Department of Biosensors and Biomedical Signals Processing, headed by Professor Tkacz originates mainly from the Faculty of Automatic Control, Electronics and Computer Science, Silesian University of Technology in Gliwice and Centre of Polymer and Carbon Materials PAS in Zabrze. In 2005 at Silesian University of Technology an interdepartmental “biotechnology” was created in cooperation with the Faculty of Chemistry and the Faculty of Energy and Environmental Engineering, and a specialty “Bioinformatics” at the Faculty of Automatic Control, Electronics and Computer Science. What are the substantive relationships between electronics, chemistry and biotechnology?

Essential compounds between these sciences are at such a high level that these areas practically cannot simply exist alone or their self-existence would be completely ineffective. Examples of proving such an opinion can be multiplied. So I will limit myself to just one, but very current. Well, today just a few hours ago I was involved in two surgical procedures at the Klinika Chirurgii Endoskopowej in Zory; the first one concerned the shoulder surgery, the second – knee surgery. During the surgery, the operating surgeon told me that if it was not the development of the above-mentioned fields and their mutual interaction, as well as a widely understood complementarity, and better compatibility, a similar surgery would require to open the corresponding joint, even as the visibility of the operating field would be very limited. As a result, the surgery would last much longer, and the process of rehabilitation of the surgical patient “on the open” would be very long, incomparable to rehabilitation after arthroscopic surgery. Biotechnology in my understanding, is the study of the technical aspects of medicine; electronics – in the context of this example – is a medical imaging, transmission and storage of data and, finally, the initial, almost on-line interpretation of data, and consequently conclusions. A patron of all this is the chemistry, that provides the knowledge base, e.g. about the materials used, both in electronics, as well as in biotechnology.

What are the relationships between the Faculties? Is this good for the development of your research interests?

Currently, the Faculty of Biomedical Engineering, the first and so far the only in Poland, moved to its new premises in Zabrze. We received a building, which has been almost completely renovated. A whole range of adaptation to the needs of the new Faculty was carried out, and already in the slightly longer perspective, the development of new, more advanced applications of biotechnology in medicine. We all have heads full of ideas. You just have to turn those ideas into reality in order to achieve the desired effect.

Employees of the Department conduct research i.a. in the technology of preparation of environmental, biomorphic carbon/polymer composites and the characterization of their physicochemical properties. What does this study concern in particular?
The team led by Professor Marta Krzesińska is involved in obtaining monolithic structural composites based, in accordance with the principles of green chemistry, on renewable and biodegradable materials.

The motivation to take on this theme was the need to create a new eco-friendly products, characterized by a unique structural properties, which would be difficult to get in the way of traditional technologies. These materials can replace conventional materials, which formation is very expensive and requires the use of harmful chemicals.

Biomorphic composites are obtained based on plants. The plant material is subjected to a strictly controlled carbonization and, in the case of large materials, activation. Obtained in such a way monolithic carbon materials are subjected to polymers infiltration, for example, chitosan solution. The plant material is known to be a cheap and publicly available renewable resource. It is characterized by high porosity, stiffness, and excellent strength, low density and resistance to damage. These properties result primarily from an anisotropic morphology of plants, which is a one-way open pore system. This construction provides the possibility of filling the plant matrix with different kinds of gaseous or liquid fillers, which means that the plant material is an excellent carrier/matrix for the preparation of a wide variety of biomorphic composites with specific physical and mechanical properties. Characteristic of the materials obtained on the basis of plant precursors is pseudo-morphic structure, which is a representation of a plant cell morphology upon which they arose.

The team developed a technology of, among others, biomorphic monolithic composite of chitosan as a filler. Chitosan is widely used in many areas of life, e.g. in agriculture, water and waste water treatment, food and cosmetic industries, and also in biomedicine. Its main advantages contribute to that, namely: bioactivity, biocompatibility, biodegradability, non-toxicity, high adhesiveness.

As a result of the research the team obtained a new class of composite materials in the form of a monolithic rigid blocks of any desired shape, with a hierarchical pore system which inner surface is coated with the chosen polymer.

The Professor Marta Krzesińska's team, in which Justyna Majewska (Ph.D., Eng.) cooperates in research, worked on the preparation of monolithic, biomorphic materials for adsorption of pollutants from aqueous solutions. We already have the first promising results in the removal of arsenic from drinking water. (Part of the results is published in journals from the Jurnal Citation Reports\(^a\)). Currently, work is also carried out on the use of biomorphic composite of chitosan for the preparation of biosensors.

The porous carbon materials obtained by carbonization of plants and resins are also an alternative for materials for the production of various kinds of sensors, for example, plants carbonizates are used as electrodes in glucose sensors. For the formation of the glucose sensors an already mentioned, pseudonatural polymer, which is chitosan, is also used. Why such alternative materials are important for the production of sensors?

