Purchase Contract

(hereafter the "**Contract**")

1. CONTRACTUAL PARTIES

1.1 **Fyzikální ústav AV ČR, v. v. i.**,

with seat: Na Slovance 1999/2, 182 21 Praha 8,
represented by: RNDr. Michael Prouza, Ph.D., Director,
registered in the Register of public research institutions of the Ministry of Education, Youth and Sports of the Czech Republic.

ID No.: 68378271
Tax ID No.: CZ68378271

Bank: [redacted]
Account No. [redacted]

(hereinafter the "**Buyer**")

and

1.2 Devmatech sp.j. E.Bojarski,

with seat: Grodkowska 6/109; 01-461 Warszawa, Poland,
represented by: Łukasz Sadowski, Emil Bojarski,
registered in Poland.

ID No.: Regon: 142408188
Tax ID No.: PL5222949552

Bank: [redacted]
Account No. [redacted]

(hereinafter the "**Seller**"),

(the Buyer and the Seller are hereinafter jointly referred to as the "**Parties**" and each of them individually as a "**Party**").

2. FUNDAMENTAL PROVISIONS

2.1 The Buyer is a public research institution whose primary activity is scientific research in the area of physics, especially elementary particles physics, condensed systems, plasma and optics.

2.2 The Buyer wishes to acquire the subject of performance hereof (**Atomic Layer Deposition system**) to perform controlled deposition of atomically thin films for research and development of new materials and components in nanoelectronics, optoelectronics, optics andbiomedicine.

2.3 The Buyer is the beneficiary of the subsidy for the project **"Solid state physics for the 21st century (SOLID 21)"**, Reg. No CZ.02.1.01/0.0/0.0/16_019/0000760 (hereinafter the **"Project"**), within the Operational Program Research, Development and Education (hereinafter the **"OP RDE"**) of the provider Ministry of Education, Youth and Sports of the Czech Republic. The subject of public procurement will be co-financed by the EU Structural Funds.

2.4 The Seller was selected as the winner of a public procurement procedure announced by the Buyer in accordance with Act No. 134/2016 Coll., on Public Procurement, as amended (hereinafter the "**Act**"), for the public contract called **"Atomic Layer Deposition"** (hereinafter the "**Procurement Procedure**"). Both the Procurement Procedure and the Contract shall be governed by the Rules for applicants and beneficiaries of OP RDE, which are publicly accessible and are binding on the Parties.

2.5 The documentation necessary for the execution of the subject of performance hereof consist of

2.5.1 Technical specifications of the subject of performance hereof attached as **Annex No.1** hereto**.**

2.5.2 The Seller´s bid submitted within the Procurement Procedure in its parts which describe the subject of performance in technical detail (hereinafter the "**Sellers's Bid**"); the Sellers´s Bid forms **Annex No. 2** to this Contract and is an integral part hereof.

In the event of a conflict between the Contract's Annexes the technical specification / requirement of the higher level / quality shall prevail.

2.6 The Seller declares that he has all the professional prerequisites required for the supply of the subject of performance under this Contract, is authorised to supply the subject of performance and there exist no obstacles on the part of the Seller that would prevent him from supplying the subject of this Contract to the Buyer.

2.7 The Seller acknowledges that the Buyer considers him capable of providing performance under the Contract with such knowledge, diligence and care that is associated and expected of the Seller's profession, and that the Seller's potential performance lacking such professional care would give rise to corresponding liability on the Seller's part. The Seller is prohibited from misusing his qualities as the expert or his economic position in order to create or exploit dependency of the weaker Party or to establish an unjustified imbalance in the mutual rights and obligation of the Parties.

2.8 The Seller acknowledges that the Buyer is not in connection to the subject of this Contract an entrepreneur and also that the subject of this Contract is not related to any business activities of the Buyer.

2.9 The Seller acknowledges that the production and delivery of the subject of performance within the specified time and of the specified quality, as shown in Annexes No. 1 and 2 of this Contract (including invoicing), is essential for the Buyer.

