CATALOG OF RESEARCH SERVICES

NANO-/MICROELECTRONICS AND PHOTONICS
PRINTED ELECTRONICS AND TEXTRONICS
ENERGY STORAGE AND CONVERSION

Warsaw University of Technology
Centre for Advanced Materials and Technologies
CEZAMAT

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Dear Customers,

The Centre for Advanced Materials and Technologies CEZAMAT at the Warsaw University of Technology is a team of professionals as well as a unique infrastructure and specialized research equipment. CEZAMAT laboratories are equipped to conduct research in, such areas as nanotechnology, semiconductor microsystems and printed electronics.

We present the latest range of services offered by the Centre for Advanced Materials and Technologies CEZAMAT of the Warsaw University of Technology in the field of nano/micro electronics and photonics, as well as energy storage and conversion.

In addition, based on our unique experience, highly specialized staff and research facilities, we can also undertake other work by previous consultation. We encourage you to contact us.

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1 PRODUCTION OF PHOTOLITHOGRAPHIC MASKS

We offer the possibility of producing photolithographic masks by electronolithography on our own or supplied substrates.

Mask parameters:

- mask substrate size 5” or 7”,
- glass or quartz substrates,
- resolution of the fabricated pattern below 300 nm (to be determined depending on the pattern),
- thickness of chromium layer 100 nm.

It is possible to select a different thickness of chromium layer (with or without anti--reflection layer) and a different substrate material and obtain a higher resolution.

PHOTOLITHOGRAPHY, ELECTRONOLITHOGRAPHY, PHOTOLITHOGRAPHIC MASKS, GLASS SUBSTRATES, QUARTZ SUBSTRATES

2 MODIFICATION OF MATERIALS PROPERTIES

2.1 ION IMPLANTATION

We offer an ion implantation process for electronics, optoelectronics, spintronics, among others. In electronic applications, ion implantation enables the manufacture of sources and drains, the threshold voltage forming of CMOS devices, the doping of the emitter, base and collector areas of bipolar devices, as well as the performing of Well and Halo implantation. For silicon electronics applications, ions of the following elements and compounds are used: B, P, As, Si. For alternative semiconductors, ions of groups IIb, IIIa, IVa, Va, VIa are used. During implantation, the substrate temperature does not exceed 100 °C. For optoelectronics and spintronics, it is possible to implant with rare earth ions and transition metal ions. The device is also suitable for defect engineering with substrates heated to 500 °C. The additional equipment of a robot for automatic wafer loading allows this tool to be used in small batch production.

Process conditions:

- ability to implant oxygen, nitrogen, hydrogen, argon, boron and other ions (in a wide mass range, that is, 1-210 AMU),
- possibility to implant on 150 mm or 200 mm substrates in automatic cycle and 100 mm. Smaller substrates by prior arrangement,
- helium-assisted substrate cooling - possibility to implant through a mask of thick photoresist,
- possibility of implantation at elevated, controlled substrate temperature from 100 °C to 500 °C,
- accelerating voltage from 5 kV to 200 kV, beam current up to 1.5 mA (depending on ion type).

IMPLANTATION, ION IMPLANTATION, OPTOELECTRONICS, SPINTRONICS, THRESHOLD VOLTAGE FORMATION, WELL AND HALO, DEFECT ENGINEERING

2.2 HIGH-TEMPERATURE DIFFUSION

We offer the performing of a diffusion process for applications in micro- and nano-electronics, photonics or photovoltaics and micromechanics.

As part of the service, it is possible to:

- performing boron diffusion at temperatures up to 1000 °C,
- process large batches in a reproducible manner in a single process: 25 substrates of 200 mm diameter and 50 substrates of 100 mm and 150 mm diameter.

BORON DIFFUSION, HIGH TEMPERATURE DIFFUSION, DIFFUSION PROCESS

2.3 THERMAL PROCESSING

We offer a process for annealing large batches of semiconductor substrates in a controlled manner.

As part of the service, it is possible to:

- annealing in an atmosphere of nitrogen, argon and/or a mixture of nitrogen and hydrogen at temperatures up to 1200 °C,
- process large batches in a reproducible manner in a single process: 25 substrates with a diameter of 200 mm and 50 substrates with a diameter of 100 mm and 150 m.

