaches are investigated for environmental protection (especially for the biological and chemical decontamination of air

and water), food security and preservation, occupational and personal safety, and the reduction of germs in medical and healthcare facilities.

Decontamination is one of the basic research directions in the field of low-temperature plasma. However, because of the intensive research in this area, some of it driven by industry, its research potential has shrunk. This is also reflected in very low funding from industry. Some technologies have already been adopted as standard and others have been replaced by alternatives. The INP has recognised this and is increasingly focusing the programme's research in other directions. Worth mentioning here is the field of plasma agriculture, a new, very promising research field. The name of the research programme should be updated so that this important development is also visible from the outside.

In order to be able to work successfully in the field of plasma agriculture in future, it is vital that the institute enters into strategic interactions with partners that have specialist competence in agriculture and others who are active in the German and in the *European Bioeconomy Strategy*. In addition, the INP is advised to redistribute topics that are also covered in other INP research programmes, such as pulsed plasmas and pulsed electric fields.

The research programme is very successful in terms of technology transfer. A spin-off company was founded (Nebula Biocides GmbH) and numerous patents have been filed. The level of third-party funding is moderate, consisting mainly of funding from the federal government, and there is no funding by the DFG or the EU. The publication output is adequate.

## 8. Handling of recommendations of the last external evaluation

The INP addressed the recommendations made by the Leibniz Association Senate in 2015 (see status report, p. A-21f). The recommendations on internationalisation of staff (recommendations 6 and 7), gender equality (recommendation 8) and increasing the number of doctoral candidates (recommendation 9) still apply.

# Appendix

## 1. Review board

*Chair (Member of the Leibniz Senate Evaluation Committee)*

| | |
|---|---|
| Ulrike **Woggon** | Institute of Optics and Atomic Physics, Technical University Berlin |

*Deputy Chair (Member of the Leibniz Senate Evaluation Committee)*

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|---|---|
| Ulf **Müller-Ladner** | Department of Rheumatology and Clinical Immunology, Justus-Liebig University Giessen, Campus Bad Nauheim |

*Reviewers*

| | |
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| Pascal **Chabert** | Laboratoire de Physique des Plasmas, École polytechnique, Palaiseau, France |
| Ursel **Fantz** | ITER Technology and Diagnostics, Max Planck Institute for Plasma Physics, Garching |
| Thomas **Hirth** | Karlsruhe Institute of Technology (KIT), Karlsruhe |
| Andreas **Holländer** | Fraunhofer Institute for Applied Polymer Research (IAP), Potsdam |
| Achim **von Keudell** | Physics of Reactive Plasmas, Ruhr University Bochum |
| Deborah **O'Connell** | School of Physical Sciences, National Centre for Plasma Science and Technology, Dublin City University |
| Jochen **Schein** | Institute of Plasma Technology and Mathematics, Bundeswehr University Munich |
| Günter **Tovar** | Institute of Interfacial Process Engineering and Plasma Technology IGVP, University of Stuttgart |

*Representative of the federal government (Member of the Leibniz Senate Evaluation Committee)*

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| Volker **Wiesenthal** | Federal Ministry of Education and Research, Berlin |

*Representative of the* Länder *governments (Member of the Leibniz Senate Evaluation Committee)*

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| Babett **Gläser** | Saxon State Ministry for Science, Culture and Tourism |

10 January 2022

# Annex C: Statement of the Institution on the Evaluation Report

## Leibniz Institute for Plasma Science and Technology, Greifswald (INP)

The Leibniz Institute for Plasma Science and Technology (INP) in Greifswald would like to thank the chair and the members of the Review Board for their great efforts during the evaluation process.

The INP is pleased and grateful for a fair and accurate evaluation report, which includes rounded and even-handed measurements as well as constructive and clear recommendations for the future development.

The INP welcomes the recommendations of the review panel, which support the INP's internal strategy and agrees with it to a very large extent.

## Statements according to main recommendations 1 - 7

The assessment of the evaluation report that the broadening of INP's research profile opens the chance to place more scientific papers in high-impact multidisciplinary journals (recommendation 1) is fully shared. To mention just a few examples from 2021, INP authors succeeded to publish one paper in Nature Materials (IF 2020: 43.841), two papers in Advanced Science (IF 2020: 16.806), two papers in Redox Biology (IF 2020: 11.799), and one paper in Biomaterials (IF 2020: 12.479). This general approach is the basis of our publication strategy also for the next years. Nevertheless, nominal impact factors (IFs) can hardly be used as single indicator of paper quality of the whole INP, especially in journals of a smaller scientific community like plasma physics as pointed out in the INP's report.

Concerning changes and planning (recommendation 2), INP fully agrees with the recommendation to prove and reconsider, which of the INP's activities offer the prospect of future cutting-edge research results in the more traditional fields. Here, the research programme Welding and Switching was mentioned as an example for dealing with plasma technologies, even though some of them are well established in industry. In fact, the prolongation of some of the traditional topics of this research programme has already been critically discussed in the frame of the continuous strategy process of the INP. Two years ago, welding research was terminated in favour of studies for optical sensors. It should be noted that, in contrast, switching studies have been intensified and arc welding research was not mentioned further in the current planning (see chapter 7.3 of the INP's evaluation document). Other aspects of the research programme Welding and Switching are mentioned under topic "Statements with respect to the evaluation of the subdivisions".