2.10 The Parties declare that they shall maintain confidentiality with respect to all facts and information, which they learn in connection herewith and / or during performance hereunder, and whose disclosure could cause damage to either Party. Confidentiality provisions do not prejudice obligations arising from valid legislation.

3. SUBJECT-MATTER OF THE CONTRACT

3.1 The subject of this Contract is the obligation on the part of the Seller to deliver and transfer into the Buyer's ownership **Atomic Layer Deposition** (hereafter the **"Equipment"**) and the Buyer undertakes to take delivery of the Equipment and to pay to the Seller the agreed upon price.

3.2 The following activities form an integral part of the performance to be provided by the Seller:

3.2.1 Formulation of conditions which are recommended to be met at the place of Buyer in order to install the Equipment;

3.2.2 Transport of the Equipment incl. all accessories specified in Annexes 1 and 2 of the Contract to the site, un-packaging and control thereof;

3.2.3 Installation and commissioning of the Equipment including the connection of the Equipment to the installation infrastructure at the site;

3.2.4 Execution of the acceptance test:

- Deposit a thin layer of Al_2O_3 with a thickness of 5 nm on a Si wafer substrate with a diameter of 100 mm (4") in the Equipment at a temperature of 300 °C using trimethylaluminum (TMA) and water as the precursors.

- The variation of the Al_2O_3 film thickness measured by ellipsometry needs to be below 1% over the whole substrate (excluding 1 mm from the edges). The ellipsometry measurements will be performed by the Buyer.

- The Al_2O_3 film needs to be conformal, uniform, dense, and pin-hole free in a test performed by scanning electron microscopy and atomic force microscopy. The test will be performed by the Buyer on 3 selected locations on the sample.

- The deposited Al_2O_3 film needs to demonstrate an atomic O/Al ratio of 1.5±0.1 in X-ray photoelectron spectroscopy (XPS). The XPS test will be performed by the Buyer.

3.2.5 Delivery of detailed instructions and manuals for operation and maintenance, including list of spare parts, vacuum, gas and electrical connection schemes - all in Czech or English language, in electronic or hardcopy (printed) versions;

3.2.6 Training of operators at the site (at least 1-day training of 4 operators);

3.2.7 Free-of-charge warranty service including service inspections;

3.2.8 Provision of free-of-charge technical support in the form of consultations.

3.3 The subject of performance (Equipment) is specified in detail in Annexes No. 1 and No. 2 hereto.

3.4 The Seller shall be liable for the Equipment and related services to be in full compliance with this Contract, its Annexes and all valid legal regulation, technical and quality standards and that the Buyer will be able to use the Equipment for the defined purpose. In case of any conflict between applicable standards it is understood that the more strict standard or its part shall always apply.

3.5 The delivered Equipment and all its parts and accessories must be brand new and unused.

4. PERFORMANCE PERIOD

4.1 The Seller undertakes to manufacture, deliver, install and handover the Equipment to the Buyer within **6 (six) months** of the conclusion of this Contract.

4.2 The performance period shall be extended for a period during which the Seller could not perform due to obstacles on the part of the Buyer.

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5. PURCHASE PRICE, INVOICING, PAYMENTS

5.1 The purchase price is based on the Seller's submitted bid and amounts to 11 000 000 **CZK** (in words: eleven millions CZK) excluding VAT (hereinafter the **"Price"**). VAT shall be paid by the Buyer and settled in accordance with the valid Czech regulation.

5.2 The Price represents the maximum binding offer by the Seller and includes any and all performance provided by the Seller in connection with meeting the Buyer's requirements for the proper and complete delivery of the Equipment hereunder, as well as all costs that the Seller may incur in connection with the delivery, and including all other costs of expenses that may arise in connection with creation of an intellectual property and its protection.

5.3 The Parties agreed that the Seller shall be entitled to invoice the Price as follows:

5.3.1 The Seller is entitled to issue an advance invoice corresponding to 30 % of the Price excluding VAT after the conclusion of the Contract;

5.3.2 The Seller is entitled to invoice the Price after the handover protocol in accordance with Section 10.4 will have been signed. In case the Equipment will be delivered with minor defects and / or unfinished work, the Price shall be invoiced after removal of these minor defects and / or unfinished work.