It concerns the fabrication of biosensors by which obtaining specific information will be faster, simpler and cheaper. Thus, we have in mind the definition of a objective function and then the further optimization process. The electrodes in glucose sensors, of course, are only one of the possible applications. Research on these materials cover a much wider range of applications.

Your scientific interests notably relate to the acquisition and processing of biomedical signals. Your involvement in the development of an interdisciplinary project on new research methodologies for the detection and treatment of bruxism – a disease that affects a large part of the population. Please explain to our readers bruxism as a disease of civilization.

Bruxism is disorder of the a neurological origin, the causes of which are not fully known and defined. However, there are well-known effects of prevalence of bruxism, which cover quite a wide spectrum, from completely trivial, such as damage to the enamel, to very serious – as headaches, shoulder girdle and spine aches, in principle, of unknown etiology. The phenomenon itself is an uncontrolled movement of the jaw and mandible, or a very strong pulse of these terminals – with difficult to imagine forces of the order of 300–400 N. The magnitude of these forces can be partly explained by the fact that among the many reflective bends in the body, consisting of nerve discharge from the brain and the nerves supplying signals to the brain (the first are afferent nerves, and the latter – efferent), only in case of the facial nerve there are three nerve endings (two control the jaw and one the mandible), rather than two as in case of other reflex arcs. The subject of our investigation is to develop a reliable method for the detection of bruxism episodes that usually carried out for many years. You spend a lot of time and commitment on them. Please explain, at least briefly, your scientific dreams, and a source of your scientific research interests, inspirations?

This type of question, madam Editor, for me is a true “grist to the mill.” Because in addition to the scientific research I deal with teaching, and I can almost endlessly talk about my academic dreams, interests and sources of inspiration. I’ll start perhaps a bit historically, from inspiration to study the Electronic Medical Systems major, which I started at the Faculty of Automatic Control, Electronics and Computer Science, Silesian University of Technology in 1977. And inspiration for me was the Jurgen Thornwald’s book “Patients”. More than 700 pages, which I read in two days, because ending each page I was terribly curious about what is on the next. This book describes a number of very interesting medical cases, such as the first kidney transplant of patient named Ruth Tucker, or the first heart transplant of patient Louis Washkandsky, done in Cape Town by the famous heart surgeon Christian Barnard. But returning to the academic dreams, I would love the research funding system to be fundamentally reformed, because as today, probably because of the lack of appropriations or outlays by the Polish government funds, it is almost impossible to accept. Following, maybe not very intensively, the media I am not alone in this opinion, so it is a little more than just a single personal dream, because it concerns a large part of research workers, especially those young people from the already mentioned in the text, with heads full of ideas. Going down to earth, I dream about us on a new and still the only one in Poland, which I want to emphasize, the Faculty of Biomedical Engineering could finish its work on proper equipment and create the conditions for employment for young researchers and Ph.D. students. We already have a lot, but we want more, because Biomedical Engineering is not only one of the many courses of study, it is the real mission understood as a service of technical sciences to the medical sciences, or maybe better – service of engineering to human health. If you look at the development of post-war Western Europe, where there are good roads, stable developed economy, economic and financial relations at a high level... What else do they want? Well, I think that there is always the dream of a long life in good health and good physical and mental condition. All these well-defined dreams are in some way correlated with the development of biomedical engineering. Therefore it is worth and necessary to have this area of science widely and quickly developed.

Your work – achievements and plans, including in the context of development of the Faculty of Biomedical Engineering as an interdisciplinary offer for chemical, electronics, environmental protection, medicine engineers – has been
appear at the end of the dream just before waking up. Bruxism treatment method should be non-invasive, and most independent from the state of consciousness of the patient. We use the registration of three signals for this purpose: the EOG (electrooculography recording eye movements), EMG (electromyography recording changes in the jaw muscle tension) and HRV (heart rate variability), which, contrary to popular belief does not only beat rhythmically but quasi-rhythmically, thus depicting some nerve control, appearing in the event of increased or decreased demand for oxygen in the body. At approximately constant volume of the heart left ventricle, controlling the amount of oxygen can be carried out only by changing of its rhythm. For over a year of research, we found a significant correlation between these signals characteristic episodes of which occur just when the bruxism appears.