ANNEALING, CONTROLLED ANNEALING

2.4 RAPID THERMAL PROCESSING (RTP)

We offer rapid thermal annealing processes for silicon substrates with heating rates up to 200 °C/s.

Process specifications:

- annealing of 4”, 6”, 8” substrates with heating rates up to 200 °C/s,
- heating of irregularly shaped substrates at a heating rate of up to 20 °C/s,

- Maximum process temperature: 1400 °C,
- processes can be carried out under a gas atmosphere of N_2, Ar, O_2, H_2, NH_3, N_2O,
- annealing under reduced pressure possible.

RTP, RAPID THERMAL PROCESSING, ANNEALING

3 WAFER BONDING

We offer bonding of substrates manufactured from a variety of materials, including semiconductor materials (silicon and others) and dielectrics (glass, ceramics and others), for use in microelectronics, nanoelectronics, photonics and microsystems. Suitable for working with circular substrates from 100 mm to 200 mm (100 mm/4", 150 mm/6", 200 mm/8") and pieces no smaller than 10 mm x 10 mm.

Bonding of specimens by the following techniques:

- adhesive bonding (glue),
- eutectic bonding (thermocompression),
- anodic bonding,
- glass frit bonding,
- direct bonding.

Process parameters:

- chamber flushed with inert gas,
- temperature control range from 50 °C to 500 °C with an accuracy of ±3 °C, a stability of ±1.0 °C and a homogeneity of ±2 %,
- clamping force up to 20 kN, with programmable adjustment,
- maximum vacuum of 5×10^{-5} mbar (process chamber pressure control by dosing process gas - N_2, ranging from 1 to 1000 mbar),
- possibility of aligning substrates using a pattern/mask alignment device.

BONDING, WAFER BONDING, SUBSTRATE BONDING, ADHESIVE BONDING, THERMOCOMPRESSION, ANODIC BONDING, DIRECT BONDING, GLASS FRIT

4 LITHOGRAPHY PROCESSES

4.1 ELECTROLITHOGRAPHY

Electronolithography, or electron-beam lithography, allows patterns to be written directly onto the resist layer, resulting in possible feature dimensions at the level of single nanometers. It gives much greater flexibility in transferring patterns onto the layer compared to other types of lithography. This approach eliminates the need to produce and expose the patterns through a mask, as used, in photolithography. Thanks to this advantage, quick changes and corrections to the design of the patterns are possible. These advantages give electron-beam lithography a great deal of flexibility useful especially in the research and prototyping phase of structures and components. The accelerating voltages used is 100 kV. The minimum diameter of the electron beam used for exposure is less than 5 nm and the minimum width of the resulting line is less than 20 nm. The maximum exposure area without stitching is 1 mm^2.

Technological possibilities:

- accelerating voltage 100 kV, exposure beam current range 0.1 - 50 nA. Exposure field sizes 100×100 µm, 500×500 µm and 1000×1000 µm,
- stitching error of the exposure fields ≤±30 nm,
- possibility to work with circular substrates with diameters of 2, 3, 4, 6, 8 inches and square substrates with side lengths of 5 and 7 inches. Possibility to process nonstandard substrates by prior agreement,
- Possibility to work with positive (e.g. 950PMMA A from MicroChem and ZEP520A from Zeon) and negative (e.g. XR-1541 from Dow Corning) e-beam resists, others possible by prior agreement,
- resists layer thicknesses from several tens of nanometers upwards are possible,
- minimum line width possible in negative resist from several nm, in positive resist from several tens of nanometers,
- accepted patterns in files: LEDB, GDS OASIS, LTxt, CIF, DXF, PNG,
- possibility of preparation and optimization of the exposure process - available software enables, among others, optimal selection and sequence of exposing areas to minimize mapping errors and shorten working time, preparation of beam dosage plan with consideration of proximity effects and visualization of exposure effects.

ELECTRONOLITHOGRAPHY, LITHOGRAPHY, ELECTRON BEAM, EXPOSURE PROCESS

4.2 PHOTOLITHOGRAPHY

We offer the complete photolithography process, starting with substrate preparation, application of the resist layer, exposure and development, up to hardening (preparation for wet or dry etching).