5.4 All invoices issued by the Seller must contain all information required by the applicable laws of the Czech Republic. Invoices issued by the Seller in accordance with this Contract shall contain in particular following information:

5.4.1 name and registered office of the Buyer,

5.4.2 tax identification number of the Buyer,

5.4.3 name and registered office of the Seller,

5.4.4 tax identification number of the Seller,

5.4.5 registration number of the tax document (invoice),

5.4.6 scope of the performance (including the reference to this Contract),

5.4.7 the date of the issue of the tax document (invoice),

5.4.8 the date of the fulfilment of the Contract, 5.4.9 purchase Price,

5.4.10 registration number of this Contract, which the Buyer shall communicate to the Seller based on Seller's request before the issuance of the invoice,

5.4.11 declaration that the performance of the Contract is for the purposes of the project "Solid state physics for the 21st century (SOLID21)", Reg. No. CZ.02.1.01/0.0/0.0/16_019/0000760

and must comply with the double taxation agreements, if applicable.

5.5 The Buyer prefers electronic invoicing, with the invoices being delivered to efaktury@fzu.cz. All issued invoices shall comply with any international double taxation agreements, if applicable.

5.6 Invoices shall be payable within thirty (30) days of the date of their delivery to the Buyer. Payment of the invoiced amount means the date of its remittance to the Seller's account.

5.7 If an invoice is not issued in conformity with the payment terms stipulated by the Contract or if it does not comply with the requirements stipulated by law, the Buyer shall be entitled to return the invoice to the Seller as incomplete, or incorrectly issued, for correction or issue of a new invoice, as appropriate, within five (5) business days of the date of its delivery to the Buyer. In such a case, the Buyer shall not be in delay with the payment of the Price or part thereof and the Seller shall issue a corrected invoice with a new and identical maturity period commencing on the date of delivery of the corrected or newly issued invoice to the Buyer.

5.8 The Buyer shall be entitled to unilaterally set off any of his payments against any receivables claimed by the Seller due to:

5.8.1 damages caused by the Seller,

5.8.2 contractual penalties.

5.9 The Seller shall not be entitled to set off any of his receivables against any part of the Buyer's receivable hereunder.

6. OWNERSHIP TITLE

6.1 The ownership right to the Equipment shall pass to the Buyer by handover. Handover shall be understood as delivery and acceptance of the Equipment duly confirmed by Parties on the Handover Protocol in accordance with Section 10.4.

7. PLACE OF DELIVERY AND HANDOVER OF THE EQUIPMENT

7.1 The place of delivery and handover of the Equipment shall be the room No. E401 in the building E of the Fyzikální ústav AV ČR, v. v. i. at Cukrovarnická 112/10, 162 Praha 6, Czech Republic.

8. PREPAREDNESS OF THE PLACE OF DELIVERY AND HANDOVER

8.1 The Seller shall notify the Buyer in writing of the exact date of installation of the Equipment at least 30 days prior to such date, ensuring that the deadline for the performance hereunder is maintained.

8.2 The Buyer shall be obliged to allow the Seller, once the deadline set forth in Section 8.1 hereof expires, to install the Equipment at the place of delivery and handover.

9. COOPERATION OF THE PARTIES

9.1 The Seller undertakes to notify the Buyer of any obstacles on his part, which may negatively influence proper and timely delivery of the Equipment.

10. DELIVERY, INSTALLATION, HANDOVER AND ACCEPTANCE

10.1 The Seller shall transport the Equipment at its own cost to the place of delivery and handover. If the shipment is intact, the Buyer shall issue delivery note for the Seller.

10.2 The Seller shall perform and document the installation of the Equipment and launch experimental tests in order to verify whether the Equipment is functional and meets the technical requirements of Annexes No. 1 and 2 hereof.

