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BOOK OF ABSTRACTS

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Wettability measurement of seeds treated under atmospheric pressure gliding arc discharge plasma

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Keywords: plasma agriculture, gliding arc discharge plasma, seeds wettability, contact angle

Plasma irradiation of plant seed surfaces has a variety of effects on seeds. One effect is the collision of energetic particles, and another is the chemical reaction caused by plasma. Water absorption is essential for plant seeds to germinate, but the seeds themselves are covered with a tough outer coat to protect themselves. Wettability of plasma-irradiated surfaces is assumed to be related to water absorption properties. To confirm this, wettability measurements were carried out on the seed surface after plasma irradiation. In this study, atmospheric pressure single phase gliding arc discharge plasma was used as the plasma source. Argon gas (Gas flow rate: 20 l/min.) was used to eliminate the factors of chemical reactions. Wettability was determined by measuring the contact angle of a drop of water on the seed surface. Amount of water droplet is as small as 0.5 µl~1.0 µl, a special device was prepared for the measurement. In the wettability evaluation experiment, kidney beans were used. Fig. 1 shows the prepared contact angle measuring device.

Fig. 2 shows contact angle measurements for 300 seconds of plasma treatment and control. The graph shows that the plasma treatment of the seeds increased the average contact angle by 14.4 degrees. In other words, plasma irradiation of the seed surface was confirmed to increase the hydrophilicity of the surface condition.

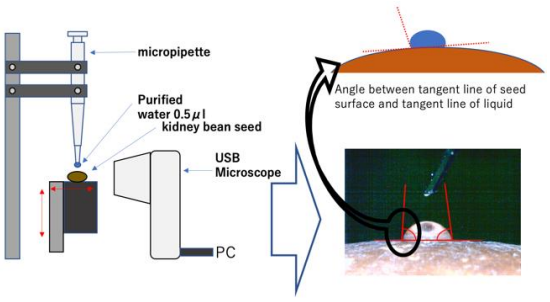

Fig.1 Experimental setup of wettability measuring device

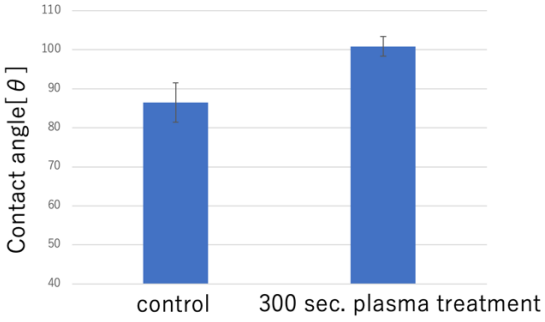

Fig.2 Change in contact angle due to plasma treatment

New building automation solutions that use the ZigBee and WiFi standard

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Keywords: ZigBee, Smart Home, building automation

Nowadays users of electrical installations pay more and more attention to comfort and convenience in everyday life. The use of executive and measuring devices allows for the creation of a system that monitors and manages the building installation, creating a so-called intelligent building. Currently used devices called Smart Home significantly facilitate modification if installation, because they do not need a communication bus. They use radio transmissions for communication.

Intelligent building not only improves the quality of life, but thanks to the use of many sensors it allows to reduce building maintenance costs. In buildings equipped with Smart Home devices it is possible to control and monitor air conditioning, lighting, roller blinds or access control.

The development of technology causes creating a smart installation to become cheaper and the installation itself is prone to easy expansion at any moment and ensures reliable operation of the entire system.

Dielectric properties, polarization process and charge transport in granular metal-dielectric nanocomposites

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Keywords: Nanocomposites, Debye relaxation, interfacial and dipolar polarization, hopping conductivity

The paper presents the research of dielectric properties of $(FeCoZr)_x(Pb(ZrTi)O_3)_{(100-x)}$ granular metal-dielectric nanocomposites below the percolation threshold. Tested materials have been prepared by using the ion beam sputtering technique in the atmosphere of argon and oxygen [1]. The impedance spectroscopy method has been used to investigate the polarization processes and dielectric relaxation mechanism in the granular nanocomposites. AC measurements at frequency region of 50 Hz – 1 MHz and measuring temperature range 81 K – 293 K have been performed. Interfacial, at low frequency region, and dipolar, at intermediate and high frequency regions, types of polarization were observed. The Interfacial relaxation process testifies to charge accumulation at the interfaces (grain boundaries) between conductive nanoparticles and surrounded them insulative matrix as well as space charge region around the contact area between measurement probes and tested sample [2]. Dipolar polarization corresponds to electric dipole formation after applying to the material an external electric field. The Conduction mechanism in the tested material is considered to be hopping carrier exchange and realizes between metallic phase nanograins [3]. It corresponds to the exponential frequency dependence of conductivity. The relaxation mechanism in $(FeCoZr)_x(Pb(ZrTi)O_3)_{(100-x)}$ layer has been estimated as a near-Debye process with relaxation time distribution. The nanocomposite exhibits dielectric type and capacitive character at the whole measuring frequency range.

References:

1. Boiko, O.; Drozdenko, D.; Minarik, P. Dielectric properties, polarization process, and charge transport in granular $(FeCoZr)_x(Pb(ZrTi)O_3)_{(100-x)}$ nanocomposites near the percolation threshold. *AIP Advances* **2022***,12*, 025396.
2. Huang, Y.; Ji, J.D.; Chen, Y.; Li, X.; He, J.; Cheng, X.W.; He, S.L.; Liu, Y.; Liu, J.P. Broadband microwave absorption of Fe_3O_4 $BaTiO_3$ composites enhanced by interfacial polarization and impedance matching. *Compos. Part B-Eng.* **2019**, *163*, 598-605.
3. Geirhos, K.; Krohns, S.; Nakamura, H.; Waki, T.; Tabata, Y.; Kezsmarki, I.; Lunkenheimer, P. Orbital-order driven ferroelectricity and dipolar relaxation dynamics in multiferroic $GaMo_4S_8$. *Phys. Rev. B* **2018**, *98*, 224306.

The electricity demand of academic buildings in 2019-2021

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Keywords: energy saving, electrical power, supply systems, COVID-19

Recent years have been a difficult period related to the Covid-19 pandemic. The pandemic left its mark on all areas of life, including the functioning of the University. The functioning of the Academic buildings is a complicated process also related to delivery of energetic media (electrical energy, thermal energy, water, gas). One of the basic energetic media is electricity. Buildings consume electricity to ensure proper working conditions, comfort and the implementation of safety tasks. These factors shape a specific electricity demand curve. The consumption of electricity in individual types of buildings is under normal conditions stable and predictable. Disturbances of electricity demand curve in building are related to the occurrence of abnormal states: failures, periods of repairs and modernization, changes in the operating pattern of devices, as well as the occurrence of external factors. The pandemic period was such an external factor that strongly influenced the normal work and functioning of the University.

The article will present the impact of the epidemic policy in 2019-2021 on the demand for electricity in modern university buildings. Types of buildings analysed are related to the implementation of the mission of educating students and conducting scientific and research works at the Lublin University of Technology. The article will present information on electricity consumption in individual months: the normal year, the total lock-down period, the periods of hybrid works and the period of gradual return to normal operation.

Fast charging of electric buses in Lublin and its impact on the power quality based on on-site measurements

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Keywords: electromobility; electric buses; power quality; harmonics

The electrification of public transport is becoming more and more popular in Poland. The 2017 commitment from the Electromobility Development Plan in Poland required a 5% share of emission-free buses in the Polish public transport fleet from January 1, 2021 and, according to the 2020 audit of the Supreme Audit Office, it was largely implemented in comparison with other goals. At the end of 2019, 8 out of 28 cities (29%) had already fulfilled this obligation, mainly thanks to support from the European Union.

Currently, there are over thirty Solaris Urbino Electric 18 buses in Lublin and 14 fast 80 kW chargers based on the Combined Charging System Type 2. Therefore, it is worth considering the impact of charging electric buses on the distribution system, especially in the vicinity of the charging point.

The subject of the study was a distribution substation that feeds 14 fast chargers located at the depot. Power quality measurements were taken throughout the week using a class A power quality analyser Sonel PQM 711 with F-2 current clamps.

The voltage variations were determined to be within the PN-EN 50160 standard limit values (±10% U_n). There were several events registered when fourth, sixth, eighth and tenth voltage harmonics were above PN-EN 50160 limit during electric buses charging. Sixth voltage harmonic (third phase) was not within PN-EN 50160 limit of 95% of the 10 min mean RMS value for one week. The obtained maximum 10-minute average values of total voltage harmonic distortion (THDU) were 3.36%; 2.27%; 2.89%, with average values 1.47%; 1.47%; 1.52% for the first, second and third phase, respectively, i.e. below the limit value of 8% required by PN-EN 50160.

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Deep learning technology for remote identification of insect pest and plant growth in ozone-mist sterilization

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Keywords: deep-learning, insect-pest, ozone, sterilization

Recently deep learning (DL) technique has been applied to agricultural management involving identification of insect pests , plant diseases and plant growth. Deep learning is a technique of machine learning that uses multi-level neural networks that allow computer to learn and extract deep abstract features automatically.

We introduce the DL technology to identify the pest control characteristics of the non-chemical ozone-mist sterilization system developed previously. Additionally, the technology is applied to know the periodic relationship between growth stages and photosynthesis vegetation of some vegetables. Fig.1 is typical results of pest detection and identification for remote-and real time recognition of non-chemical sterilization. Total number of images for seven class of insect pests (aphid, moth, beetle, fly, whitefly, mosquito, ant) are collected from sticky traps, the public IP102 dataset, and images on Web site. Each bounding box includes confidence (precision) and the point information of the box. Numerical decimal values of each box indicate the identification precision of insect pests.

Fig.2 shows the local green index intensity profiles defined by 2G-R-B (Red,Green, Blue:R,G,B) of the spinach planted in ozone-treated soil (12gO_3 in 3kG soil) and none-treated soil. It is noticed that the remarkable difference between the Imax values(0.75 for ozone treated and 0.60 for none-treated) occurs at 50 days after seeding.

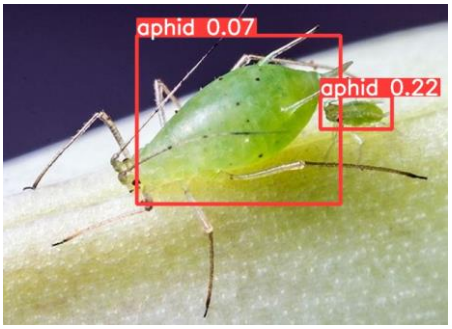

Fig.1. Identification of images of aphids

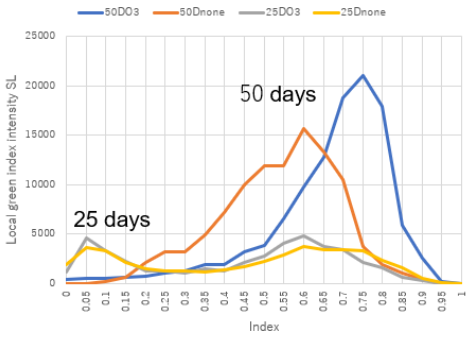

Fig.2 Effect of ozone soil treatment on SL

A digital platform to support remote laboratory classes in power electronics

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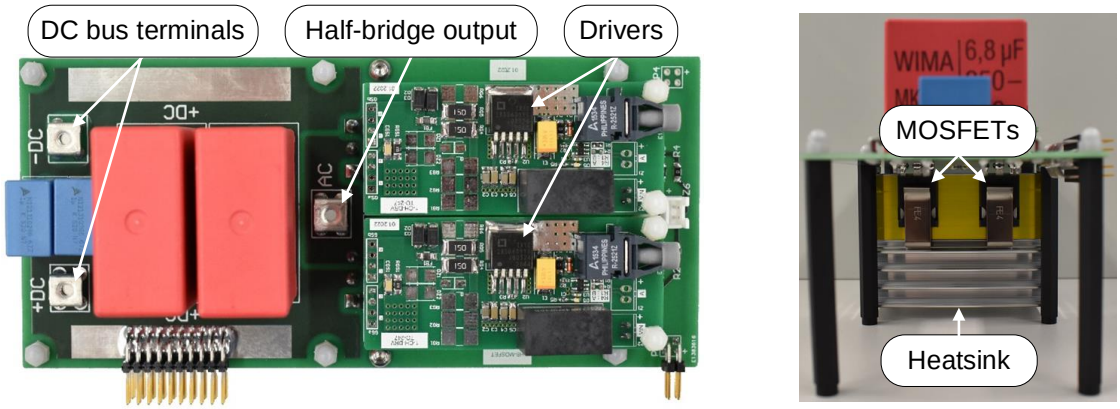
Keywords: power electronics, remote lab classes, educations, strategic partnerships

E-learning in higher education has been introduced a time ago to a greater or lesser extent to supplement the basic residential education. Remote learning mainly concerned seminars and projects, where remote education platforms were used for the exchange of educational materials and asynchronous content evaluation. The emergence of an extraordinary situation related to the suspension of classroom activities as a result of COVID-19 meant that remote learning was immediately implemented for all types of classes.