Process conditions:

- suitable for working with round substrates up to 200 mm (50 mm/2”, 100 mm/4”, 150 mm/6”, 200 mm/8”) and pieces no smaller than 10 mm x 10 mm,
- possibility of alignment the patterns relative to the images on the top surface (TSA) with an accuracy of 0.5 µm and the bottom surface (BSA) with an accuracy of 1.0 µm,

- exposing by proximity, contact (soft contact, hard contact) and vacuum contact,
- exposure of photosensitive layers (photoresist) up to 200 µm,
- compatibility with mask sizes of 2.5”x2.5”, 5”x5”, 7”x7”, 9”x9”,
- Spectrum of exposure beam shaped by filters, possible wavelength 365 nm, 434 nm,
- exposure in constant-time and constant-dose mode, also constant-dosage mode also in intervals,
- Range of table movement during alignment in X ≥ ±5 mm, Y ≥ ±5 mm, ϕ ≥ ± 3°,
- table and mask parallelism during alignment and illumination ≤ Δ6 µm automatically provided.

PHOTOLITHOGRAPHY, RESIST, PHOTORESIST, PATTERN CENTERING, EXPOSURE PROCESS

5 THIN FILM DEPOSITION

5.1 MAGNETRON SPUTTERING

We offer magnetron sputtering for applications including semiconductor electronics, photovoltaics, optoelectronics. The PVD system is ideal for both single processes for research and development and small production runs on substrates of both standard and non-standard dimensions up to 200 mm in diameter.

The system allows up to four materials to be sprayed sequentially without removing the sample from the vacuum chamber and coming into contact with air. Two sputtering modes (RF and DC) allow dielectric and metal layers to be produced, while reactive sputtering in a nitrogen and oxygen atmosphere is also possible.

Process conditions:

- possibility to perform the process on substrates with a diameter of up to 200 mm (smaller pieces as well as small pieces are also possible),

- deposition of Al, Ti, Cr, Mo metal layers and AlN, TiO_2, Al_2O_3, TiN, AlO_xN_y, TiO_xN_y and other dielectrics (other materials possible by prior arrangement),
- layer thicknesses from a few nanometers to approximately 1 µm,
- magnetrons allowing DC, RF and pulsed DC operation.

SPUTTERING, MAGNETRON SPUTTERING, PVD SYSTEM, SEQUENTIAL SPUTTERING, RF SPUTTERING, DC SPUTTERING, PULSED DC

5.2 PECVD

We offer Plasma Enhanced Chemical Vapour Deposition (PECVD) for applications including nanoelectronics, photonics, micromechanics, passivation, encapsulation or masking layers. The tool makes it possible to deposit layers of oxides, nitrides and oxynitrides of silicon with adjustable refractive index, as well as to obtain layers of materials with different mechanical stresses in a controlled manner.

Process conditions:

- layer thicknesses from tens of nanometers to single micrometers,
- 13.56 MHz RF plasma generator and a generator with a frequency range of 50-450 kHz,
- possibility to work on single substrates up to 200 mm in diameter, as well as on smaller substrates of any shape,
- deposition of layers of silicon dioxide (SiO_2), silicon nitride (SiN_x), silicon oxynitride (SiO_xN_y), amorphous silicon (a-Si) with controllable composition and stresses.

CVD DEPOSITION, PECVD, MASKING LAYERS, SILICON OXIDE, SILICON NITRIDE, SILICON OXYNITRIDE, AMORPHOUS SILICON

5.3 THERMAL OXIDATION

We offer a process for oxidizing large batches of silicon substrates in a controlled and reproducible manner. The ability to obtain good quality thermal oxides in the thickness range from single nanometers to micrometers.

As part of the service, we offer:

- wet oxidation at temperatures up to 1200 °C,
- dry oxidation with low oxygen flow at temperatures up to 1000 °C,
- the possibility of reproducibly processing large batches in a single process: 25 substrates of 200 mm diameter and 50 substrates of 100 mm and 150 mm diameter.