10.3 Handover procedure includes handover of any and all technical documentation pertaining to the Equipment, user manuals and certificate of compliance of the Equipment and all its parts and accessories with approved standards.

10.4 The handover procedure shall be completed by handover of the Equipment confirmed by the Handover Protocol containing specifications of all performed tests. The Handover Protocol shall contain the following mandatory information:

10.4.1 Information about the Seller, the Buyer and any subcontractors;

10.4.2 Description of the Equipment including description of all components, their hardware/software setups (i.e. communication address, etc.) and serial numbers;

10.4.3 Description of executed tests according to Section 3.2.4 of the Contract: type of test,

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duration and achieved parameters;

10.4.4 List of technical documentation including the manuals;

10.4.5 Confirmation on training, its participants and extent;

10.4.6 Eventually reservation of the Buyer regarding minor defects and unfinished work including the manner and deadline for their removal and

10.4.7 Date of signature of the Equipment Handover Protocol.

10.5 Handover of the Equipment does not release the Seller from liability for damage caused by its defects.

10.6 The Buyer shall not be obliged to accept Equipment, which would show defects or unfinished work and which would otherwise not form a barrier, on their own or in connection with other defects, to using the Equipment. In this case, the Buyer shall issue a record containing the reason for his refusal to accept the Equipment.

10.7 Should the Buyer not exercise his right not to accept the Equipment with defects or unfinished work, the Seller and the Buyer shall list these defects or unfinished work in the Handover Protocol, including the manner and deadline for their removal. Should the Parties not be able to agree in the Handover Protocol on the deadline for removal of the defects, it shall be understood that any defects shall be removed / rectified within 14 days from the handover of the Equipment.

11. <u>TECHNICAL ASSISTANCE – CONSULTATIONS</u>

11.1 The Seller shall be obliged to provide to the Buyer free-of-charge technical assistance by phone or e-mail relating to the subject-matter hereof during the entire term of the warranty period. The Seller undertakes to provide to the Buyer paid consultations and technical assistance relating to the subject-matter hereof also after the warranty period expires.

12. <u>REPRESENTATIVES, NOTICES</u>

12.1 The Seller authorized the following representatives to communicate with the Buyer in all matters relating to the Equipment delivery:

[redacted]

12.2 The Buyer authorized the following representatives to communicate with the Seller:

[redacted]

12.3 All notifications to be made between the Parties hereunder must be made out in writing and delivered to the other Party by hand (with confirmed receipt) or by registered post (to the Buyer's or Seller's address), or in some other form of registered post or electronic delivery incorporating electronic signature (qualified certificate) to epodatelna@fzu.cz in case of the Buyer and to [redacted] in case of the Seller.

12.4 In all technical and expert matters (discussions on the Equipment testing and demonstration, notification of the need to provide warranty or post-warranty service, technical assistance etc.) electronic communication between technical representatives of the Parties will be acceptable using e-mail addresses defined in Sections 12.1 and 12.2.

13. TERMINATION

13.1 This Contract may be terminated early by agreement of the Parties or withdrawal from the Contract on the grounds stipulated by law or in the Contract.

13.2 The Buyer is entitled to withdraw from the Contract without any penalty from the Seller in any of the following events:

13.2.1 The Seller is in delay with the delivery of the Equipment longer than 2 weeks after the date pursuant to Section 4.1 hereof.

13.2.2 Technical parameters or other conditions required in the technical specification defined in Annexes No. 1 and 2 hereto and in the relevant valid technical standards will not be achieved by the Equipment at acceptance.

13.2.3 Facts emerge bearing evidence that the Seller will not be able to deliver the Equipment.

13.2.4 The Seller will not meet the qualification criteria set within the Procurement Procedure.

13.3 The Seller is entitled to withdraw from the Contract in the event of the Buyer being in default with the payment for more than 2 months with the exception of the cases when the Buyer refused an invoice due to defect on the delivered Equipment or due to breach of the Contract by the Seller.

13.4 Withdrawal from the Contract becomes effective on the day the written notification to that effect is delivered to the other Party. The Party which had received performance from the other Party prior to such withdrawal shall duly return such performance.