The most difficult task, especially for technical universities, turned out to be laboratories, especially in the field of key subjects for a given field of study. The implementation of such classes is theoretically not able to bring appropriate learning outcomes for engineers and in the long term is generally unacceptable. As the COVID-19 situation is still unclear, and there may be other reasons for suspending classes in the future, it is essential to develop tools to allow for acceptable remote lab classes in engineering studies.



(a) (b)

Fig. 1. Universal half-birdge: top (a) and bottom (b) view

The main result of the *Digital platform supporting remote laboratory classes in electrical engineering, mechatronics and automation* Erasmus+ project is a set of tools (interfaces, applications) enabling the implementation of selected key laboratory activities for a given field of study in a remote form, but emulated in such a way that it reflects the activities carried out in the laboratory as much as possible and ensures appropriate interaction on the part of the student (the possibility of influencing on the course and results of the laboratory exercise). This result is achieved through the use of appropriate IT tools and the use of real laboratory equipment (Fig. 1) adapted to remote control based on Raspberry Pi.

Principles certification and homologation of product and automotive vehicles in freemarket economy

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Keywords: certification, homologation, notification, product compliance assessment, ignition wires, ignition system.

In the paper basic legal acts (norms, directives, UNECE regulations) are presented [1-4]. Legal rules of tests and certifications in so-called voluntary and regulated – mandatory areas discussed. Also procedures of conformity assessment according to “module approach” are characterized.

Procedures for the homologation of product groups that work may specially influence on users safety are presented. This group of products is enclosed by “old approach” (sector) derivatives. Such a type tests can be realized only in notified laboratories, that poses specialized technical and staff back-up.

References:

1. Norma ISO 3808:2002: *Road vehicles – Unscreened high-voltage ignition cables – General specifications, test methods and requirements*.
2. Warunki techniczne WT-IST/47/94 – ZCN – wyd. 5: *Przewody zapłonowe przeciwzakłóceniowe, Wymagania i badania w zakresie bezpieczeństwa użytkowania*.
3. Dyrektywa komisji 2004/104/WE z dnia 14 października 2004 r. *dostosowująca do postępu technicznego dyrektywę Rady 72/245/EWG odnoszącą się do zakłóceń radioelektrycznych (zgodności elektromagnetycznej) pojazdów oraz zmieniająca dyrektywę 70/156/EWG w sprawie zbliżenia ustawodawstw Państw Członkowskich odnoszących się do zatwierdzenia typu pojazdów silnikowych i ich przyczep*. Dziennik Urzędowy Unii Europejskiej nr L 337/13.
4. Regulamin EKG nr 97. *Jednolite przepisy dotyczące homologacji systemów alarmowych (VAS) pojazdów i pojazdów samochodowych w zakresie ich systemów alarmowych (AS)*.

The Effect of High Voltage Stimulation on Agaricus Bisporus Cultivation

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Keywords: agaricus bisphorus, high voltage discharge, electrical stimulation, mushroom yield

We present a pre-study on the effect of pulsed discharge stimulation on the yield of Agaricus bisporus mushroom. The idea itself was inspired by the phenomena of mushroom outbreak around a lightning strike point, which has been reported for years in many cultures. The results obtained by Japanese scientists has led to believe, that applying the high voltage electricity, simulating the lightning strike, can almost double the yield of some mushroom species [1]. As part of a four-year study, scientists in northern Japan have been bombarding a variety of mushrooms in lab-based garden plots with artificially induced lightning to see if electricity actually makes the fungi multiply [2]. Still little is known about the mechanism of the mushroom outbreak. One of the theories suggest, that the rupture of hypha caused by lightning is a stimulation for fruit body formation of mushroom [3]. Another one is that the high voltage activates the enzymes, which causes the mushroom fruit bodies to develop plentifully [4]. The latest results (Takaki, et al.) show that lightning-strength jolts of electricity can more than double the yield of certain mushroom species compared with conventional cultivation methods.

Taking the above mentioned research under consideration, we have undertaken the problem of repeating the results obtained by the Japanese researchers with our domestic species of mushrooms. Agaricus bisporus is an edible mushroom native to grasslands in Europe and North America. A. bisporus is cultivated in more than seventy countries, and is one of the most commonly and widely consumed mushrooms in the world, including Poland.

We have used a pre-conditioned ready set for domestic A. bisporus cultivation. Four sets with two configurations of high voltage treatment and two reference samples were proposed. 20-level high-voltage Marx generator was used for creating an artificial high-voltage arc. The preliminary results have shown, that the high voltage stimulation has nearly doubled the yield of A. bisporus in comparison to reference samples.

[1] K. Takaki, R. Yamaguchi, T. Kusaka, H. Kofujita, K. Takahashi, Y. Sakamoto, M. Narimatsu, K. Nagane, International Journal of Plasma Environmental Science & Technology, Vol.4 No. 2 (2010)

[2] Julian Ryall, Lightning Makes Mushrooms Multiply , National Geographic News (2010)

[3] S. Ohga, S. Iida, Journal of Forest Research, Vol.6 (2001)

Mathematical model of a single phase induction motor with 50Hz / 150Hz magnetic frequency converter

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Keywords: single-phase induction motor, magnetic frequency changer

Electric machines are the most common devices used in everyday life and the number of their types is increasing with the development of science, engineering and technology. The development of electrical machines over the next few years will be mainly related to the evolution of computer hardware, consumer appliances and public transport applications and systems (land, sea and air), micro-electromechanical systems, special applications such as nuclear technologies, weapons systems and others. The development of special machines with unconventional topologies is also foreseen, such as written pole motors, transverse flux motors (TFMs), hybrid, piezoelectric, resonant, oscillating, superconducting, rotary-linear, etc. In this group of unconventional machines is included a single-phase motor with a 50Hz/ 150Hz magnetic inverter. The magnetic circuit of the single-phase motor model and its components are shown in Figure 1.

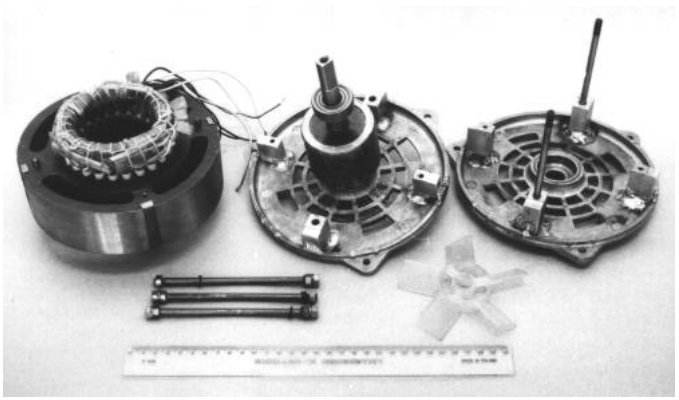

Fig.1. Components of the model of a single-phase induction motor with magnetic frequency converter

The aim of this work is to present a mathematical model of a single-phase induction motor with a magnetic frequency converter in terms of the state variable method. The determination of the motor characteristics requires the solution of a system of nonlinear equations. These equations form the basis for the construction of a scheme, built for use with a simulator, which performs the integration operation of the equations and generates as an output signal, the time form of the state variables and other output variables. The circuit model of the hybrid motor in the PSpice application is represented as two segments. It includes passive elements R, L, C, ABM functional elements and controlled voltage and current sources. The motor model allows the determination of fluxes, voltages and currents in the motor circuit as well as speed characteristics as a function of time.

Electromagnetic compatibility of selected elements of building automation

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Keywords: electromagnetic compatibility, building automation

In new buildings, modern materials and construction technologies are used to ensure optimal living conditions. In buildings, apart from ensuring the basic needs of the user, great emphasis is placed on ensuring the highest possible comfort of use. That is why complex electrical installations are more and more often found in buildings. There is a wide range of devices and types of installations on the building automation market. These systems are divided into open systems, i.e. those in which the transmission protocol is known, and closed systems (the transmission protocol is known only to the manufacturer). Building automation systems can be wired (bus or mains) or wireless. Among wireless systems, there are several popular standards, such as Wi-Fi, ZigBee or Z-Wave. Wireless systems are gaining popularity due to the ease of installation and configuration. Unfortunately, in order to fully equip the building with building automation, it is necessary to install several dozen or even several hundred wireless modules.

The purpose of this work is to test the electromagnetic compatibility of selected building automation components and a comparison of the obtained results with the values given in the EN 55014 standard. Tests were carried out on radiated disturbances emitted by equipment in a GTEM 1000 cell in the frequency range from 30 kHz to 1GHz, and conducted disturbances with a frequency change from 150 kHz to 30 MHz. The following devices were tested:

- the power supply - ZPS640HIC230 without load and working with a laptop and with the switch output 6 contacts - txa 206A, as well as with the universal dimming module - DIMinBOX DX2,
- router - N301,
- central unit for intelligent home management - Fibaro Home centre 3.

The results of measurements of radiated and conducted disturbances of the tested building automation devices do not indicate exceeded emission levels. However, they allow to determine the difference between the level of emission and the permissible limits specified by the standard. The presented selected results of EMC tests indicate that the tested devices are properly designed and constructed and will be safe in operation.

Ohmic Contact Formation on 4H-SiC by CO_2 Laser Annealing of Metal Film on the 4H-SiC

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[1]Department of Computer and Information Sciences, Sojo Univ., Kumamoto, Japan.

Keywords: CO_2 laser, Annealing, 4H-SiC, Ohmic contact

Ohmic contact formation on a 4H-SiC by CO_2 laser annealing of a metal film on the 4H-SiC were performed to reduce the process time in comparison to a conventional furnace annealing. The 4H-SiC was composed of a 3.5-μm-thick n-type epitaxial layer on n^+-type substrate. Pt/Pd film was deposited on the backside of the 4H-SiC substrate by sputtering. Then, CO_2 laser was irradiated to the Pt/Pd film. The pulse width of the irradiated CO_2 laser was as long as ~100 ns. The laser shot frequency was 100 Hz. The laser spot size on the sample surface was ~300 μm in the diameter. The fluence of the laser shot was 16 mJ per a laser shot. After the laser irradiations, surface profiles at the laser irradiated positions were measured by a laser profiler. Also, I-V curve between two positions at the laser irradiations were measured.

Fig. 1 depicts the optical microscopic image and surface profile at the laser irradiated position. The ablation depth at the laser irradiated position is as small as 151 nm. That indicates the laser damage is negligible small.

Fig. 2 shows I-V curve between two Pt/Pd electrodes before and after the laser annealing. I-V curve before the laser annealing is also plotted for comparison. By the laser annealing, much more current flows between the two Pt/Pd electrodes. Also, the I-V curve after the laser annealing shows linear characteristic. The linear characteristic indicates formation of Ohmic contact between the laser annealed Pt/Pd to the SiC. According to these results, CO_2 laser annealing can be a potential candidate for formation of Ohmic contact between a metal and SiC.

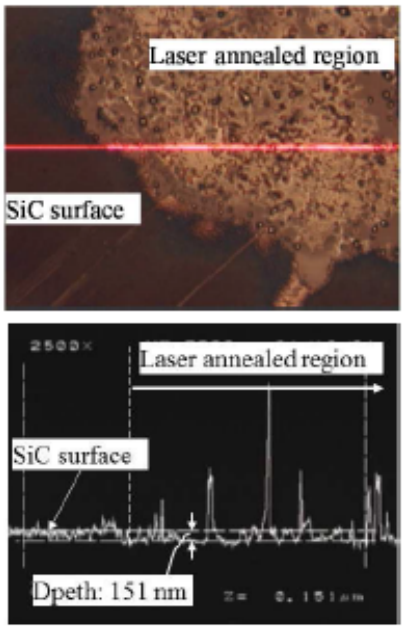

Fig.1. Optical microscopic image and surface profile at the laser irradiated position.

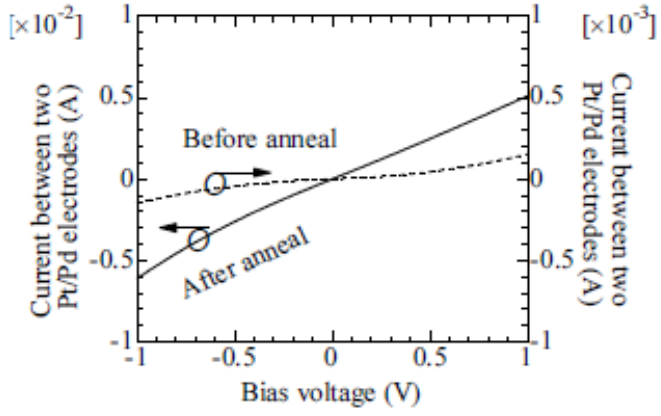

Fig.2. I-V curve between two positions before and after the laser annealing..