OXIDATION, THERMAL OXIDATION, DRY OXIDATION, WET OXIDATION, OXIDES

5.4 LPCVD DEPOSITION PROCESSES

We offer processes for the chemical vapour deposition of polysilicon and silicon nitride films under reduced pressure (Low Pressure Chemical Vapor Deposition).
We perform:

- chemical vapour deposition under reduced pressure (Low Pressure Chemical Vapor Deposition) of polysilicon at temperatures up to 900 °C,
- low pressure chemical vapour deposition of silicon nitride at temperatures up to 900 °C,
- reproducible processing of large batches in a single process: 25 substrates of 200 mm diameter and 50 substrates of 100 mm and 150 mm diameter.

LPCVD, CHEMICAL DEPOSITION, POLYSILICON VAPOUR PHASE, SILICON NITRIDE VAPOUR PHASE

5.5 PULSED LASER DEPOSITION

We offer deposition of thin films of oxide materials by Pulsed Laser Deposition. The tool enables the manufacture of single layers or heterostructures and the execution of single processes or short production runs. It is possible to run the process under high vacuum (UHV) or under an oxygen or nitrogen process atmosphere.

Process conditions:

- laser characteristics: wavelength 248 nm, frequency up to 50 Hz,
- substrate temperature: from room temperature to 1000 °C,

- possibility to use up to 8 different materials in one process,
- possibility to limit the exposure of the produced layers to air.

PLD, THIN FILM DEPOSITION, COATINGS, LASER ABLATION

6 LAYERS ETCHING

6.1 WET ETCHING

We offer etching of a variety of substrates and deposited layers using wet-chemical processes.

Processes include controlled and reproducible etching of:

- silicon dioxide layers,
- poly- and monocrystalline silicon layers,
- silicon nitride and silicon oxide layers,
- thin metallic layers - e.g. aluminum, titanium and others.

Each process can also be performed in production mode on 100 mm/4”, 125 mm/5”, 150 mm/6” and 200 mm/8” substrates in batch mode (up to 25 substrates) and dry--in/dryout.

WET ETCHING, CONTROLLED ETCHING, REPRODUCIBLE ETCHING, DRY-IN DRY-OUT

6.2 DRY ETCHING

We offer ICP/RIE plasma etching (ICP - Inductively Coupled Plasma, RIE - Reactive Ion Etching). This process allows etching of a wide range of dielectrics, metals and semiconductors on both standard and non-standard substrates up to 200 mm in diameter. Depending on the process, high selectivity, highly anisotropic etch profiles, including vertical wall profiles, can be achieved.

We offer etching in oxygen, chlorine, fluorine, argon and nitrogen plasmas. We also perform cryogenic etchings at temperatures of up to -150 °C, including etching in silicon of high aspect ratio structures.

Etching processes can be controlled in situ using a laser interferometric system.

DRY ETCHING, ICP, RIE, PLASMA ETCHING, CRYOGENIC ETCHING, SILICON ETCHING, REPRODUCIBLE ETCHING

7 CLEANING PROCESSES

7.1 LABORATORY GRADE CHEMICAL CLEANING

We offer cleaning of silicon substrates, quartz substrates and photolithographic masks.

- We perform the processes on:
  - silicon and quartz substrates with diameters of 50 mm/2”, 100mm/4”, 150 mm/6”, 200 mm/8”,
  - photolithographic masks with dimensions of 2.5” x 2.5”, 5”x 5”,7” x 7”, 9” x 9”.

- Types of cleaning processes:
  - SPM (Sulfuric Peroxide Mix) a mixture of H_2SO_4 and H_2O_2 to remove organic contaminants,
  - SC1 (Standard Clean 1) a mixture of NH_4OH, H_2O_2 and deionized water to remove organic contaminant ions,
  - SC2 (Standard Clean 2) a mixture of HCl, H_2O_2 and deionized water to remove metallic impurities ions.

Megasonic rinsing system for removal of submicrometer particles left over from cleaning processes, together with a system for discharging accumulated electrostatic charge. Cleaning is carried out in a dry-in/dry-out system.