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14. INSURANCE

14.1 The Seller undertakes to insure the Equipment against all risks, in the amount of the Price of the Equipment for the entire period commencing when transport of the Equipment starts until duly handed over to the Buyer. In case of breach of this obligation, the Seller shall be liable to the Buyer for any damage that may arise.

14.2 The Seller is liable for the damage that he has caused. The Seller is also liable for damage caused by third parties undertaken to carry out performance or his part under this Contract.

15. WARRANTY TERMS

15.1 The Seller shall provide warranty for the quality of the Equipment for a period of 24 months.

15.2 The warranty term shall commence on the day following the date of signing of the Handover Protocol pursuant to Section 10.4 hereof. The warranty does not cover consumablethings.

15.3 Should the Buyer discover a defect, he shall notify the Seller to rectify such defect using the e-mail address[redacted]. The Seller is obliged to notify the Buyer without delay about any change of this email address. The Seller shall be obliged to review any warranty claim within 3 business days from its receipt and to propose solution, unless agreed otherwise by the Parties.

15.4 During the warranty period the Seller shall be obliged to rectify any claimed defects within 14 business days from receipt of the Buyer’s notification. In cases of unusual defects, the Seller shall be obliged to rectify the defect in the period corresponding to the nature of the defect and to define the deadline for the handover of the rectified Equipment.

15.5 During the warranty period any and all costs associated with defect rectification / repair including transport and travel expenses of Seller shall be always borne by the Seller.

15.6 The repaired Equipment shall be handed over by the Seller to the Buyer on the basis of a protocol confirming removal of the defect (hereinafter the “**Repair Protocol**”) containing confirmations of both Parties that the Equipment was duly repaired and is defect-free.

15.7 The repaired portion of the Equipment shall be subject to a new warranty term in accordance with Section 15.1 which commences to run on the day following the date when the Repair Protocol was executed. However, the aggregate warranty period shall not exceed 48 months.

15.8 The Seller declares that he shall ensure paid post-warranty [out-of-warranty] service for the period of 10 years after the expiration of the warranty; the service terms shall be identical to those of Sections 15.3 and 15.4.

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15.9 The Seller undertakes to provide the Buyer with updates of the software controlling the Equipment for the entire term of warranty service.

16. CONTRACTUAL PENALTIES

16.1 The Buyer shall have the right to a penalty in the amount of 0.1 % of the Price for each commenced day of delay with the performance pursuant to Section 4.1 hereof.

16.2 The Buyer shall have the right to a penalty in the amount of 0.1 % of the Price for each commenced day of delay with rectifying of defects claimed within the warranty period.

16.3 In case of default in payment of any due receivables (monetary debt) under the Contract, the defaulting Buyer or Seller (the debtor) shall be obliged to pay a contractual penalty in the amount of 0.1 % of the owed amount for each commenced day of delay with the payment.

16.4 The Buyer shall be entitled to claim a contractual penalty against the Seller in the amount of 30 % of the Price, in case it will subsequently take advantage of the opportunity to withdraw from the Contract pursuant to Section 13.2.1 and 13.2.2.

16.5 Contractual penalties are payable within 30 days of notification demanding payment thereof.

16.6 Payment of the contractual penalty does not prejudice the rights of the Parties to claim damages.

17. DISPUTES

17.1 Any and all disputes arising out of this Contract or the legal relationships connected with the Contract shall be resolved by the Parties by mutual negotiations. In the event that any dispute cannot be resolved by negotiations within sixty (60) days, the dispute shall be resolved by the competent court in the Czech Republic based on application of any of the Parties; the court having jurisdiction will be the court where the seat of the Buyer is located. Disputes shall be resolved exclusively by the law of the Czech Republic.

18. ACCEPTANCE OF THE PROJECT RULES

18.1 The Seller, using all necessary professional care, shall cooperate during financial inspections carried out in accordance with Act No. 320/2001 Coll., on Financial Inspections, as amended, or during other financial inspections carried out by any auditing entities (particularly by the Managing Authority of the Operational Program Research, Development and Education) and shall allow access also to those portions of the bid submitted within the Procurement Procedure, the Contract and related documents which may be protected by special legal regulation, given that all requirements set forth by legal regulation with respect to the manner of executing such inspections will have been observed.

