Laboratory of Biocybernetics

University of Ljubljana, Faculty of Electrical Engineering, Ljubljana, Slovenia

http://lbk.fe.uni-lj.si/index_si.html

Since its foundation in 1963 by the late Academician Professor Lojze Vodovnik, the Laboratory of Biocybernetics has been involved in the study of interaction between electromagnetic fields (EMFs) and biological systems. This includes both the investigation of harmful effects of EMFs on organisms and the exploitation of beneficial effects of EMFs for therapeutic and diagnostic purposes. The research activities of our group have been directed above all towards the latter. During the period from the mid-1960s to the end of the 1970s, the major research topic was Functional Electrical Stimulation (FES). Extensive work was done in collaboration with Slovenian Institute of Rehabilitation on the use of electric currents for the restoration of impaired motoric functions caused by different types of neuromuscular diseases. Considerable success was achieved in paraplegic persons and in hemiplegic patients recovering from brain stroke. The major advantage of FES implemented in the so-called Ljubljana School of Walking has been its combination of efficacy and simplicity of application. The idea behind this type of FES has been adopted by many rehabilitation centers in the world. At our school it is being developed further in the Laboratory of Robotics at our faculty. A FES Museum at the faculty contains 43 exhibits dating from the beginning of the 20th century to the beginning of the 1990s.

CURRENT RESEARCH: Since 1980s, our main field of research are the investigations of the influence of electromagnetic fields and electric currents on the physiological state of cells, tissues, organs, and the body as a whole. The aims of this research are to understand the basic mechanisms of bioelectric phenomena and to facilitate their use for therapeutic purposes. Major directions pursued in our group are cell membrane electroporation with its applications in electrochemotherapy of tumors (ECT) and electrogene therapy (EGT), electrical stimulation of chronic wound healing and non-invasive measurements of tissue perfusion and oxygenation. To gain an insight into the studied phenomena, we are also modeling the distribution of electric currents and electromagnetic fields within cell suspensions and tissues. We are also developing the electronic devices for application in these fields of research, as well as information technology for clinical trials. We regularly present the results of our research in articles in SCI-ranked scientific journals (45 articles in 2000-2004), as well as at scientific conferences and meetings.

We are cooperating with several research institutions and industrial partners from around Europe. Our research on tissue samples and experimental animals is performed jointly with the Institute of Oncology in Ljubljana and with two institutes in France (Institute Gustave Roussy in Villejuif and Institute of Pharmacology and Structural Biology in Toulouse). Within the Cliniporator project of the 5th European Framework, we have collaborated with partners from France, Belgium, Denmark, Germany, Italy, and Sweden, in developing a prototype of a clinical electroporator - a device for electrochemotherapy and electrogenetherapy in patients. Within the ESOPE project (**www.cliniporator.com**) of the 5th European Framework, we are currently working with four medical and research centers from France, Denmark, Ireland, and Slovenia, with the goal of establishing standard operating procedures for electrochemotherapy and electrogenetherapy.

EDUCATION: Students are encouraged to participate in our research, and some start with their work in the very first year of undergraduate studies at our faculty. After graduation, some pursue a postgraduate course, deepening and broadening their knowledge. Four to six students graduate in our lab each year, and two to three postgraduate students obtain their M.S. or Ph.D. degrees.

Left: Development of electronic circuits for electroporation devices. Top right: Printed circuit boards designed in our laboratory. Bottom right: Green fluorescent protein (GFP) fluorescence after successful insertion of the GFP reporter gene into muscle cells by means of electroporation.

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Laboratory for Epitaxy and Nanostructures

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Main topics of interest: BASIC RESEARCH

The basic research activities of the laboratory are focussed on electronic, structural and optical properties of thin organic semiconductors, specifically 3,4,9,10-perylene tetracarboxylic acid dianhidride (PTCDA) , and 3,4,6,7 -naphthalene tertacarboxylic acid dianhidride. In addition we are interested in mechanisms that drive growth of these materials in an epitaxial fashion.

Currently we are concentrating our efforts on these topics:

• Ellipsometry of thin organic layers: Thin (<60 nm) layers of PTCDA are grown by evaporation in high vacuum on Si(111) or highly oriented pyrolitic graphite. The ellipsometric angles are subsequently measured as a function of azimuth angle, by rotating the sample around the axis oriented along the growth direction. The resulting behaviour bears a signature of dielectric anisotropy of the layers.

• Metal-organic semiconductor contacts: We are applying transport measurements and ballistic electron emission microscopy (in collaboration with Dr. Stefan Heun at Elletra Synchrotron Radiation Source, Trieste, Italy), to investigate the interface parameters of Au-PTCDA contacts.

• Electronic energy band structure of organic semiconductors: Through the use of in situ angular resolved synchrotron radiation photoemission at the Syncrotron Radiation Center, Stoughton (WI), we are aiming at characterization of electronic band structure. This is a government funded collaboration between our laboratory and the group of Prof. Marshall Onellion from the Physics Department of the University Of Wisconsin-Madison.

APPLIED RESEARCH

The laboratory is currently involved in the collaboration with a local firm A. J. Kogoj in the development of gas sensors based on suitable thin organic layers. The government funded project principal targets are sensors for NO which is a major pollutant present at the vehicle exhaust pipes.

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