Efficient and reproducible process execution

CHEMICAL CLEANING, SUBSTRATE CLEANING, MASK CLEANING, SPM, SC1, SC2, MEGASONIC, DRY-IN, DRY-OUT, REPRODUCIBLE CLEANING

7.2 PRODUCTION GRADE CHEMICAL CLEANING

We offer efficient and reproducible processes for cleaning large batches of silicon substrates and preparing them for further process steps. Processes are performed

on 100 mm/4”, 125 mm/5”, 150 mm/6” and 200 mm/8” substrates in batch mode (up to 25 substrates).

The processes include:

- SPM cleaning at temperatures up to 120 °C,
- SC1 cleaning at up to 80 °C,
- SC2 cleaning at up to 80 °C,
- removal of native SiO_2 in dilute HF solution.

Cleaning is carried out in a dry-in/dry-out system.

CHEMICAL CLEANING, PRODUCTION CLEANING, SUBSTRATE CLEANING, SPM, SC1, SC2, DRY-IN DRY-OUT, REPETITIVE CLEANING

8 SCANNING ELECTRON MICROSCOPY

We offer sample characterization using a high-resolution scanning electron microscope (HRSEM) Auriga 60 from Carl Zeiss with resolution capability better than 2.0 nm 1 kV, better than 1.0 nm 15 kV, magnification: from 20 to 2,000,000:

- accelerating voltage: from 0.1 kV to 30 kV,
- diameter of test samples up to 200 mm,
- possibility of characterization with angular tilt up to 65 degrees,
- ability to characterize sample cross sections.

SEM, TOPOGRAPHY IMAGING, MORPHOLOGY OF MATERIALS, NANOMATERIALS, DEFECT

9 ELLIPSOMETRIC MEASUREMENTS

We perform complete ellipsometric measurements of samples.

We offer:

- measuring substrates with a maximum diameter of 200 mm,
- determination of the thickness of thin layers of transmission or partially transmission materials,
- estimation of the composition of multicomponent materials,
- thickness measurements of multilayer materials and determination of optical parameters of these layers,
- mapping (2D) of the determined parameters (thickness and optical parameters) on the sample surface,
- spectral range of measurement from 190 nm to 2100 nm,
- range of angle movement of arms from 40° to 90°,
- wide base of materials that allows matching the model to the measurement conditions and the measured materials.

ELLIPSOMETER, ELLIPSOMETRIC MEASUREMENTS, ELLIPSOMETRIC ANALYSIS, COMPOSITION ESTIMATION, THICKNESS MEASUREMENT, 2D MAPPING

10 MODELING AND SIMULATION OF NEW TECHNOLOGIES IN THE FIELD OF ELECTRONICS AND PHOTONICS

We offer concept testing, modeling, and simulation of structures, instruments, systems, and processes. We use specialized software and expertise for this purpose.

Activities include in particular, support in the creation of models and demonstrators of instruments and their components or integrated systems based on innovative designs and technologies in electronics and/or photonics (including structures, instruments and semiconductor systems, sensors, MEMS/MOEMS, microfluidics, energy harvesters and others), as well as materials engineering.

MODELING SIMULATION OF SEMICONDUCTOR DEVICES AND SYSTEMS, PROCESS MODELING

11 TECHNICAL CONSULTING FOR TECHNOLOGY IMPLEMENTATION

The consulting offer includes actions concerning the implementation of technology for the manufacture of electronic instruments, photonic instruments, printed electronics, biosensors, microfluidic solutions, and MOEMS, which will be used in products developed by the company. The service may include assistance in the selection and purchase of technology equipment suitable for the needs, assistance in the installation and commissioning of technology equipment, and assistance in the implementation and optimization of technology processes at the company's site.

CONSULTING, TECHNOLOGY IMPLEMENTATION, SELECTION OF EQUIPMENT, IMPLEMENTATION ASSISTANCE, PROCESS OPTIMIZATION

12 DEVELOPMENT OF MATERIALS FOR PRINTING TECHNIQUES

We offer preparation of materials for printing techniques for dedicated applications. We have the necessary equipment for producing pastes and inks, allowing us to weigh, grind, homogenize, and grind substrates. We have experience in working with nano/micro materials as various nanoforms of carbon: nanotubes, spheres, flakes etc.