19. FINAL PROVISIONS

19.1 This Contract represents the entire agreement between the Buyer and the Seller. The relationships between the Parties not regulated in this Contract shall be governed by the Act No. 89/2012 Coll., the Civil Code, as amended.

19.2 In the event that any of the provisions of this Contract shall later be shown or determined to be invalid, ineffective or unenforceable, then such invalidity, ineffectiveness or unenforceability shall not cause invalidity, ineffectiveness or unenforceability of the Contract as a whole. In such event the Parties undertake without undue delay to subsequently clarify any such provision or replace after mutual agreement such invalid, ineffective or unenforceable provision of the Contract by a new provision, that in the extent permitted by the laws and regulations of the Czech Republic, relates as closely as possible to the intentions of the Parties to the Contract at the time of creation hereof.

19.3 This Contract may be changed or supplemented solely by means of numbered amendments in writing, furnished with the details of time and place and signed by duly authorised representatives of the Parties. The Parties expressly reject modifications to the Contract in any other manner.

19.4 The Parties expressly agree that the Contract as a whole, including all attachments and data on the Parties, subject-matter of the Contract, numerical designation of this Contract, the Price and the date of the Contract conclusion, will be published in accordance with Act No. 340/2015 Coll. on special conditions for the effectiveness of some contracts, publication of these contracts and Contract Register, as amended (hereinafter the "**CRA**"). The Parties hereby declare that all information contained in the Contract and its Annexes are not considered trade secrets under § 504 of the Civil Code and grant permission for their use and disclosure without setting any additional conditions.

19.5 The Parties agree that the Buyer shall ensure the publication of the Contract in the Contract Register in accordance with CRA.

19.6 This Contract becomes effective as of the day of its publication in the Contract Register.

19.7 The following Annexes form an integral part of the Contract:

Annex No. 1: Technical specification on the subject of performance

Annex No. 2: Technical description of the Equipment as presented in Seller's bid

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19.8 The Parties, manifesting their consent with the entire contents of this Contract, attach their signature hereunder.

In Prague

For the Buyer:

[redacted]

RNDr. Michael Prouza, Ph.D.
Director

In Warsaw

For the Seller:

[redacted]

Łukasz Sadowski
Emil Bojarski

Annex No. 1 - Technical specification on the subject of performance

ATOMIC LAYER DEPOSITION SYSTEM

The atomic layer deposition (ALD) system needs to satisfy the following technical specification (parameters, parts and components), which are described in detail below. The ALD system must be supplied complete including all necessary hardware and software parts and accessories needed for ALD operation, processes control and monitoring. All parts and accessories need to be connected in such a way to ensure full operation and provide all required functions. The delivered ALD setup needs to meet the acceptance test. Additionally, we require detailed training of our ALD operators and technical support free of charge for a minimum of 2 years.

Deposited materials

1. The ALD system must be able to deposit atomically thin layers of these materials: Al_2O_3, HfO_2, ZnO, TiO_2, SiO_2 and Si_3N_4 on different substrates (e.g. Si wafer, glass, graphene, nanostructured materials, etc.). The deposition of these materials in the ALD system needs to be well experimentally demonstrated and reported in theliterature.
2. The ALD system is able to deposit continuous and homogeneous atomically thin layers of the above-mentioned materials on flat, structured, porous, and powdersubstrates.
3. The delivered ALD system needs to meet the acceptance test. The acceptance test includes repeatable deposition of thin layers of Al_2O_3 with a thickness of 5 nm on a Si wafer substrate with a diameter of 100 mm (4“). The variation of the Al_2O_3 film thickness needs to be below 1% over the whole substrate (excluding edges). The ALD deposition should be conducted at 300 °C using trimethylaluminum (TMA) and water as the precursors.
4. The delivery of the ALD system needs to include detailed ALD deposition process parameters for the successful deposition of Al_2O_3, HfO_2 and SiO_2.