Computer simulation of the superconducting transformer in the power grid

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Keywords: superconducting transformer, power grid, short-circuit fault

Power devices constructed with the use of high-temperature superconductors have unique properties that enable the minimization of power losses in the transmission and distribution of electricity. Due to high current density, there is a way to build smaller, lighter and easier to transport installations. In highly urbanized areas, this will allow for a much better use of underground cable ducts and areas of indoor transformer stations. In addition, cryogenic cooling in many situations will contribute to the improvement of operational safety and will enable the use of superconducting machines in facilities subject to rigorous fire protection restrictions.

During short-circuit fault, the superconducting transformer is able to significantly reduce the dynamic effects of the short-circuit current within a few milliseconds. However, windings based on a high-temperature superconductor coated conductor have a very low mass and thus a low heat capacity. Despite the cryogenic cooling and the already limited current, the second generation high temperature superconductor winding will be exposed to thermal damage, the probability of which will appear in a relatively short time of several dozen milliseconds.

The paper presents a numerical analysis of a short-circuit fault in three-phase power system with 10 MVA 115/16.5 kV superconducting transformer. The transformer model takes into account highly nonlinear electrical and thermal properties of the superconducting tape as well as the accumulation of heat in the transformer windings during the fault.

Ni and SUS mixture thin film preparation by sputteringusing NiO2 and SUS powder mixture target

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In general, thin films that have intermediate layers, i.e., gradient functional thin films, are used in a many fields. The use of gradient functional thin films lowers the costs of such cutting tools by applying high-hardness thin films to the surface of an easily machinable material. However, one problem of this approach is poor adhesive strength between the prepared thin film and the base material resulting in the thin film peeling from the base material. Gradient functional thin films simultaneously provide bonding surfaces similar to the base material and hard cutting surface to address this problem. We have previously reported the preparation of A6061 thin films on JIS-S25C steel via sputtering deposition. Furthermore, we reported that A6061 plasma coating was highly effective in reducing hydrogen entry into materials in a corrosive environment. However, the A6061 plasma coating on stainless steel (SUS304) did not markedly increase the hydrogen-entry resistance under corrosive environments; we attribute this result to the difference in the crystal structure between the base material and the film. We also found that the hydrogen embrittlement prevention was improved by doping of small amounts of Ni. Therefore, gradient functional thin films that have an greater Ni contents at the surface of the thin film in contact with the hydrogen gas, and a greater SUS304 content at the boundary with the base SUS304 may be an effective and low-cost strategy to prevent hydrogen embrittlement. In this study, we prepared gradient functional thin films for hydrogen entry prevention by a sputtering deposition method with powder targets. The composition ratio of nickel (Ni) and SUS304 was varied over the film thickness using 11 types of nickel oxide (NiO) and SUS304 mixed powder targets[1-3].

To investigate the hydrogen-entry resistance properties, Ni-doped SUS304 thin films were prepared using a conventional RF magnetron sputtering deposition system, Si and SUS304 substrates were employed as the base materials. The chamber was evacuated to a base pressure of $<5\times10^{-3}$ Pa with a molecular pump and a rotary pump. The gas pressure was changed from the base pressure to 10 Pa by feeding Ar gas into the chamber. NiO and SUS304 mixed-powder target was used for Ni doped SUS304 thin-film preparation. The NiO powder (99.9%) particles had a mean diameter of 63 □m, and the SUS304 powder (99.9%) had a mean diameter of 150 □m. The holders were covered with the target powder such that the powder was level on the target. The distance between the target and the substrate was 30 mm. The temperature at the substrate surface varied from RT to 100 °C. The RF power of the deposition was 100 W.

The quality of the films prepared using the Ni/SUS mixed powder targets was also investigated. Ni-doped SUS304 thin films with a smooth surface morphology were successfully prepared using a mixed NiO/SUS304 powder target. The film surface was composed of fine island-shaped particles, and the particle size and deposition rate increased with increasing NiO content in the powder target. The narrow-scan XPS spectra of the film prepared using the Ni/SUS mixed powder target were obtained. Figure 1 shows the Ni and Fe concentration ratio in the film as a function of the mass ratio of NiO:SUS in the mixed powder target, which means the mass ratio of NiO and SUS powder introduced into the same target holder. The change of the Ni and Fe concentration ratio was nearly linear with increasing NiO and SUS powder mixture.

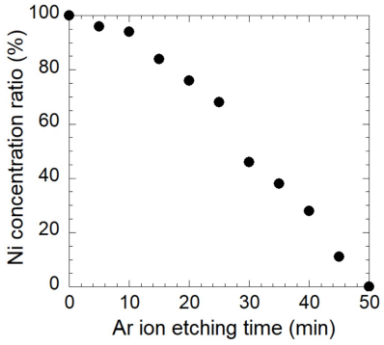

Fig. 1. Ni concentration ratio of the prepared film with Ar ion etching

Gradient functional thin films were deposited by sputtering from 11 types of mixed powder targets. At first, the 100% SUS304 powder was used as the sputtering deposition target. Next, the target was changed to 10%NiO/90%SUS304, and the deposition was performed on the same substrate under the same conditions. Then, gradient functional thin films were prepared by sequentially switching the mixed powder targets from 20%NiO/80%SUS304 to 100%NiO. An XPS depth profile of the prepared film is shown in Fig. 1 with Ar ion etching performed for 5 min between each measurement, corresponding to etching of several tens of nanometers. These results suggest that the Ni concentration ratio of the prepared film decreased with the etching time.

In conclusion, Ni-doped SUS304 thin films with a smooth surface morphology were successfully prepared using a mixed NiO/SUS304 powder target. The film surface was composed of fine island-shaped particles, and the particle size and deposition rate increased with increasing NiO content in the powder target. The processing plasma and elemental concentration ratio of the prepared films could be controlled via the NiO:SUS304 ratio in the mixed powder target.

[1] H. Kawasaki, Y. Suda, T. Ohshima, Y. Yagyu, M. Shinohara and T. Ihara, Jpn. J. Appl. Phys 58, SAAD04 (2019).
[2] H. Kawasaki, Y. Suda, T. Ohshima, Y. Yagyu and T. Ihara, Jpn. J. Appl. Phys. 60 SAAB10 (2021)
[3] H. Kawasaki, Y. Suda, T. Ohshima, Y. Yagyu and T. Ihara, K. Mitsuhashi, H. Nishiguchi and Y. Suda, Jpn. J. Appl. Phys. 61, SA1019 (2021).

Analysis of hydrogen tanks technology for mobile and stationary applications

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Keywords: hydrogen technology, green hydrogen, thermal insulation, hydrogen tank

Fighting climate change might be the greatest challenge of this generation. It means finding solutions to replace fossil fuels as our primary energy source to reverse the on-going global warming. The development of renewable energy sources has become essential, although the intermittent nature of such sources carries the need to provide an additional carrier that allows for a continuous supply of energy. Hydrogen can be such an energy carrier. The most energetically concentrated form of hydrogen is liquid hydrogen. However, this state of hydrogen requires a very low temperature - below -240.18 ° C. The energy density is very high in this hydrogen state, but liquefying and keeping the hydrogen liquid is very energy intensive. The storage of cryogenic liquid is difficult due to the continuous boiling of the liquid due to heat input through leaks in the tank shells or connections, valves, etc. To avoid pressure build-up, the tank must be properly insulated to slow down the evaporation process as much as possible. The use of insulating materials is a passive insulation method. The second method is active insulation methods combining insulation materials with heat dissipation devices such as a cryocooler.

In the paper, we present selected aspects of designing liquid hydrogen tanks. The design involved simulation of thermal processes, and the results were used in the selection of insulation materials and insulation configuration. By determining the thermal power penetrating inside the inner tank, it is possible to determine the mass of evaporated hydrogen in accordance with the adopted criterion, e.g. loss of 1% or 5% of hydrogen per 24 h with the assumed insulation parameters. By comparing the power required to meet the adopted criteria the correctness of the tank structure is checked. Depending on the results obtained, a material or several different materials and techniques are selected for the effective insulation of a tank with a specific purpose and dimensions. Of course, this translates into the cost of making the tank or simplifying its structure, for instance not using vacuum insulation.

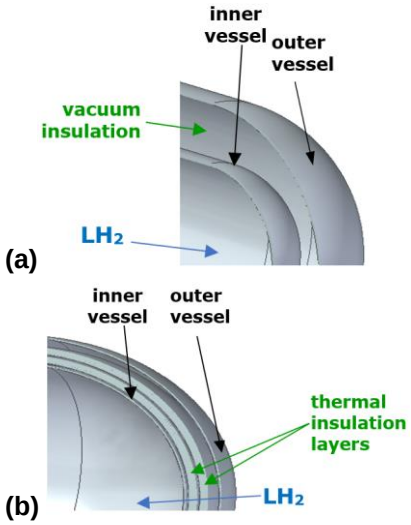

Figure. Basic insulation system of liquid hydrogen tank: (a) vacuum, (b) layer

The use of materials with the lowest thermal conductivity coefficient for cryogenic insulation of liquid hydrogen tanks is not always economically justified. More layers of insulation with a lower thermal conductivity coefficient, cheaper, easier to manufacture and use can be better. It may be a thin layer of vacuum in a special tank design. If we want to limit the dimensions of the tank, we can use a combination of various insulations, e.g. solid, multi-layer or even air layers, or include vacuum-based insulation (MLI and Perlite-Vacuum insulation), which are easier than vacuum insulation. The type of insulation used also depends on the capacity of the tank. In large tanks storing hundreds of kg of hydrogen, for example, 5% of its loss within 24 hours can be assumed - it usually results from the weaker insulation used. In a different manner, in small capacity tanks, a 1% loss of liquid hydrogen per day is usually assumed. In order to meet this criterion, better thermal insulation is usually require

Heat transfer nanofluids based on aqueous ethylene glycol and metal oxide nanoparticles

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Keywords: electric double layer, heat transfer fluids, zeta potential, nonaqueous solvents

Nanofluids based on aqueous ethylene glycol show a broad range of liquid state, and their heat conductance is higher than the heat conductance of pure solvent. The stability of dispersion against aggregation and sedimentation may pose a problem. Dispersions of highly charged particles are relatively stable due to electrostatic repulsion. The electrostatic component in the interaction curves was estimated by measurements of electrophoretic mobility. SDS has a moderate ability to induce high negative zeta potentials. In contrast high positive zeta potentials were induced by CTMABr. Positive zeta potentials were also induced by addition of HCl to the dispersion. The relationship between absolute value of zeta potential and average particle size estimated by DLS was studied.

Fiber optic methods for measuring pressure in switching and switchgear apparatus

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Keywords: optical fiber sensors, pressure sensing, vacuum measurement, vacuum sensor

The idea of Smart Grid, which is successfully implemented in Western Europe, has forced the distribution system operators to intensify their activities aimed at developing the grid infrastructure in Poland [1]. To fulfill the idea of Smart Grid, it is necessary to use advanced switching and distribution equipment and to measure as many network parameters as possible.

Many methods are known and in use to measure the pressure within a vacuum apparatus, the most popular of which is the partial discharge method. This method can detect pressures above 250 Pa, which makes it very useful for determining chamber leakage [2]. Unfortunately, this method has two significant disadvantages. The first one is the necessity of disassembling the device and transporting it to the laboratory for testing, which increases the unreliability coefficients SAIDI and SAIFI [3], and the second one is the problem of creating an inertial system that allows to measure the evaporation only between the contacts. Therefore, a lot of research is being conducted to enable pressure control inside the vacuum apparatus directly at the point of installation of the device in the grid which will minimize the number of planned powers.

Fiber-optic pressure sensors are attracting increasing interest from researchers because they are very tempting for industrial applications due to their electromagnetic immunity and small size, as well as their ability to be used in extreme environmental conditions. The most established and widespread sensors based on fiber optic technology are Fabry-Pèrot sensors based on a vacuum-enclosed cavity that is susceptible to pressure changes [4] and sensors based on fiber optic Bragg gratings [5, 6], which are highly susceptible to deformation which is a convenient alternative to conventional measurement methods. A significant problem in the application of optical fiber technology for pressure measurements is the susceptibility of the optical fiber to thermal effects, therefore suitable methods of compensation of temperature influence on the measurement are necessary.

1. Węgierek P., Staszak S., Pastuszak., EKTOS – innovative medium voltage outdoor vacuum disconnector in a closed housing dedicated to the network Smart Grids, Wiadomości Elektrotechniczne 2019, R87, nr 11, p.21-25
2. Kamarol M., Ohtsuka S. Hikita M., Saitou H. Sakaki M. Determination of Gas Pressure in Vacuum Interrupter Based on Partial Discharge, IEEE Transactions on Dielectrics and Electrical Insulation Vol. 14, No. 3; June 2007 p. 593 – 596
3. Raport PTPiREE za rok 2021
4. K. . H. Y. ; Totsu and M. Esashib, “Vacuum Sealed Ultra Miniature Fiber Optic Pressure Sensor Using White Light Interferometry,” in 12th International Conference on Solid-State Sensors, Actuators and Microsystems, 2003, pp. 931–934.
5. F. Urban, J. Kadlec, R. Vlach, and R. Kuchta, “Design of a pressure sensor based on optical fiber Bragg grating lateral deformation,” Sensors, vol. 10, no. 12, pp. 11212–11225, 2010
6. B. McMillen, C. Jewart, M. Buric, K. P. Chen, Y. Lin, and W. Xu, “Fiber Bragg grating vacuum sensors,” Appl. Phys. Lett., vol. 87, no. 23, pp. 1– 3, 2005

Forces and stresses in the windings of a superconducting fault current limiter

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Keywords: fault current limiter, superconducting tape, short-circuit.