We have a paste and ink production line consisting of equipment with the following parameters:

- ultrasonic baths with capacities of 2-3 l and 6-10 l,
- ultrasonic homogenizer: 750 W, from 250 µl to 1 l,
- planetary mixer: 90 different speed patterns by changing the speed ratio, speed: up to 1430 rpm,
- tri-roller: maximum product grinding to <1µm, capacity from 0.02 to 20 l per hour,
- evaporator: speed range of 5-280 rpm, reversible direction of rotation; heating temperature range: from room temperature to 180 °C,

- mortar grinder: the amount of charge ~10-190 ml with a maximum grain size of 8 mm.

PRINTING PASTES, PRINTING INKS, NANOFORM CARBON-BASED MATERIALS, GRAPHENE

13 CHARACTERIZATION AND TESTING OF MATERIALS

We offer characterization and testing of materials used in printed electronics. We study the rheological, electrical, and mechanical properties of printing materials.

13.1 TESTS OF ELECTRICAL PROPERTIES

We measure current, voltage, capacitance, current frequency and resistance (2-wire and 4-wire). We have an electrical measurement kit including 2 multimeters,a nano-voltmeter, and a DC power supply.

Measurement ranges:

- voltage: 100 mV - 1 kV,
- current: 100 µA - 10 A,
- resistance: 100 Ω - 100 MΩ,
- capacitance: 1 nF - 100 µF,
- frequency: 3-300 kHz.

CURRENT, VOLTAGE, CAPACITANCE, FREQUENCY, RESISTANCE.

13.2 TESTING OF RHEOLOGICAL PROPERTIES

We measure the viscosity of non-Newtonian liquids, record liquidity curves, and determine the function of non-Newtonian liquids under sustained flow rate behavior conditions. The use of a rotational rheometer allows measurement at controlled shear rates or controlled shear stress.

Technical data:

- dimensions: 480 mm x 300 mm x 290 mm,
- viscosity range: 0.002 to 125 000 P,
- precision: 1.0 % of maximum range value,
- torque range: 0.05-50 nm,
- torque resolution: 0.01 mNm,
- speed range: 0.01 to 1000 min^{-1},
- temperature range: -20 °C to +180 °C,
- range of shear rate: 0.013 to 6000 s^{-1},
- range of shear stress: from 4.5 to 16 300 Pa.

We also measure the viscosity of liquids using a viscometer.

Technical data:

- speed range: 0.1-200 rpm,
- temperature detection range: -20 °C to 180 °C,
- viscosity measurement accuracy: ±1.0 % of full scale range,
- viscosity repeatability: ± 0.2 % of the full-scale range.

VISCOSITY, LIQUIDITY CURVES, VISCOMETER, RHEOLOGICAL PROPERTIES

13.3 MECHANICAL PROPERTY TESTS

13.3.1 TESTS IN A CLIMATE CHAMBER

We offer testing in a climate chamber. We test the exposure of materials to various environmental conditions by adjusting parameters such as humidity or temperature. We try the effect of external conditions on products, materials, or electronic devices. The device can test the simulated effects of the sun on the product.

Technical data:

- temperature range: from -70 °C to +180 °C,
- temperature range: from 10 °C to +95 °C,
- humidity range: from 10 % to 98 %,
- first range of dew point temperature: from 7 °C to +94 °C,

- second range of dew point temperature: from -10 °C to +7 °C,
- temperature fluctuation of no more than 0.3 K.

Internal dimensions (W x H x D): 650 x 750 x 400 mm, capacity: 200 l

CLIMATE CHAMBER, TEMPERATURE TESTS, HUMIDITY TESTS

13.3.2 STRENGTH TESTS

We test the strength of materials in tension and compression. We determine the maximum force, or resistance, that a material puts up when subjected to tensile/compressive forces.

Technical data:

- test force range 0-20 kN,
- adjustable speed range: 0.0002~1,000 mm/min,
- accelerating voltage range: 0.5~30 kV,
- force resolution of 1/100,000 (31 bits).

LOAD CAPACITY, TENSILE STRENGTH

14 DEVELOPMENT OF PERSONALIZED SOLUTIONS IN THE FIELD OF PRINTED ELECTRONICS

We offer the development of printed electronics, flexible electronics, and textronics solutions for the required application. We print on planar surfaces such as polymer films, paper, or textiles using screen printing technology. Selected examples of developed solutions include disposable electronics for telemedicine or smart wound dressing for remote wound monitoring.