**What is the proposed revolution in the treatment of bruxism?**

It’s probably still too early to judge if this will be a revolution. But it seems that we have developed a reliable method for the detection of bruxism episodes. Further research will focus on, in order to effectively apply the developed method, and also use some kind of biofeedback, or natural feedback for the generation of electrical impulse relaxing clenched or grasing jaw and mandible. The task, though conceptually simple, for the successful implementation will require the use of the latest technological achievements, such as for example wireless transmission of electrical impulses of the relatively small values of electrical parameters – millivolts and a mile or microamps. In short, for the success it is still a lot of intensive research that we consistently perform in collaboration with dentists from the Medical University of Silesia. But I assume it will work. I strongly believe that this time, perhaps a bit more than the facts, the best ideas, are ideas of relatively simple in concept.

Research funding was already a part of our conversation..., but after all, proposed by the Government Strategic programs of research and development, resulting from scientific policy and innovation policy, are supposed to support the development of the Polish economy and the public sector? It is known that preference is given to research for solving specific technical, scientific or social problems, the implementation of which should contribute to the consolidation of research teams and integration of scientific and economic communities around key issues in the development of the country. One such programs is StrategMed – prevention and treatment of diseases of civilization. Does your scientific inquiry fit in to StrategMed?

In the context of previous questions, it is not likely, because bruxism generates a difficult and unpleasant to control episodes of pain, but is not a disease causing risk to the patient’s life. I do not wish, however, that such a formulation would build an opinion that we deal with side topics. Before mentioned StrategMed program is very well known – to me and my team. There were two competitions so far; and in April of this year an advertisement for the third is scheduled – according to NCBiR the last one. We participated in the first contest with topics related to the currently very fashionable personalized medicine. Participation in such a competition is very demanding organizationally, because you have to create at least five-subject research consortium, including the industrial partner; the minimum amount of funds for which you are applying is 10 million PLN. This attempt was ineffective. I hope that we can get more time to convince our partners from the first call and retry the request, which related to the development of the fourth dimension in coronary arteries tomography. Briefly speaking, it often happens that the tomographic study of coronary artery do not provide cardiologists with sufficiently comprehensive information to make a decision about eligibility for treatment of aorto-coronary arts. Sometimes the artery closed 70% must give way to the treatment for an artery only blocked in 30%, but has a much greater risk of detachment of atherosclerotic plaques. Effective assessment of this fact is not possible only on the basis of passive tomographic studies. What is needed is a piece of dynamics involving adding some information about blood flow in analyzed artery. And it is precisely this mentioned before fourth dimension. The task is extremely complex computationally, and following reports in the literature, requires the use of methodology applying LBM Lattice Boltzmann Method. To imagine it well, I might add that using commonly available personal computers, computing time considerably exceed common sense. Specialized graphics processors of high computing power are frequently used. Our application in the first competition was poorly evaluated in formal terms, to which we have appealed against to the relevant committee, but unfortunately unsuccessfully. Let me add to the full clarity that in Poland in all cardiac clinics about 15,000 coronary arteries tomography procedures are performed annually costing about 1500 PLN each, which totals in more than 22 million PLN, and diagnostics in this area still does not give reasonable assurance as to the correct surgical qualifications. But I will appreciate my observation would not be treated as unjustified criticism of the system, and research funding policy; an issue to change it was already brought up in our conversation.

**Is your Department, or maybe you personally, the beneficiary of the resources available to strategic research programs?**

Currently no, but despite losing in the first StrategMed competition, we intensively prepare ourselves to participate in the contest, which will be announced in April 2015. If this time as well we do not have the luck with the reviewers who are true experts in the subject and who guard against formal errors, and for that they see eg. the economic importance of the proposed topics, we will compete, along with our foreign partners in the Horizon 2020 program. There are much more possibilities there than those offered by the national strategic programs.

We started our conversation from the substantive links between electronics, chemistry and biotechnology, which dates back to the beginning of the twenty-first century. From your statements there is a certainty that biomedical engineering is an avant-garde, very interesting and forward-looking field of science...

In general we can say that we are doomed to success. It is so, because we cover a wide spectrum of research eligible for issues related to biomedical engineering. Four Departments of the Faculty of Biomedical Engineering, Silesian University of Technology are involved in biomedical image analysis, biomechanics, biomaterials, and finally widely understood acquisition, metrology and biomedical signal processing. I have not mentioned a very important area of our activity on bioinformatics. We have in the Department a specialist in the subject, who has defended his Ph.D. thesis on the methods of structural classification of proteins under my supervision, and two Ph.D. students, who are conducting intensive research in this area as well.

I said a lot about the importance and necessity of the development of biomedical engineering...

We simply want to live a long and comfortable lives, in good health and fitness – which I sincerely wish to all readers of CHEMIK monthly.

**Thank you very much for the interesting conversation and let me invite you to our monthly with publications of your achievements.**

Interview conducted by Anna Czumak-Bieniecka (2nd February 2015)