The article presents the results of calculations of forces and stresses occurring in the windings of a superconducting fault current limiter during a short-circuit. The limiter consisting of two coaxial windings connected in parallel and wound in opposite direction ensures the limitation of the short-circuit current in the first period before the current is switched off by the circuit-breaker. During this time the windings are strained by the forces generated by the action of the magnetic field on the superconducting tape with the high current.

The design of the fault current limiter consists of two parallelly-connected and magnetically-coupled windings cooled by a single stage cryocooler. Magnetically-compensated windings made of high temperature superconducting tape give a very low voltage on the limiter at a nominal current.

Limitation of the short-circuit time and the value of the maximum initial fault current reduces the thermal and dynamic effects of the passage of a fault current. Using devices which limit the value of a fault current can lower the level of required short-circuit capacity of the elements of the system.

The perfect fault current limiter is required to have large impedance in fault conditions and zero impedance at work currents. Such requirements are met by a Superconducting Fault Current Limiter (SFCL). An increase of current caused by the occurrence of a fault current causes the transition of the superconducting material from the superconducting state into the resistive state. This increases the impedance of short-circuit loop, allowing the fault current value to decrease.

During a short-circuit, the temperature of the windings increases from cryogenic temperature to room temperature. Forces also act on the windings. The direct cause of the forces acting on the superconducting windings is the influence of the magnetic field on the HTS tape with the fault current. The direction and value of the forces were determined on the basis of the magnetic flux density distribution calculated in the FEMM software.

SSCL separator mass change

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The SFCL was tested in the Short-circuit Endurance Testing Laboratory of the Institute of Electrical Engineering in Warsaw. The short-circuit tests were successfully carried out. After analyzing the experimental results and after analyzing the results of the numerical models of the limiter, I change the concepts of using SFCL in the power industry. I go from Superconducting Fault Current Limiter (SFCL) to Superconducting Surge Current Limiter (SSCL). This change will reduce the heating time of the SFCL limiter from 0.08 s to 0.01 s.

The most important thing is that after a short-circuit of (0.01 s) SSCL the limiter returns from the resistive state to the superconducting state after less than 1 s, and exactly after = 0.55 s. This is of fundamental importance from the point of view of power engineering. The power system, after disconnecting during the fault, is reconnected after less than 1 s. So this (0.01 s) SSCL limiter can be reconnected to the system after less than 1 s. The limiter operating in the (0.08 s) SFCL regime cannot be re-included in the system after less than 1 s, because it returns to the superconducting state only after 1.55 s.

Based on the new concept, a change in the design of the limiter was analyzed. This is the change in the mass of the limiter. The superconducting part does not change. The copper part of the limiter is changed, as it rapidly receives the heat generated in the HTS tape during a short- circuit.

After limiting the short-circuit, the limiter connected to the protection system, changes parameters as a result of the limiter temperature increase.

The recovery time of the HTS tape from the resistive state to the superconducting state increases when the mass of the limiter decreases. Weight reduction by up to 20% does not increase the transition time of the limiter from the resistive state (after a short-circuit) to the superconducting state to over 1 s ($t_{R\text{-}N}$ (20%) = 0.71 s). So the limiter can be turned on again by the power system after the short-circuit is reduced. Weight reduction reduces the cooling time of the limiter to the initial temperature (in this case to 72 K). The only disadvantage of reducing the mass of the limiter is the reduction of its parameters I_c / $I_{r\ max}$ (72 K).

The technical capabilities of electric vehicles produced today and available commercially

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Keywords: electric vehicle, electric drive system, hybrid vehicle

The article compares the technical parameters of 10 selected electric vehicles, such as: supply voltage, battery capacity, vehicle range and maximum torque, power and maximum rotational speed achieved by the electric motor. A graph of the maximum torque in selected electric passenger vehicles is presented. The value of the torque of the engine installed in the vehicle indirectly influences the driving dynamics and directly its transport possibilities. The greatest maximum torque of the engine is achieved by the Tesla S85D car with a value of 658 N m. The Tesla S60 car has a slightly lower value (65.3%) of the maximum engine torque. Among the electric vehicles mentioned, the lowest value of the maximum engine torque is reached by the Fiat 500e, which is 200 N m. This is only 30.4% of the value achieved by the Tesle S85D. The power of electric motors in selected passenger cars was compared, with the Tesla S60 electric motor having the highest value of 283 kW. The lowest value of the electric motor power is achieved by the VW e-UP, which is 60 kW. This is about 21.2% of the value achieved by the Tesle S60.

A comparison of the maximum rotational speed of electric motors in selected passenger vehicles is presented. The highest value of the maximum speed of the electric motor is achieved by Tesla models with a value of 16,000 revolutions per minute. The Nissan Leaf reaches the lowest value of the maximum rotational speed of the electric motor. This is about 65.6% of the value achieved by Tesla vehicles. However, when comparing the value of the supply voltage of electric vehicles of selected passenger cars, the difference is negligible. The Tesla and Renault models have the highest value of the supply voltage of electric vehicles, and the lowest value is the Volkswagen e-Golf. The VW e-UP has the smallest battery capacity with a value of 18.7 kWh, which is 4.5 times smaller compared to the Tesla S85D battery capacity (85 kWh). The real test range is smaller than the declared range. The declared range is obtained in laboratory conditions, while the test range is obtained when driving in road conditions. The biggest difference in range is visible for Tesla Model 3 Long Range (60.7% of the declared range value), and the smallest is Hyundai Kona Electric 64 kWh (92.9%).

Surgical procedure lighting unit

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Keywords: surgical procedure lighting, light fixture, LED pulsed power supply

The presented topic is related to the construction of a lighting unit for surgical procedures.

The project is the implementation of a combination of technologies: improving color rendering, increasing the homogeneity of the light beam, low propagation of thermal energy and pulsed power supply, which is highly efficient, precise and fully controllable. This power supply offers an extremely high level of safety. These combined features provide unique performance characteristics to the treatment lighting unit. The combination of these technologies is both innovative and exhausts modern technology resources

The lighting fixture in this case is a ceiling-mounted or optionally wall-mounted structure. This configuration improves the ergonomics of movement in the field of medical work activities.

Contrary to the known constructions, a homogeneous light beam is not obtained with the use of one light source. A single dome with several light-emitting elements is also not used. The property was obtained through the use of a solar-canopy composed of five independent modes. Each module has up to 30 lensed light LED sources.

The lamp uses modular LED diodes, thanks to which an extremely low energy consumption and has negligible thermal radiation to the treatment area were obtained.

Through the technique of mixing modules from two families of obtaining white color: manner of a mask and independently combining monochrome colors, this configuration is especially useful for distinguishing colors from the red palette. This allows for a correct visual assessment of the condition of the tissues. Also The luminaire provides a good depth of the light beam.

Design and Analysis of Standing-Wave Pulsed-Field Magnetisation System for HTS Bulks

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Keywords: high-temperature superconductors, pulsed-field magnetization, finite element analysis, type-II superconductors

The following paper consists of design considerations for pulsed-field magnetisation (PFM) system that utilizes standing wave generated by coil. Parametric analysis of magnetisation circuit is carried to determinate performance of a magnetisation process of the YBCO bulk. The lumped circuit model shown in Fig. 1 of pump is analysed and finite element method is used to calculate magnetic field stored inside superconducting bulk for various circuit parameters.

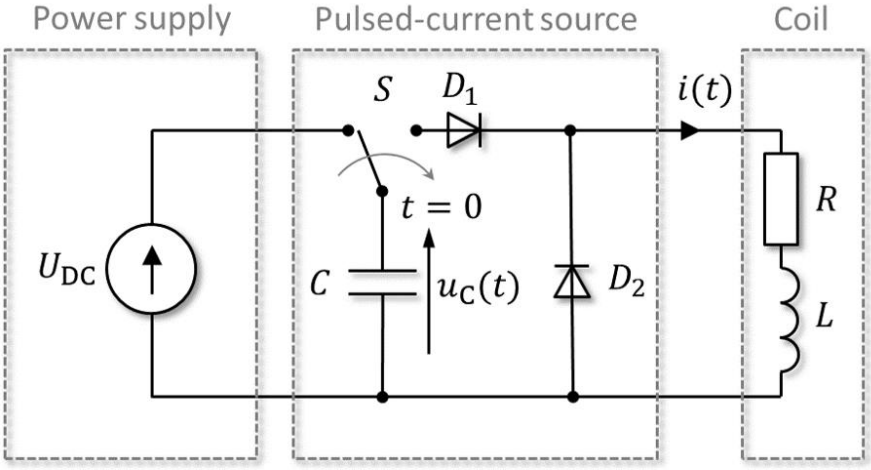

Fig. 1. Circuit model of a RLC flux pump system

The flux pump designed for a pulsed-field magnetisation has to fulfil the requirements of achieving the given magnetic flux density applied to the HTS bulk. A mathematical model is derived and analysed for a proposed topology of an electric circuit for the flux pump. The model allows for analysis of the influence of circuit parameters on current waveforms in the designed circuit. The data obtained from current waveforms can be used for choosing other components of the flux pump. Analysis is carried out to correlate value of capacitance and coil parameters – resistance and inductance with a current, and consequently – applied field waveforms. As a result of an analysis, the influence of circuit components on parameters such as peak applied field and it's rate-of-change is determined. The analysis shows that peak applied magnetic flux density depends mostly on capacitance and voltage of capacitor bank with minor influence from the number of turns for a given wire diameter, whereas the field rate-of-change depends on the inductance. The obtained numerical models are then verified experimentally.

Improvement of technical parameters of vacuum interrupters used in ecological switchgear of medium voltage

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Keywords: vacuum interrupters, dielectric strength, noble gases, environmental protection

Continuous increase in demand for electricity and poor technical condition of the existing power infrastructure makes it necessary to build new power networks with better technical parameters to ensure reliable supply of electricity to end users. Switching devices used as elements of medium voltage lines are divided into two types. The first of them are devices with open construction and constantly gaining in importance devices with closed construction. The most common enclosed devices are those that extinguish the electric arc in SF_6 gas or in a vacuum environment. Sulfur hexafluoride (SF_6) is one of the so-called fluorinated greenhouse gases that have the effect of increasing the temperature of the atmosphere, and it is the most potent of its kind classified to date. The parameter known as the global warming potential for sulfur hexafluoride is 22200, which is the equivalent effect of 1 kg of SF_6 and 22200 kg of carbon dioxide. An alternative to SF_6 gas is apparatus based on vacuum technology.

One of the ways of improving the technical parameters of vacuum switchgear is to increase the rated operating pressure of vacuum chambers by dosing selected noble gases into them. As part of the research work, measurements have been carried out on the electrical strength of vacuum insulation systems in the environment of residual gases being helium and neon. The difference in the pressure range in which the electrical strength is kept constant was observed. The chamber filled with residual gases in the form of helium lost its insulating capacity at a pressure equal to $p = 2{,}00 \times 10^{0}$ Pa, while the chamber with residual gases in the form of neon at a pressure equal to $p = 4{,}00 \times 10^{-1}$ Pa. The decrease in the insulating capacity of the chamber filled with air molecules occurred at a pressure value equal to $p = 3{,}50 \times 10^{-1}$ Pa.

The differences described above provide some alternatives related to the insulating medium used in vacuum interrupters used in electric power switching apparatus. Thanks to the use of e.g. neon or helium, it is possible to increase the nominal working pressure of such a vacuum interrupter, maintaining its full insulating capability. Increasing the working pressure rating of a vacuum interrupter will make it easier to maintain its tightness, and thus reduce the likelihood of it leaking. In addition, the use of gases such as helium or neon are environmentally friendly and contribute to the reduction of greenhouse gas emissions into the atmosphere.

Teaching computer science in the field of Electrical Engineering

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Keywords: computer science, electrical engineering, microcontrollers, microcomputers

In the process of educating engineers in the field of electrical engineering and related sciences, the block of IT subjects will be of increasing importance. Increasingly, designed electrical or even power devices are increasingly coupled with microprocessor elements. This layer is responsible for controlling and monitoring the operation of the device. This approach makes it easier for the manufacturer to adapt the offered product to the expectations of customers. The offer therefore becomes more flexible, and thus more attractive compared to the competition.

In view of the above, it appears that in the process of educating future electrical engineers, it becomes necessary to put more emphasis on the IT block of education. Particular attention should be paid to the interface between electrical engineering and computer science, i.e. programming microcontrollers and designing control and measurement systems with their help.