The four mentioned main strategic areas of INP's research and development (recommendation 3) had and have been defined with strong focus on topics of the High-Tech-Strategy of the Federal Government related to the European Sustainable Development Goals besides industrial demands. Such top items reflect the main research areas of the institute. Based on this, the topics have been broken down to smaller and essential attractive research and development goals that fit in general to INP's approach to plasma technology. In 2021, the annual retreat of the strategic development aimed to a clear growth opportunity connected with realignments in specific areas and new strategic

partnerships. Because the evaluation document was written before and close to the annual retreat, these changes were not described clearly enough at that time. Meanwhile, INP has been working on successful projects in all of the above-mentioned areas for a longer or shorter period of time.

Further, the number of engineers and people with expertise in chemistry has been increased among others according to significantly raised hydrogen-related activities. Today, 37% of the scientists at INP are physicists followed by 22% engineers, 19% biologists, and 19% chemists. In 2019, the research group Materials for Energy Technologies was founded to build up in-house expertise in chemistry and material science (see chapter 3.1 of the evaluation document). Moreover, the INP has intense and long-lasting collaborations with the Leibniz Institute for Catalysis and with the Leibniz Institute for New Materials. More recently, close co-operations with the Hydrogen and Fuel Cell Center, ZBT GmbH, and with the Max-Planck-Institut für Eisenforschung have been set up, to mention only few examples. In the area of Industry 4.0, new collaborations with industry have been initiated, especially related to the fields of surface treatment and diagnostics.

Concerning controlling and quality management (recommendation 4), INP consequently supports women as members of the boards. In the Scientific Advisory Council (SAC), the total number of board members is limited and changes are only feasible in case a present member leaves the board after finishing her or his period. Within the next four years, changes will become possible and INP will motivate appropriate female candidates to join the SAC. Regarding the Board of Trustees, a discussion has been started at the recent Management Board session to either expand the number of members or to fill up open positions with appropriate female candidates. Therewith changes are much more feasible than before.

Related to the recommendations and comments concerning the human resources (recommendation 5), the INP thanks for this commendatory statement regarding to our working conditions and career planning schemes. Indeed, it will be forward-looking to point out this fact much better in future open position advertisements. In 2021, INP successfully applied for the "HR Excellence in Research" Award of the European Commission. This is a visible sign that it is important for us to create an ideal working environment for excellent research. A publicly available action plan (https://www.inp-greifswald.de/fileadmin/user_upload/documents/4-action_plan_20201221.pdf) summarizes the working conditions as well as the training and development efforts as strengths of the INP. The action plan includes, among others, annual one-day mandatory trainings on personnel recruitment and implied issues for all executive personnel and selection board members to improve the personnel recruitment process. These trainings will be used to sensitize the management team as well as the executive personnel to point out these strengths of INP in every advertising process.

Concerning the general PhD student recruitment approach (recommendation 6), the institute thanks the Review Board very much for pointing out this ongoing and highly important task to secure the scientific perspective of the INP. Naturally, the recruitment of graduates as PhD students has to be performed in competition with other research

institutions and universities. Due to the low birth rates in the 1990s, the general challenge is given by a shortage of candidates in most fields of employment including science. INP will counteract this difficult situation by an intensified promotion of the appeal of both the region and the working conditions at the institute (see recommendation 5). The joint professorships held by INP staff members at the Universities of Greifswald and Rostock are intensively used to attract PhD students. Starting in 2021, the new master programme medical physics (Medizinphysik: Bildgebung und Therapie) at Greifswald University includes plasma medicine as one mandatory module under the responsibility of INP professors. This will become another chance to attract young people for a scientific career at INP.

Concerning gender equality issues (recommendation 7), the institute thanks the Review Board for the positive recognition of INP's progress to raise the share of female employees. In INP's human resources development strategy, this is generally the most important aspect, with a special focus on women in leadership positions. Following the standards and recommendations of the Leibniz Association, INP has defined target quotas for women in leadership positions. They were estimated on the basis of the so-called cascade model, which allows a more realistic planning. These target quotas are regularly redefined. INP offers female employees the opportunity to participate in mentoring programmes to support their targeted scientific and personal career. These programmes are complemented by custom-tailored support measures of the INP. Female scientists will be especially encouraged to apply for the three new joint professorships (W1) appointed with cooperating universities in Mecklenburg-Vorpommern.