Technical specifications:

- maximum print area: 35 x 40 cm,

- maximum substrate size: 45 x 45 cm,
- maximum squeegee width: 40 cm,
- squeegee feed speed: 0-300 mm/s,
- squeegee pressure: 0-12 kg,
- pneumatic table for flexible substrates,
- possibility of stencil printing as well as using screens,
- ProAlign Vision system.

ELECTRODES, GRAPHENE SENSORS, TELEMEDICINE, TELEREHABILITATION, ELECTRONIC TATTOOS, GRAPHENE ELECTRODES, HEATERS, INFRARED RADIATORS, SCREEN PRINTING, STENCIL PRINTING

15 TRANSFERRING TECHNOLOGY TO AN INDUSTRIAL SCALE

We offer scaling of printing technologies to industrial scale - preparation for implementation into production, including concept testing, digital modeling, and simulation of products, their components, and processes. We use specialized software, specialized, unique measurement equipment, and researchers expertise.

Activities include support in creating instrument demonstrators and their components or integrated systems. In addition, we offer activities to support the implementation of technology for the manufacture of printed electronic instruments to be used in products under development. The service may include assistance in the selection and purchase of technology equipment suitable for the needs, assistance in the installation and commissioning of technology equipment, and assistance in the implementation and optimization of technology processes at the company's headquarters.

16 PRODUCTION 2D/3D BIO-PRINTS

We offer 2D/3D bioprints using the Direct Printing Dispenser, Drop-on-Demand, or Fused Deposition Modelling.

Specifications:

- number of print head slots: 3,
- resolution in X Y axis: 1 µm,
- layer resolution: 1 µm,
- work surface: 130 x 90 x 70 mm,
- cartridge capacity with printing material: 3-10 ml (depending on the type of head),
- pressure range: 0-200 kPa,
- operating temperature range of print heads: 4-250 °C (depending on the type of printhead),
- table temperature range: 4-65 °C,
- calibration: automatic and manual,
- supported files: STL, GCODE.

We offer bioprints using 6 types of heads:

- pneumatic print head:
  - pneumatic dosing,

    - temperature control accuracy: 0.5 °C,
    - heating capacity: 30-65 °C,
    - cartridge capacity: 3 ml;
- temperature-controlled print head:
    - pneumatic dosing,
    - temperature control accuracy: 0.5 °C,
    - heating capacity: up to 65 °C,
    - cooling capacity: up to 4 °C (or 17 °C below room temperature),
    - cartridge capacity: 3 ml;
- electromagnetic droplet print head:
    - single droplet or stream printing
    - contact printing of bio-inks and hydrogels of high and low viscosity,
    - microvalve cap: SMLD 300G,
    - heating capacity: up to 65 °C,
    - cartridge capacity: 3 ml;
- Syringe print head:
    - dosing by piston extrusion of drops or fibers,
    - for biomaterials and bio-inks of high and low viscosity,
    - precise control of flow rate and extruded volume,
    - cartridge capacity: 3 ml;
- thermoplastic print head:
    - for thermoplastics,
    - replaceable stainless steel cartridge,
    - adjusting the diameter of the printed fiber,
    - heating capacity: from room temperature to 250 °C,
    - cartridge capacity: 10 ml.

3D BIOPRINTER, HYDROGEL, BIO-INK

17 PRINTING ON THREE-DIMENSIONAL SUBSTRATES

We offer functional prints on three-dimensional substrates (e.g., spheres, hemispheres, cylindrical substrates) by Aerosol Jet Printing.

Technical data:

- ultrasonic or pneumatic atomization,
- low-temperature processing,
- printing width: from 10-20 µm (depending on the substrate),
- thickness of a single print layer: 100 nm,
- printing speed: up to 200 mm/s (typically 100 mm/s),
- printing range: 30 x 30 cm,
- temperature control: 25-60 °C,
- possibility to use heterophase inks.