Currently, a number of solutions dedicated to educational purposes are available. Starting with microcontrollers from the Arduino family, through Raspery Pi microcomputers, or the whole range of products offered as part of the M5 family. Of particular note is CrowPi 2, as shown in Figure 1, dedicated to the Raspery Pi microcomputer version 3 and 4 offered by Shenzhen Yikenuo Technology Development Co., Ltd. in the form of a laptop with a number of integrated additional devices. The device after installing a dedicated operating system allows you to learn programming in C/C++ or python languages, but also supports the practical application of acquired programming skills to the software of available devices.

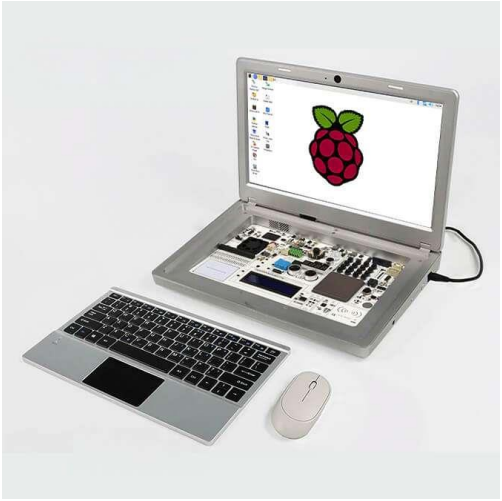

Fig 1. CrowPi 2 – Raspberry Pi education platforms

Use of bifilar winding to enhance germination of rapeseed

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Keywords: bifilar winding, rapeseed, germination force

Rapeseed is one of the main oil crops in Poland and worldwide. Rapeseed is used in many industrial sectors. Above all they are used for pressing rapeseed oil, as an addition to biofuels or as animal feed due to their high protein content.

In Polish conditions rapeseed is sown in the second half of August. This month is one of the hot months and more and more often there are periodic droughts. In order to make maximum use of the moisture in the soil it is necessary to ensure that the rapeseed has the greatest possible germination strength. This will help them reach the minimum growth stage faster to survive drought conditions.

A bifilar winding was used as an electrostatic field source to increase the germination force. The rapeseed was exposed to the electrostatic field by varying the field strength and exposure time. The seeds prepared in this way were sown on Petri dishes. In the next step the germination power of these seeds was tested according to the PN-R-65950 standard in comparison with seeds not exposed to electrostatic field. The study shows that the electrostatic field affects the germination strength of the seeds. It is possible to increase it even by several percent compared to the seeds not subjected to the action of electrostatic field. In the case of optimal selection of field parameters, it is possible to increase the germination strength by more than 20%.

Measurements of soil moisture with a dagger probe using the FDR technique

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Keywords: dagger probe, soil moisture, FDR

Soil is a heterogeneous and multiphase material. It consists of solids, air and water, for which a distinction is made between free and bound water. One of the most important soil physical properties are: soil moisture, soil electrical conductivity and soil density. From a biological point of view, moisture is a key soil parameter. Therefore, many methods and measurement techniques have been developed to determine soil moisture.

This paper presents a new soil moisture probe utilizing Frequency Domain Reflectometry (FDR) measurement technique. A dagger probe, patented at the Institute of Agrophysics, Polish Academy of Sciences, was used for the study. This probe is characterized by increased mechanical strength in one plane so that it can be successfully used in on-the-go mode, during which the probe needs to withstand high mechanical stresses caused by multiple insertion and removal from the soil. The probe design, in addition to adequate strength, has a high measurement accuracy, so it can be mounted on mobile platforms for irrigation and soil fertilization in precision agriculture.

Measurements were made for soil of different moisture content and salinity. A vector network analyzer type ZVCE from Rohde&Schwarz in the frequency range from 3.74 MHz to 3 GHz was used for the measurements. From the obtained characteristics, characteristic points were determined. These points were correlated with soil moisture and calibration curves were fitted to obtain the highest coefficient of determination.

One-dimensional mathematical model of conduction-cooled current leads

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Keywords: superconductivity, current lead, conduction cooling, mathematical model

Current leads are part of superconducting electrical equipment. Current leads are part of a cryostat connecting external devices operating at room temperature to devices operating at cryogenic temperatures. The warm end of the current lead connected to the current source is at room temperature (293 K), the cold end of the current lead connected to the superconducting device operates at cryogenic temperatures. Current leads can be made of both non-superconducting and superconducting material, both HTS and LTS. In superconducting devices, the power losses generated in the current leads have a large portion of the thermal energy that the cooling system is designed to dissipate so as to maintain the temperature of the superconducting device at a specified level. When the cooling power of the cryocooler is too low, the heat flux entering the cryostat through the current leads and the Joule heat generated in the current leads by the current supplying the electrical device can prevent the superconducting device from cooling to the required operating temperature. Due to the need to minimise resistance, current leads should have as large a cross-section as possible. On the other hand, a large heat flux flows through the large cross-section to the inside of the cryostat by thermal conduction. Reducing the cross-sectional area of the current leads reduces the heat input from the outside, but at the same time increases the Joule losses in the current leads, through which a large current flows. In this paper, the one-dimensional mathematical model of conduction-cooled current leads has been presented.

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Reference list

[1] Kozak S., Modelowanie elektrycznych urządzeń nadprzewodnikowych, Prace Instytutu Elektrotechniki, zeszyt 221, Warszawa, 2005.

[2] Janowski T., Stryczewska H. D., Wac-Włodarczyk A. (red.), Technologie nadprzewodnikowe i plazmowe w energetyce, Lublin, 2009.

[3] Buyanov Y. L., Fradkov A. B., Shebalin I. Y., A review of current leads for cryogenic devices, Cryogenics, vol. 15, no. 4, pp. 193-200, Apr. 1975

[4] Buyanov Y. L., Shebalin I. Y., Current leads to a cryostat working under short-term load conditions, Cryogenics, 15(10):611–3, 1975

[5] Chang H.-M., Kim M. J., Optimization of conduction-cooled current leads with unsteady operating current, Cryogenics, vol. 49, no. 5, pp. 210–216, May 2009

Electromagnetic disturbances in a plasma reactor at different interelectrode distances

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Keywords: plasma reactor, emc, electromagnetic disturbances

In the Glidarc plasma reactor, the flow of electric current in the gas ensures the generation of plasma. The arc discharge is a highly nonlinear and asymmetric load, associated with dynamically varying transients and short-circuit phenomena.

The static and dynamic characteristics of a plasma reactor depend on many factors that can be related to the plasma reactor geometry, the operating gas delivery system, and the power supply system. By changing the reactor geometry, working gas composition, and power supply parameters, the electrical and thermal parameters of the discharge in the discharge chamber of the plasma reactor can be influenced.

Gas enters the chamber of a three-phase reactor at a finite velocity, between the working electrodes. Previous analyses of conducted electromagnetic disturbances studied in the power path of the GlidArc-type plasma reactor indicate that the reactor is a source of electromagnetic disturbances. Stable reactor operation depends on the power system, and existing disturbances in the system can affect the inhomogeneity of plasma generation. Therefore, it is important to identify disturbance levels that depend on various factors. In the case of this paper, the analysis deals with the disturbance level at different distances between the working electrodes.

$NiMoO_4$ supported on γ-Al_2O_3 for syngas production with solar energy assistance"

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Keywords: low-temperature plasma, syngas, dry reforming

The production of synthesis gas (syngas; a mixture of H_2 and CO) is an important industrial process in the conversion of natural gas to liquid fuels and block-substrates for further synthesis of chemical products. Dry reforming has received much attention as a technology to produce syngas for the production of sulfur-free liquid fuels and oxygenated chemicals at a low H_2/CO ratio by syngas. Dry reforming of methane with CO_2 is a well-known process that has been extensively studied owing to its industrial importance to produce syngas.

Recently, considerable attention has been paid to the dry reforming of light hydrocarbons such as ethane and propane as an alternative hydrocarbon for the production of syngas. Propane, which is here hydrogen source; is a compressible liquid andit can be easily stored and transported. Propane was expected to produce more surface carbon species compared to natural gas due to a higher carbon atom content, consequently, creating an ideal environment for the challenge that needed to be overcome. Moreover, utilizing higher hydrocarbon substrate is preferred as it requires less energy for the bond breakup. Furthermore, higher hydrocarbons are known to have a lower flammability limit which is 5.3–15% for methane and 2.2–9.6% for propane. It exists in gaseous form at standard temperature and pressure. The Dry reforming of propane (DRP) with CO_2 was examined over NiMoO4 supported on γ-Al_2O_3. The possibility of support a lab scale process with solar energy was analysed.

Detection of plasma-induced pressure wave using optical wave microphone

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Keywords: optical wave microphone, pressure wave, plasma

The authors have developed an optical wave microphone and used it for the detection of pressure wave generated by plasmas including dielectric barrier discharge and plasma jet. Because the optical wave microphone, that works based on Fraunhofer Diffraction of laser, has higher sensitivity compared to other optical methods and can be used in strong electric field without disturbing original sound distribution, it is suitable to be applied in plasma field. Most of discharges emits shock wave at the moment of breakdown as local heating occurs very immediately, which degenerates to sound wave. The authors already succeeded to detect pressure waves emitted from each micro-discharge in a surface dielectric barrier discharge device and two-dimensional distribution of pressure wave was successfully visualized by combining CT scan technique.

In this work, the optical wave microphone is applied to plasma jet. Plasma jet attract much attention for its potential applications in medical, and aeronautic fields. Regarding plasma actuator, the working mechanism is not revealed yet. It is also known in the medical application of plasma jet that plasma induced flow is formed on the surface of liquid target after plasma jet irradiation. In the authors' experimental setup, a capacitive plasma jet is used in He gas flow. The device is composed of a glass tube, and two metal sheet electrodes that are wrapped at the outer wall of the glass tube. Then, a burst wave with sinusoidal waveform is applied to the high voltage electrode to generate plasma jet intermittently as it is more suitable way to measure the waveform of generated pressure wave. The amplitude of the applied voltage was 20 kV. The optical wave microphone is set below the glass tube. The position of the electrodes on the glass tube is changed to estimate the propagation speed of the generated pressure wave. In addition, the measurement position of the optical wave microphone is changed by adjusting the distance from the tip of the glass tube to the optical wave microphone. As the result, firstly, pressure wave was detected even in He gas flow with the optical wave microphone. It was also found that it was difficult to recognize time difference among pressure waves observed at different electrode positions. This result means that the propagation speed of generated pressure wave is rather fast because the sound speed in He gas is 1000 m/s theoretically and it shows higher speed when it is in the form of shock wave around breakdown position. It was confirmed by changing the measurement position that the signal intensity of the optical wave microphone increased with the increase of the measurement distance from the glass tube as the mixture rate of air in He gas, that is, refractive index increased. The propagation speed also degenerated when the measurement position was farther from the glass tube. This observation of pressure wave must be very important when treating liquid targes and the observed pressure wave could influence the plasma induced flow that is observable on the liquid surface.

Machine learning in low voltage future grid

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Keywords: regression, artificial neural networks, energy storage (BESS), LV grid

The article is a continuation of the research carried out by the authors in the field of power regulation in the LV grid. The authors present the possibility of using Machine Learning technology by DSO in the future smart grid. Based on supervised learning, the Selectively Coherent Model of Converter System Control for LV grid (SCM_CSC) was proposed.

This is a new, fresh approach to combining off and on-line calculations for DSO, which is part of the decarbonization process. The main nucleus of the model is the ANN neural network prepared on the basis of the obtained preliminary predictive results by regression machines.

For selected scenarios of PV systems operation, the LV grid of the future dynamically regulates the power flow with the use of AC / DC converter systems as Battery Energy Storage System element (BESS).

The objective function is to maintain the required voltage conditions for high PV generation in the area of LV grid feeders and to minimize power flows tendency the MV grid.

On the basis of training and validation data prepared for ANN, the mean Absolute Percentage Error (MAPE) was obtained in the range of <0.01%: 0.5%>, which is the level of (200 W– 300 W) error in the selection of BESS power control.

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Measurement of microwave plasma parameters using the LIF laser fluorescence methods

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Keywords: laser induced fluorescence, microwave plasma, NO radicals

For several decades, the Centre for Plasma and Laser Technology has been conducting experimental studies of various plasma sources. The studies included microwave discharge plasma under atmospheric pressure. The main advantages of plasma generated with microwave involve lower implementation costs, ease of use, greater efficiency and better process reliability.

As part of current research, generator plasma was tested using laser fluorescence method (LIF). The LIF method consists in the excitation of the medium using laser radiation followed by measurement of the laser-induced fluorescence radiation intensity.Thanks to this we obtained information about plasma molecular composition. In the experiment we used a plasma generator in which plasma is being produced at the end of an electric conductor made of tungsten. The electric conductor was located inside the channel with selected working gas. Working gas was excited and ionized by microwaves. As a result the plasma occurs in the form of a flame. Microwave plasma is used to deactivate bacteria and fungi, improve quality of foods like e.g. spices and modify surfaces. We investigated spatial distribution of nitrogen oxide radicals in the microwave plasma flame using air with nitrogen as working gas. We also checked the influence of plasma parameters on the intensity of the LIF signal. We changed the microwave power from 100W to 280W. The air and nitrogen flow rates range was 10-20 L / min.