## Additional statements to chapters 4 and 5

On page B7 in Chapter 4 under section *Organisational and operational structure* is written:
*It is important to ensure the continued transparency of these processes, including from an outside perspective. At the same time, the INP should make sure to maintain the flexibility of its scientific structure in order to continue to be able to adapt dynamically to new developments in the future.*

Maintaining the flexibility of the scientific research structure of the institute is an important permanent task at INP. Therefore, on the one hand the annual retreat is used as platform to define research and performance goals, changes and financial issues as well as actions related to human resources and ad hoc topics for immediate action. On the other hand, the research progress is monitored and monthly discussed with the research programme and department leaders. These meetings ensure adequate short-term measures. Additionally, the Scientific Advisory Council, the Board of Trusties and the General Assembly evaluate the results regularly, partly supported by external project executing agencies and partners. Therewith the institute ensures the responsible and sustainable use of available resources according to its mission and strategy.

On page B9 in Chapter 5 under section *Leading scientific and administrative positions* is written:
*The INP incorporates an impressive wealth of expertise in several key fields under a strong leadership. However, in view of the age structure among the top managers at the INP, several upcoming retirements can be foreseen in the intermediate future and need to be addressed in good time. Early measures should be taken as soon as possible to develop a reliable strategy for the imminent transition process.*

Considering the future allocation of leading scientific and administrative positions, the institute has fully recognized the situation and has acted using a variety of measures in the past years. For example, the junior research groups are well-dimensioned platforms to give excellent researchers a chance for a career in leading research positions. This is one way INP develops young female and male employees to future leaders. In addition, INP has filled job vacancies in several research departments with young supervisors, too. After submission of the evaluation document this strategy has been continued. For example in 2021, the research department Plasma Sources was taken over by a young postdoc right after his doctoral graduate. In 2022, a young excellent specialist will follow as supervisor of the research department Plasma Modelling. Based on additional financial funding by the Leibniz Association, three W1 professorships will be allocated beginning in 2023.

## Statements with respect to the evaluation of the subdivisions

INP thanks the Review Board very much for the constructive and clear comments and recommendations with respect to INP's subdivisions (chapter 7) – our Research Programmes. There are some aspects, where the INP would like to give a more detailed response.

It is written on page B11 under section 7.2 related to the research programme Plasma Chemical Processes:

*The INP also plans to address surface diagnostics in the future – a welcome development, but one that will necessitate incorporating more chemist's expertise. The programme would also benefit from a stronger link to research programme 7.1 (Materials and Surfaces) and from strengthening the plasma modelling area, as recommended in chapter 3.*

The request for more chemists has been answered in INP's statement to recommendation 3. With respect to modelling and surface diagnostics it should be mentioned that research activities in plasma diagnostics, plasma modelling, plasma sources and others are organised in working groups spreading their expertise over many research programmes. As an example, there is a well developed surface diagnostics at INP, which is used mainly by the research programmes Materials and Surfaces and Bioactive Surfaces. It is available for the programme Plasma Chemical Processes as well. The Plasma Modelling department is involved in the research activities of almost all research programmes. The detailed description of plasma-chemical processes in the frame of plasma simulations with strong relation to experimental studies is one of INP's specific expertise rep-

resenting a strong contribution of the modelling group in the research programmes Plasma Chemical Processes and Materials and Surfaces since many years. As a matter of course, INP aims at the strengthening and extension of plasma modelling research together with the extension of research data management and science-oriented IT.

It is written on page B12 under section 7.3 related to the research programme Welding and Switching:

*The programme has recognised experimental and modelling expertise in its scientific domain and strong links with industry. The focus is on multiphysics modelling of arcs. However, many of the areas where the programme has been successful in the past, have now been adopted by industry, while, in other areas, alternative solutions have been found, e.g. in semiconductor physics. The institute should therefore close down these activities and develop its more promising research topics.*

A renaming of the research programme Welding and Switching is in discussion since 2021. Starting this year, INP will pursue the research programme under the new name "Thermal Plasma Technologies". Topics related to the increasing use of renewable energy sources and requirements for $CO_2$ neutral technologies (as pointed out in chapter 7.3 of the INP's evaluation document) require cutting-edge research in electrical engineering as well. New technologies and switching concepts are needed for high power DC switching, increasing battery energy storage and industrial DC-power grids. For physical reasons, semiconductors cannot replace arcing based switching devices for all technical voltage levels and, in particular, for DC. Coupling of electrical engineering research with thermal plasma modelling and diagnostics lasts as a unique characteristic of the INP, e.g. compared to other electrical engineering research institutions. Since 2021, new strategic partnerships like the cooperation with the Technical University Bergakademie Freiberg support the new focus point of using thermal plasmas for chemical conversion processes.

It is written on page B13 under section 7.6 related to the research programme Decontamination:

*Worth mentioning here is the field of plasma agriculture, a new, very promising research field. The name of the research programme should be updated so that this important development is also visible from the outside… The level of third-party funding is moderate, consisting mainly of funding from the federal government, and there is no funding by the DFG or the EU.*

Regarding the name of the research programme Decontamination, a renaming was already in plan after the evaluation. INP is very glad that this is supported by the Review Board. Following the internal plan of annual retreats, the name will be changed soon. The institute is also pleased to announce that third party funding will be doubled in 2022 compared to 2020, a very good basic for further funding from DFG and EU.