AEROSOL PRINTING, PRINTING ON 3D MATERIALS, AEROSOL JET PRINTING

18 CONSULTING SERVICES AND SOLUTION ANALYSIS IN THE FIELD OF PRINTED ELECTRONICS

We offer specialized consulting in the analysis of solutions in the field of printed electronics. We analyze received concepts, evaluating potential areas of application of printed electronics components. Based on our long experience in printed electronics work, we help select the appropriate printing technology and dedicated materials for this technology. We provide testing services for the developed method in terms of its electrical properties and durability, while supporting the optimization of the production process.

Our activities include support creating models, demonstrators, and device components. In addition, we offer assistance in the adaptation of new technologies for the production of printed electronic devices. As part of our services, we provide advice on the selection and purchase of suitable technological apparatus, assistance

during the installation and commissioning of devices, and support the process of implementation and optimization of technological procedures at the site of your company.

The implementation of printed electronics solutions could provide significant economic benefits by reducing production costs. The technologies used are characterized by scalability and the variety of substrates used for printing, including three-dimensional substrates and various materials such as paper materials, ceramics, polymer films, glass, or functional fabrics. The resulting structures have considerable precision, reaching the order of 1 µm, and are characterized by small thicknesses (starting at 100 nm).

PRINTED ELECTRONICS, SCALABILITY, OPTIMIZATION, CONSULTING

NANO/MICROELECTRONICS AND PHOTONICS, PRINTED ELECTRONICS, AND ENERGY STORAGE AND CONVERSION AT CEZAMAT WUT

Laboratory: ISO 4 – 260 m^2, ISO 5 – 1580 m^2, ISO 6 – 870 m^2, ISO – 1100 m^2.

RESEARCH TEAMS:

- Intelligent Semiconductor Systems Department (SEMINSYS), head: Piotr Wiśniewski PhD Eng., piotr.wisniewski@pw.edu.pl,

- Department of Printed Electronics, Textronics, and Assembly, head: Prof. Małgorzata Jakubowska PhD Eng., malgorzata.jakubowska@pw.edu.pl,

- Department of Energy Storage and Conversion, head: Michał Struzik PhD Eng., michal.struzik@pw.edu.pl

EXAMPLE EQUIPMENT:

- Auriga 60 high-resolution scanning electron microscope (HR-SEM Carl Zeiss with resolution capability above 2.0 nm @1 kV, above 1.0 nm @15 kV, magnification: from 20 to 2 000 000;
- Carl Zeiss' Axio optical microscope (magnification from 12.5 to 1500);
- spectroscopic ellipsometer Uvisel2 from Horiba Jobin Yvon (measurement spectral range: 190-2100 nm);
- EVGroup bonding system EVG510/200 (EVG);
- EVGroup EVG6200NT/200/TB /200/TB mask aligner;
- Spin-coating substrate preparation system |Step SpinMask 300 from AP&S;
- Semi-automatic stations for applying resist layers (photosensitive emulsion) and its development from EVGroup (EVG);
- Device for etching in chlorine and fluorine plasma using reactive ions (RIE – Reactive Ion Etching) PlasmaPro 100 ICP (Inductively Coupled Plasma) from Oxford Instruments;

- Device for deposition of layers by magnetron sputtering (including reactive) PlasmaPro 400 from Oxford Instruments;
- Oxford Instruments PlasmaPro 100 plasma deposition (Plasma Enhanced Chemical Vapour Deposition) is used for deposition of silicon dioxide (SiO_2), silicon nitride (SiN_x), silicon oxynitride (SiO_xN_y), amorphous silicon (a-Si), with the possibility of controlling the composition and mechanical stress;
- IBS FLEXion 200 ion implanter for ion implantation – acceleration voltage up to 200 kV, heating substrates up to 500 °C;
- Equipment for chemical treatment of substrates (etch/clean–batch spray) from Siconnex;
- Electron beam lithography device JBX-9300FS from Jeol;
- Two sets of horizontal furnaces for medium and high-temperature processes and LPCVD (Low Pressure Chemical Vapour Deposition) from Thermco;
- Resist processing – a set of Sawatec devices enabling controlled thermal treatment of resists;
- Printing machine (Aurel C920);
- Aerosol printing machine (Optomec 300aj);
- BioX bioprinter.

CONTACT:

We invite you to cooperate and contact

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