The study showed that the amount of NO radicals in the flame of the plasma supplied with air increases with the increase of microwave power, while the intensity of air and nitrogen flow does not affect the intensity of the LIF signal. Moreover, the change in plasma power does not affect the LIF signal intensity, if nitrogen is used as working gas.

Electrostatic filtration of solid particles suspended in air with DBD-type ionizer

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Keywords: air purification, dielectric barrier discharge, SDBD ionizer

Air pollution by particulate matter is one of the major environmental risk to human health in the modern world. Inhaling particulate matter suspended in air can lead to respiratory disorders and health diseases. In order to reduce the inhalation of harmful pollutants, we have developed a small two-stage electrostatic precipitator (ESP) for indoor air filtration. The main component of the ESP is the SDBD (Surface Dielectric Barrier Discharge) ionizer, which is used both for ionization of pollutant particles and to pump polluted air via so called electrohydrodynamic effect.

As part of our study, we measured the filtration efficiency of the ESP with different geometries of discharge electrodes and applied voltage. Test were carried out on an model of electrostatic precipitator consisting of and SDBD ionizer and simple electrostatic collector. To measure the filtration efficiency we used the optical particle size analyzer Topas Lap 322. As the source of air pollution we used dust with a particle distribution ranging in size from about 0.2 μm to 20 μm. Studies have shown that changes in the geometry of the discharge electrodes and applied voltage affect the filtration efficiency of the ESP. Studies showed that filtration efficiency increases with an increasing voltage from about 10 kV to 14 kV and then starts to decrease. The highest filtration efficiency of about 95% was achieved for the ionizer with a flat electrode and applied voltage of 14kV. To further increase filtration efficiency, we have developed a flow controller that forces air flow close to the discharge region of the ionizer, thus increasing the amount of electrically charged particles in the flow. The use of a flow controller allowed us to increase filtration efficiency to about 97%

This research was funded by National Centre for Research and Development (NCBiR), grant number LIDER/17/0110/L-10/18/NCBR/2019.

Composites Fe/SBA-15 obtained by chemical vapor deposition $Fe(CO)_5$ onto SBA-15 mesoporous silica

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Department of Electrical Engineering and Electrotechnologies,
Laboratory of Electrochemistry, Lublin, Poland

Keywords: SBA-15, Chemical vapor deposition, BET, XRD, Mössbauer spectroscopy, zeta potential

$Fe(CO)_5$ was deposited on SBA-15 from gaseous phase and the adsorbed iron precursor was degradated at 250 °C. Composites without sulfur and halides could be potential application as catalysts and catalyst supports. Our obtained composites containing 1.3–157.5% of Fe_2O_3 (SiO_2=100%). The new materials were characterized by specific surface area (BET), XRD (X-ray diffraction), Mossbauer spectroscopy, electron microscopy coupled with EDS (energy dispersive X-Ray spectroscopy), and electrophoretic mobility.

Preparation of multi-elements mixture thin film by sputtering deposition using mixture powder target

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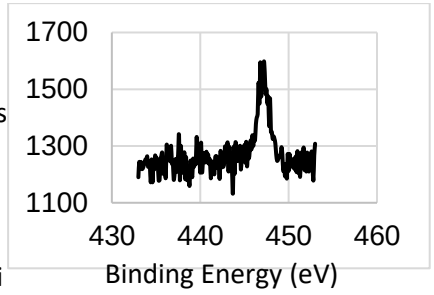
Keywords: sputtering, powder target, transparent conductive film

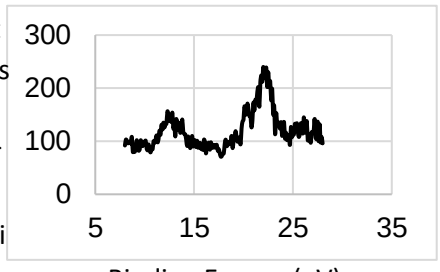
To prepare multi-element thin films, we have been developing a plasma process method using powder targets. Several kinds of powders are mixed and then placed in a target holder in a vacuum chamber in this method. Multi-element thin films are deposited on a substrate set on the opposite side of the vacuum chamber to the target holder. Using this approach, it is easy to control the target powder mixture to change the doping density. This method has been used to prepare several kinds of functional thin films; for example, dielectric films and/or magnetic composite oxide films. We have also used this approach to fabricate transparent conductive films. For example, thin films consisting of indium (In), gallium (Ga), and zinc (Zn) oxides (denoted as IGZO) have been used as transparent conductive films for liquid crystal and/or electroluminescent displays. Usually, IGZO films are prepared by expensive methods such as sintering target sputtering. In this paper, IGZO thin films are prepared in one step by sputtering deposition using powder targets consisting of mixtures of indium oxide (In_2O_3), gallium oxide (Ga_2O_3), and zinc oxide (ZnO). The properties of the prepared films, such as surface roughness, surface crystalline, and elements composition are investigated.

Thin film was prepared using conventional sputtering deposition system with powder targets. A powder target was placed in a target holder. In this experiment, In_2O_3, Ga_2O_3, and ZnO powders were mixed by a powder mixer. The weight ratio of the powders was changed to vary the target composition. RF plasma was generated at an electric power of 100–200 W for powered electrode.

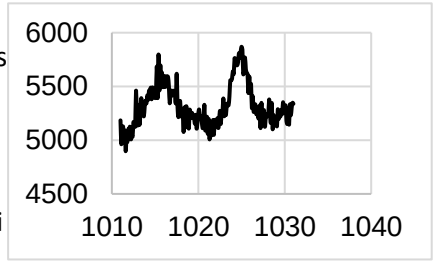
Fig.1 shows the XPS narrow spectrum of In, Ga and Zn in the prepared film. All elements can be detected. As the results, IGZO thin films were prepared by sputtering deposition using targets consisting of mixtures of In_2O_3, Ga_2O_3, and ZnO powders.



(a) In 3d



(b) Ga 3d



(c) Zn 2p

Fig.1 XPS narrow spectrum of the prepared film

DMC method in CR fuel injection system diagnostics

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Lublin University of Technology, Lublin, Poland

Keywords: automotive troubleshooting, system Common Rail, oscilloscope measurements

Systems controlling car engine fuel feed must comply with strict environmental standards. During using a car the diagnostics which detects resultant damage is essential. That is why new diagnostic methods are being developed which would detect faults in case they are not detected by self-diagnostic systems.

The article presents a non-standard diagnostic method and the results of its employment in Common Rail type fuel injection system diagnostics. The method is based on the analysis of oscillograms recorded by a specialist oscilloscope EDIA-PRO. The oscilloscope will permit to accurately examine the work of injectors and falls in fuel pressure on feeding rail.

In research work examinations on sample of three hundred defects in CR systems of various car makes were carried out. All the defects concerned the cases in which it was not possible to define explicitly defects with standard diagnostic methods. The analysis was conducted on the basis of documentation collected in Auto-Electro-Service SAHIB workshop and in work results of Scientific Association PRIVE in Lublin University of Technology.

Control of the drug packaging process

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Keywords: automation, PLC controller, packaging

The purpose of this thesis was to develop a control system for a functional model that counts down tablets. An overview of industrial solutions for drug packaging and weighing with the use of mass volumetric and quantitative identification was done.

I did an overview about asynchronous motor, inductive, capacitive and optoelectronic sensors, PLC controller and pneumatic actuators. I tried to describe how they are built, how they work and what they are used for. In case of asynchronous motor, I also described the methods of adjustment and start-up.

For an exemplary functional model, an electrical system was designed including: sensors, actuators and a controller, a control algorithm was developed, which was then implemented by programming the selected PLC controller in Ladder Diagram language. I also made a new mechanical construction which mas more optimized.

An electromagnetic force control concept for resistance welding machines

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Keywords: electromagnetic actuator, force control, resistance welding, spot welding systems

The paper is focused on new type force control concept dedicated for resistance welding systems. The concept is based on system of electromagnetic actuators. Control of forces during resistance welding process is extremely difficult because of sensitivity of parameters: short time of the process together with wide range of required forces and varied mechanical properties of welded materials. Up to date welding machines were controlled by pneumatic force control systems. Such and “old method” is characterized by numerous drawbacks, mostly complexity of the system. Recently such systems started to be replaced by servo-mechanical control systems. Unfortunately servo-motors have not enough high dynamics required for rapid welding process. Initial examination of electromagnetic systems shows that they are interesting players in application of force control in spot welding processes.

The paper will contain description of the concept of electromagnetic force control in welding system, description of required parameters, trajectories of typical forces applied for welding electrodes and results of initial modelling of the process. The paper will also include description of an experimental test bench and first results of experimental force generation. Proper control and monitoring system based on Arduino will be presented and examined. General view of the test bench is presented in Fig. 1.

The paper will include conclusion with discussion of results and general assessment of proposed system for practical application of welding systems, taking into account different scales of welding currents, forces and different sizes of welded components.

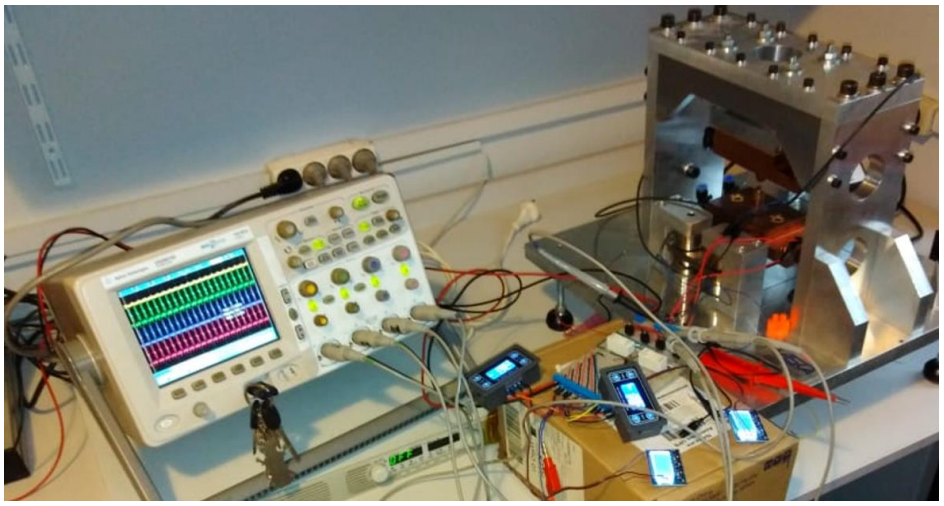

Fig. 1. Experimental test bench for force control examination

Review of plasma technologies application in agriculture, biomedicine, power and environmental engineering

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Kumamoto University, Kumamoto, Japan

Keywords: thermal and non-thermal plasma, power systems of plasma reactors, ozone disinfection and sterilization, bio-plasma

Research on plasma technologies has been carried out in Department of Electrical Engineering and Electrotechnologies (DEE&Et) of Lublin University of Technology (LUT) for almost thirty years now. It started from new, based on magnetic frequency tripler's, power system for ozone generator installation that has been working in the existing drinking water treatment plant in Grodzisk Wielkopolski in early 80-ties of XX century. Research on power supply systems (PPS) has been continued for gliding arc discharge reactors (GAD) in cooperation with Orleans university, France and then with Kumamoto and other Japanese universities and it has been devoted to environmental and agriculture application. From the 2003 to 2005 within the 5th EU Framework Program, DEE&Et has been coordinating the EU Project: ENK6-CT-2002-80668: Centre of Excellence for the Application of Superconducting and Plasma Technologies in Power Engineering with acronym CoE ASPPECT in which new laboratories and the site the CoE ASPPECT has been built and where research on plasma technologies are continuing up to now.

Many environmental, agricultural and biomedical problems are the result of the generation, distribution and conversion of multiple forms of energy. They not only cause climate change, as a result of environmental pollution and greenhouse gas emissions, but are also the cause of many of civilisation's diseases such as asthma, cardiovascular diseases, respiratory diseases, lung and skin cancers and new variants of previously unknown viruses and bacteria and their accompanying diseases. Fighting these problems is the most important challenge of the 21st century.

The paper reviews selected applications of plasma technologies that are already used in energy, environmental engineering and biomedicine and that have a chance to be used in the near future.

Numerical simulations of a flat phantom in the near-field of symmetric dipole antenna

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Keywords: Near-field, numerical simulations, dipole antenna, Sim4Life

The paper presents a numerical electromagnetic simulations of SAR limited to human tissues based on FDTD algorithm using Sim4Life platform. Flat-bottomed dielectric vessel (flat phantom) and half-wave symmetric dipole antenna were modeled. Simulations were done for the frequency of 3GHz. The analysis were performed according to the IEEE/IEC62704-1 standard and include distributions of electric and magnetic fields around the phantom and antenna. Finally, SAR distributions for the varying distance between the antenna and the phantom was presented.

Optical tweezers for a biological cell measurement

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Sojo University, Kumamoto, Japan

Keywords: Optical tweezers, radiation pressure force, mechanical property of cell

Optical tweezers are a technique to manipulate a small object by laser radiation pressure force under an optical microscope. We have developed various techniques to manipulate and to investigate biological cells with the optical tweezers. For manipulation technique, we developed a use of a pulse laser beam to generate instantaneous strong force. Radiation pressure is proportional to power of light so a pulse beam can generate instantaneous strong force. We call this as pulse laser beam assist optical tweezers (PLAT). By use of technique, we demonstrated to extract particles adsorbed on a substrate by instantaneous force and to manipulate the particle freely. we also performed to pick up a particle fixed on cell surface by irradiation of pulse laser beam.

For investigation technique, a cell palpation system is a system to measure mechanical properties of an individual biological cell by use of optical tweezers. Every biological cell is thought to have individual characteristics on mechanical property, because its cytoskeleton and cell membrane cortex may be influenced by surroundings. So we develop a cell palpation system. We are now performing cancer cell measurements for screening of anticancer drugs.

Thermonuclear reactors for future power generation

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Keywords: thermonuclear fusion, tokamak, stellarator, superconducting magnets

In this paper, the idea of power generated from nuclei synthesis of hydrogen isotopes: deuterium and tritium is described. Conditions of magnetic confinement of the high temperature plasma in order to maintain thermonuclear fusion are formulated.

Tokamak and stellarator solutions of the magnetic systems of the thermonuclear reactor are depicted with some issues concerning application of the low temperature (LTS) superconducting strands.

Applicability of the high temperature superconductors (HTS) desirable for use in the next generation fusion reactors is also considered. Recent advances in magnetic fusion are shown to obtain power generation.

Air purification with Dielectric Barrier Discharge electrostatic precipitator

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Katarzyna Garasz[1], Adam Tomaszewski[1]

[1]Institute of Fluid Flow Machinery, Gdańsk, Poland

Keywords: air purification, electric discharge, EHD flow

Inhalation of dust particles, volatile organic compounds (VOCs) and microorganisms suspended in ambient air can cause serious problems to human health, among other, increasing the risk of both respiratory and cardiovascular diseases. In order to reduce the negative influence of polluted air on human health we have developed a small, two-stage electrostatic precipitator (ESP) design to purify air in inhabited spaces (workspaces, hospital rooms, etc.). The precipitator consist of an ionizer that used Surface Dielectric Barrier Discharge (SDBD) to electrically charge pollution particles suspended in air, as well as, to generate an electrohydrodynamic (EHD) flow of the polluted air towards an electrostatic collector, where the removal of the particles takes place. Experimental studies and numerical CFD simulations of the EHD flow allowed us to optimize the construction of the precipitator and eliminate the formation of the air vortices in the main flow, which reduced the effective filtration efficiency. The filtration efficiency of the developed precipitator was measured using an optical aerosol spectrometer. The results showed that total mass filtration efficiency was 97% for particles ranging in size from 0,4 μm to 40 μm. The air flow structures inside the precipitator were measured using Particle Image Velocimetry (PIV) method. Maximal flow rate of the air generated by the SDBD ionizer was found to be 50 l/min. We also found that during continuous work the concentration of the ozone generated by the precipitator is less than 0.06 ppm, which is considered a safe level for human health.

This research was funded by National Centre for Research and Development (NCBiR), grant number LIDER/17/0110/L-10/18/NCBR/2019.

Application of gliding arc reactor in improving beetroot germination using plasma activated water

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Lublin University of Technology, Lublin, Poland
[2]Department of Environmental Physics, Comenius University, Bratislava, Slovakia
[3]Department of Plant Protection, University of Life Sciences in Lublin, Lublin, Poland

Keywords: low-temperature plasma, gliding arc discharge, plasma activated water, beetroot germination.

One of the applications of low-temperature plasma in agriculture is to improve the germination process through interaction of the reactive oxygen and nitrogen species (RONS) with biological material. An alternative to treatment in the gas phase is the use of plasma activated water (PAW), which facilitates the uniform contact of RONS with the entire surface of the seeds and eliminates the risk of thermal damage caused by the proximity of the discharge. The study presents the results of an experiment on the effect of PAW generated in atmospheric gliding arc reactor on the process of germination of beetroot (*Beta vulgaris*) seeds. Imaging of the seed surface using optical and scanning electron microscopy (SEM) were auxiliary methods to evaluate the type of treatment effect.

The study was carried out for different plasma treatment times (5, 10 and 20 minutes) of distilled water and with fixed geometry (two copper electrodes 80 mm long, with an angle of 12° between them) and power of the discharge system, using air as the working gas. Hydrogen peroxide and nitrites concentrations after treatment were measured using colorimetric methods, which showed significant concentrations of NO_2^- increasing with treatment time.

When using both the optical microscope and the scanning electron microscope, imaged samples are characterized by oval shaped parenchymal cells, of random size, with a very developed, concaved structure. The cells are not densely packed and intercellular spaces can be observed. After the PAW treatment, the structure became folded and wrinkled, and also revealed signs of rupture in comparison to the control sample. Changes are noticeable for PAW with 5 min of plasma treatment. On the other hand, besides the undulating structure, longer times resulted in the flattening of the outer edges of the cells.

Compared to the control, which had a rather high variability within samples, PAW treatment allowed for an increase in the average value of both germination energy and germination capacity. The best results were obtained for PAW with a treatment time of 20 min, for which all seeds from all samples germinated after 7 days. When comparing mean sprout lengths, after 7 days, each treatment type allowed greater lengths, with a slightly greater advantage for PAW with 20 min plasma treatment (a 46% increase over the control). After 14 days, the differences for the plasma treatment are less noticeable (4 to 17% increase over the control).

Measurement of corrective forces in the orthopaedic Cheneau brace

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Keywords: orthopaedic brace, scoliosis, pressure force, grapheme sensors

The subject of the research is the analysis of the dynamics of forces in the intelligent Cheneau brace prototype. The traditional Cheneau static brace is the main method for idiopathic scoliosis treatment. The orthosis corrects deformation of the spine by exerting multi-point pressure forces on the patient torso around the spine and thorax. This work focuses on the analysis of data collected by the prototype device that was in clinical trials with a small group of patients. It was undertaken to systematise the results and create rules for the implementation in the decision making system. The described studies are part of the research for a doctoral dissertation.

The intelligent Cheneau brace is a portable system based on the STM32 microcontroller that collects forces values data at real time from sensors mounted on the orthosis in order to determine the reference range of applied pressures and to find the optimal values to increase the effectiveness of scoliosis treatment. For this purpose, a device with a frequency of 1 measurement per second was designed. The sensors used in the device were an in-house made thin-film graphene sensors. In all patients' tests, the sensors in the brace are placed in the same areas to compare the results from all cases - to be able to find out where there are the highest values of pressure and whether in all the examined patients the biggest forces occur on the sensors located in same area. The essence of the research is to determine forces distribution in the same areas with different patients, which sensors are most active during the day, and whether they are the same in different patients. The data collection process is carried out with every 1 second, then these results are averaged in optimal time samples for results analysis. Based on those research, it is possible to determine how the time of day affects the pressure exerted on patient torso in the brace and how human activity (sleeping, standing, sitting posture) impacts those forces.

The collected data was analysed focusing on the interaction of individual sensors within the spine and thorax areas. Due to the fact that tests were carried out on larger number of patients, the comparison of the force values from individual sensors for different people and their activity during the day between several patients were possible. The comparison of collected results with X-rays of the spine in the brace from the whole treatment cycle allows to assess how wearing the brace impacts the effective correction of the spine curvature. Considering the analysis of a person's skeletal system and the generated pressures, it will be possible to optimize the method of posture correction. The research described above is intended to highlight the need for research into the field of spine defects using modern technology.

The method of dynamic selection of the clock frequency of the frequency-to-code converter

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Keywords: clock frequency, frequency measurement, frequency-to-code converter, measurement channel with frequency carrier of information

Converting the value of a physical quantity into frequency value is one from the most popular conversion methods used in both commercial converters and newly created constructions. The frequency signal is often chosen to transmit information in locations with high levels of electromagnetic interference. The advantages of transmitting information by means of a variable frequency include, inter alia, increased immunity to interference and the ease of processing even many frequency signals at the same time.

Variable frequency can be measured by various methods. One of them is the use of a microprocessor system that performs digital period measurement, using for this purpose a counter with an additional register attached, which capturing the current state of the counter without using program instructions . A counter operating in this mode works continuously, i.e. after reaching its maximum value, it starts counting from the beginning. Structure of the discussed measurement system is presented in Figure 1.

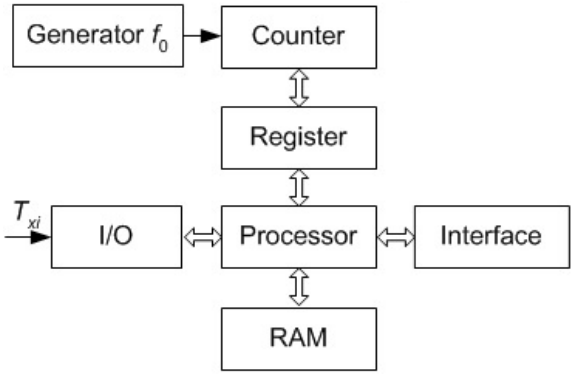

Fig. 1. Signal period measurement using microcontroller with a counter and state capturing register.

The direct conversion of a variable frequency into numerical values in a frequency-to-code converter is mainly limited by two errors: quantization and averaging. The article discusses the method of reducing the quantization error by dynamic selection of the clock frequency that controls the counter contained in the frequencyto--code converter. The method makes it possible to control the current quantization error and, accordingly, to select the frequency of the clock signal of the system processing the periods of the tested signal.

Hyperthermal ablation of cancer cells with the heated ferromagnetic nanoparticles

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Keywords: CNTs; CVD; RF fields; hyperthermal ablation

Carbon nanotubes have unique chemical, mechanical, electrical, and magnetic properties, which result in a wide range of possible applications, from electronics to medicine. They are a promising material to be used for many innovative solutions.

One of the medical application of carbon nanotubes could be to use them to selectively destroy cells (particularly cancer cells). For this purpose, CNTs filled with a ferromagnet (e.g. iron) are delivered, in a similar way to drug delivery systems, to diseased cells. The nanotubes are then heated externally by thermal ablation in radiofrequency (RF) electromagnetic field which causes the temperature of the cell to rise and the cell to die from the excess heat. It is well known that the penetration of RF fields through tissue is highly effective. Therefore, it should be possible to treat malignant tumours non-invasively anywhere in the body.

The main aim of this research was the examination of the possibility of destroying cancer cells with the heated ferromagnetic nanoparticles. The research goal involved the production of nanostructures that can react with the external electromagnetic field. These nanostructures were multi-walled carbon nanotubes filled with iron (Fe-MWCNTs) produced by the electrothermal method - catalytic chemical vapor deposition (CCVD). The structures were examined on scanning electron microscopy (SEM) and thermogravimetric analysis (TGA).

Then, the influence of the RF field on the possibility of heating particles in the nanoscale was investigated. Relevant properties of the nanoparticles in terms of functionalization for biomedical applications were exploited and their magnetic properties were investigated to determine the heat generation efficiency induced by exposure of the particles to an external electromagnetic field. The rate of temperature change was verified and compared with other samples, considering one variable. Four concentrations of carbon nanotubes in water were investigated: 3.75, 7.5, 15 and 30 mg/ml. All the samples of the four concentrations were exposed to the electromagnetic field of three frequencies: 110.2 kHz, 168.5 kHz and 329 kHz. The reaction of the samples was measured for 40 minutes of exposure. The expected result was obtaining of temperature increase in order to check the possibility of future application of carbon nanotubes in medicine for hyperthermia therapy. The general assumption was direct proportionality, both in concentration and frequency.

The results have proven the predictions to be true. The highest heating rate was obtained for the highest concentration in the highest frequency exposure. The rest of the samples have also proved to gain temperature, however respectively lower. Always the highest temperature change was obtained at 329 kHz for any of the concentrations. Therefore, the potential of application in medicine in the future has been confirmed.

Modelling of transients in transformers wound with 2G HTS tapes

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Keywords: superconducting transformer, 2G HTS tape, transient states

The paper presents modelling of transient states carried out with the use of the computer model of the superconducting transformer HTS 21 MVA 70/10.5 kV developed in the PSpice program. The computer model includes the description of the Jiles-Atherton magnetic hysteresis loop and Rhyner's power law for HTS tapes.

The analysis included two types of 2G HTS High Temperature Superconductor tapes used in the winding construction: SF12050 tapes without a copper stabiliser and SCS12050 tapes with a copper stabiliser layer. The modelling was carried out for two types of transients: short-circuits of the HTS transformer during operation and its connection to the power grid.

A comparison was made of the short-circuit currents, the first five pulses of the switching-on currents and the temperature increases during the short-circuit and connecting the transformer to the power grid for two types of HTS 2G tapes.

The conducted analysis allowed to determine the influence of thermal and electrical parameters of both types of HTS tapes on effective current limitation in transient states and the possibility of using them in the construction of HTS transformers.

Measurement of water absorption characteristics of seeds by using gliding arc plasma treatment

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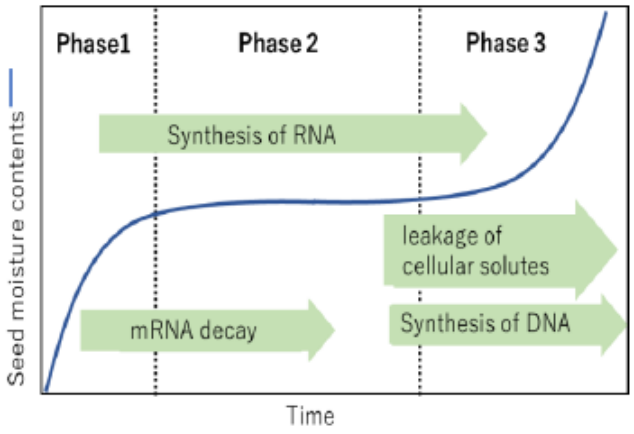
Keywords: plasma, agriculture, absorption characteristics of seed, gliding arc

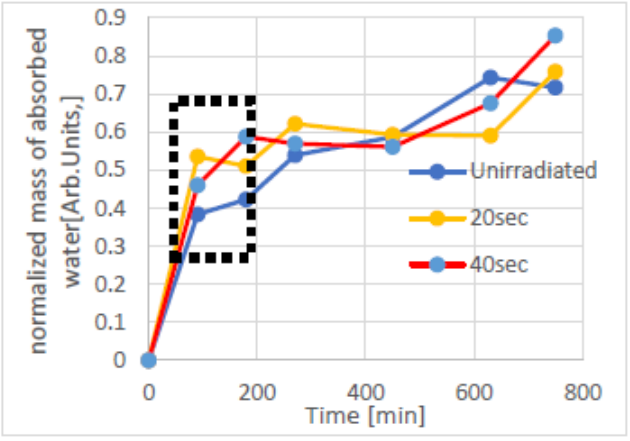
Plasma technology is applied in industry that include medical, food products and agriculture owing to advance a technology with high pressure non thermal plasma. In agriculture, reported that plasma has activation effect on seed germination. However, mechanism of this phenomenon remains an open question. Irradiated seed surface has changed various properties with plasma. In previous our research, we investigated hydrophilization of seed surface with plasma irradiation. We consider that water absorbed water of seed associated with hydrophilization of seed surface. The purpose of this study is investigated change of seed's water absorption ability with plasma.

Germination of seed has complex process include water absorption and many chemical reactions. Fig.1 shows increase moisture contents in germination process. This process separated in to three phases. Phase I is the early phase in process, include uptake water of dry seed. This amount of uptake water depends on physical properties of seed surface.

In this research we carried out experiment to measurement mass of water that is seed absorbed. In this Experiment, compare irradiated radish seed with plasma to unirradiated radish seed. This seed sample was irradiated with Gliding Arc discharge plasma operated in Ar gas. These seed sample was irradiated for 20 seconds and 40 seconds.

Fig.2 shows increase mass of water that each seed sample absorbed. In the early phase, the absorption amount of 20 seconds irradiated sample was about 40% higher than unirradiated seed sample. We consider this increase depend on hydrophilization of seed surface plasma irradiation.





Iodine doping effects on electrical and optical properties of amorphous carbon nitride thin films

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Keywords: amorphous carbon, iodine doping, electrical conductivity, optical property

Amorphous carbon and amorphous carbon nitride thin films have unique properties such as high hardness, transparency, and chemical inertness. These unique properties are suitable for a hard coating film on mechanical tools, a wear-resistant film on hard disks and a transparency coating film on optical components. The use of amorphous carbon films in automobile engine parts is estimated to have contributed to an annual reduction of 10,000 tons of CO_2, making them an important material from the perspective of the environment protection. For the electrical and optical device applications, the control of the electrical properties such as resistivity, conduction type and carrier concentration is required. In this work, we investigated the iodine doping effects of to the hydrogenated amorphous carbon nitride (a-CN_x:H) films.

a-CN_x:H films were deposited by RF plasma CVD with CH_4 and N_2 gasses. After film deposition, iodine doping was carried out in the vessel with Ar flow. The sample was placed in the petri dish with the iodine solid, then this dish was heated at 100℃. The iodine was turned from a solid state into a gas and the sample was exposed to iodine vapor by this thermal process.

Figure 1 shows the UV-Vis spectrum of a-CN_x:H film with N/C ratio of 0.38 before and after iodine doping. The three absorption peeks were appeared around 230 nm, 290 nm and 360 nm, also broad shoulder was appeared around 460 nm after iodine doping. The peak around 230 nm is attributed to I^-, and the two peaks around 290 nm and 360 nm are attributed to I_3^-, and the broad peak around 460 nm is attributed to I_2. Such absorption peaks are observed for iodine doped polymer, this result suggests the charge-transfer band between a-CN_x:H and iodine molecules were formed like conductive polymer. The optical gap E_{04} was decreased from 3.42 eV to 2.38 eV after iodine doping. Figure 2 shows the current-voltage characteristic. After iodine doping, the electrical resistivity is decreased from $1.14 \times 10^{11}\ \Omega \cdot \mathrm{cm}$ to $6.41 \times 10^{16}\ \Omega \cdot \mathrm{cm}$. We will also report on the iodine doping effect on a-CN_x:H film with different N/C ratio on the conference.

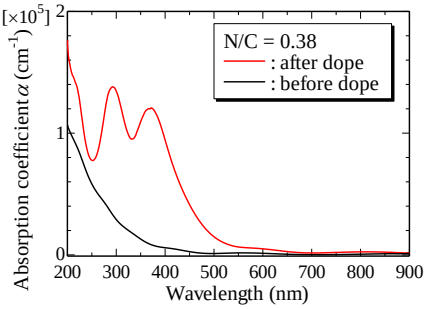

Fig. 1. UV-Vis spectra of a-CN_x:H thin films before and iodine

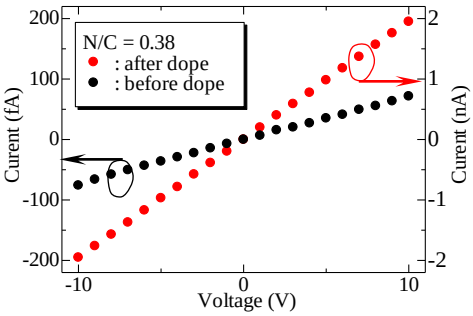

Fig. 2. *I-V* characteristic of a-CN_x:H thin films before and iodine dopoing.

Impedance sensors for measuring the electrical parameters of the cell culture

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Keywords: impedance, sensors, biocompatibility, ECIS

Each new concept usually starts a series of challenges that must be faced. When developing a new device or optimizing the device currently used, the designer focuses on obtaining the best possible parameters. From an engineering point of view, depending on the type of device, the most important requirement may be to ensure high mechanical strength, obtain the appropriate electrical parameters or achieve a specific physicochemical resistance required. This is not the case with biomedical applications. It is necessary to meet many, incl. the above-mentioned properties simultaneously. However, the most important requirement that an application must meet is biocompatibility. No matter how robust and efficient the device developed may be, if it does not have the appropriate level of biocompatibility, it cannot be used. If the basic assumption is not met, from the point of view of biomedical research, such a device becomes a worthless item.

The main assumption of biocompatibility is that, regardless of the function performed, the material or the device made of it may not cause any health detriment. This refers to the first and most important principle of Hippocrates Primum non nocere (Latin "First, do not harm"). Correct material selection is a key factor in a successful application. In practice, no synthetic material is fully accepted by the biological environment. Each material has a different level of indifference. The required degree of biocompatibility for a given application depends on the intended use and the time of its use. Due to the wide variety of materials it is important to be aware of which one can be used for a specific application. Only an appropriate degree of incorporation into the host (i.e. an organism whose body is the environment of another organism) ensures the absence of local or systemic, thrombotic, allergic, toxic or other immune inflammatory reactions. A wide range of available raw materials, with a different degree of biocompatibility, enables the selection of such a material that shows a favorable response in a given biological environment, while fulfilling the required function.

Beginning with implants, through drug delivery systems, tissue engineering structures, and ending with biosensors, the scope of potential biological mechanisms and interactions is very difficult to estimate. In order to determine the potential impacts caused by the materials used, they are tested to verify the toxicity and carcinogenicity of the leaching products and degradation. Moreover, the parameters related to decomposition, corrosion and the nature of dissolution are determined, taking into account temperature, pressure and salinity level corresponding to the environment of the human body.

When assessing the possibilities of using a given material in medical applications, it is necessary to conduct a number of biological experiments. The test carried out under strictly defined conditions is to determine whether the properties of the material are sufficient and meet the requirements. Most often, such verification is aimed at finding out the regularities governing a specific biological system in various situations. The observation of cellular behavior changing over time or under the influence of external factors provides a lot of important information. It enables the specification of the toxicological profile of the test substance. The aim of the experiments described was to approximate the degree of biocompatibility and the possibility of using conductive materials other than noble metals for in vitro research on cells.

Competitiveness of using a cold storage in an air-conditioning system

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Keywords: cold storage; lithium-ion battery; energy efficiency; air-conditioning systems; demand management

The purpose of this article is to present a novel concept of a cold storage system in terms of its properties, parameters and mathematical model. The developed innovative design of the cold storage is characterised by its high dynamics of operation and high energy efficiency. The properties described in the analysis of the mathematical model were proven on a prototype. The competitiveness of the developed cold storage is shown in a comparison against a system with lithium-ion batteries and a system without any storage powered directly from the grid. The obtained efficiency of an air-conditioning system based on cold storage is superior to the results of the systems it was compared to. The proposed construction requires significantly less energy in comparison to systems storing energy in lithium-ion batteries. Moreover, the financial costs are over 5 times lower and utilisation costs are close to zero.

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The impact of photovoltaics on the electricity grid in Poland

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Keywords: photovoltaics, photovoltaic installations, renewable energy sources, power grid

The increasing number of renewable energy sources in the distribution network is influenced by dynamically changing weather phenomena. Recently, photovoltaic installations, whose rapid development can be observed in our country for several years (at the end of February 2022, the installed capacity of photovoltaics in Poland amounted to 8768 MW), have become increasingly popular [1].

Although photovoltaics is a controllable source, it is not predictable and thus has limited availability. When determining the power balance, the safety limit of the National Power System is determined by fully available sources [2]. As indicated by the Energy Regulatory Office, despite the increase of electricity production capacity (total installed capacity in the system), the available capacity is decreasing.

The impact of photovoltaic installations on the power system, in the face of the increase in new capacity, poses many challenges for the traditional transmission networks. These concern the prevention of overloading of existing transmission lines, which can lead to thermal overloads, as well as disturbances of threshold values of grid frequency and voltage [3]. This is all the more important as these threats result in interruptions in energy supply (so-called blackouts) and destabilisation of the transmission system.

Another problem accompanying photovoltaic installations is the fact that the sunlight is not always linked to the temperature, which is the direct cause of the increase in demand for electricity (air conditioning systems). This can lead to situations such as the 8 April 2008 in Szczecin, when the biggest blackout in Poland occurred. It was caused by strong winds and heavy wet snowfall, which resulted in four high voltage power lines being switched off [4].

The impact of photovoltaics on the Poland electricity grid in terms of overloads leading to blackouts is somewhat limited, thanks to cross-border interconnection systems. However, there is the problem of uncontrolled energy flows, and even if we take care of good grid quality, the challenge remains in terms of energy quality. The impact of photovoltaics on the electricity grid can be negative in some respects, but the presence of PV installations in the system also has many advantages. The development of new energy generation technologies, such as photovoltaics, as well as plans to end the operation of coal-fired power plants, are forcing certain changes, including the introduction of new market solutions. At the same time, it should be stressed that RES are not solely responsible for energy supply disruptions [5].

1. Raport Instytutu Energetyki Odnawialnej Rynek Fotowoltaiki w Polsce 2021
2. W. Mielczarski, „Spór odnawialnych źródeł energii z atomem, „Energetyka – Społeczeństwo – Polityka” 2018, nr, 1.
3. „Grid Stability Issues With Renewable Energy Sources, How They Can Be Solved”,https://www.hivepower.tech/blog/grid-stability-issues-with-renewable-energy-how-they-can-be-solved
4. G. Bartodziej, M. Tomaszewski, “Blackout w rejonie Szczecina. Uwagi i wnioski”, Politechnika Opolska, “Energetyka” – październik 2008
5. M. T. Sarniak, "Researches of the Impact of the Nominal Power Ratio and Environmental Conditions on the Efficiency of the Photovoltaic System: A Case Study for Poland in Central Europe", Sustainability 2020, 12, 6162; doi:10.3390/su12156162