Tool design and components

5. A deposition reactor includes an outer vacuum chamber and an inner reaction chamber made of AISI 304/316L stainless steel or analogous.
6. The reactor chamber can be heated in the whole volume to a temperature of a minimum of 450 °C to avoid unwanted contamination, condensation, and deposition of materials or precursors on the chamber walls. The outer vacuum chamber does not need to be water-cooled.
7. The deposition reactor is equipped with dedicated vacuum feedthroughs to connect an ellipsometer, quartz crystal microbalance (QCM) and a mass spectrometer/residual gas analyser (RGA).

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8. Samples are manually loaded in the deposition reactor using a load lock vacuum chamber.
9. The load lock chamber is equipped with a sample loading port, a pressure gauge and additional feedthrough suitable for connecting an ellipsometer.
10. The load lock chamber is connected to a glovebox, enabling inserting samples into the chamber under an inert gas atmosphere.
11. The system includes a glovebox with a length of a minimum of 1200 mm and a width of a minimum of 650 mm that allows a single person to perform operations in inert nitrogen conditions. The glovebox has got a stainless steel design and pipework. It is equipped with a removable chemically resistant front window and gloves, which are compatible with organic solvents. The glovebox is equipped with small and large transfer chambers (antechambers) and a vacuum pump. The glovebox has got integrated high vacuum feedthroughs (KF40/KF50) for connecting other devices. Automatic oxygen and moisture purification system with auto purge and regeneration function with attainable purity at O_2 <1 ppm, and H_2O <1 ppm. The glovebox is equipped with an oxygen and moisture analyser for real-time purity monitoring. The internal solvent removal system includes a unit for organic contaminants removal (e.g. activated carbon filter).
12. The deposition reactor is equipped with a sample heating stage enabling a temperature control up to 450 °C with the precision of ±1°C or better.
13. The ALD system is supplied with sample holders of different lateral dimensions: 200 mm (8“) diameter, 100 mm (4“) diameter, 20×20 mm, 10×10 mm, a set of holders for small and porous samples of different sizes, and a capsule holder for powder samples containing a porous lid. The deposition reactor should enable deposition on samples with a minimum sample thickness (height) of 50 mm.
14. The deposition reactor is equipped with accessories for depositing ALD films on porous three-dimensional (3D) materials and powders by forcing the precursors to flow through substrates.
15. The ALD system allows conformal deposition on high aspect ratio pore structures using diffusion enhanced technology.
16. The ALD system includes plasma-enhanced ALD (PEALD) mode, enabling deposition of improved film properties at lower temperatures. The deposition reactor has its own gas inlet for the PAELD and is equipped with a remote plasma source which is at least 40 cm away from the sample to avoid any possible damage to the films. The plasma source has a power in the minimum range of 100-3000 W and a frequency of 2-3 MHz. The PEALD can be performed up to deposition temperatures of 450 °C. The plasma ignition can be realized at standard deposition pressures (i.e. it does not require lowering of the pressure in the reaction chamber).
17. A vacuum in the deposition chamber is maintained by a dry vacuum pump (oil backstreaming is unacceptable). The pump is equipped with a vacuum booster delivering a minimum pumping speed of 500 m^3/h. The vacuum pump is compatible with corrosive gases and can be placed remotely from the ALD system.

18. The exhaust of the ALD system must be equipped with a scrubber and a particle filter designed for the abatement of all toxic gases and remaining particles to eliminate any risk for operators and the environment.
19. The load lock chamber has its own high vacuum pumping system and venting. The vacuum pump needs to deliver a base pressure below 50 Pa.
20. The ALD system contains in situ thickness monitor using a quartz crystal microbalance (QCM) as the sensor, enabling continuous thickness monitoring during the ALD deposition.
21. The construction of the ALD system must enable future installation of an ozone source.

Precursor and gas delivery

22. The deposition reactor contains a minimum of 6 independent precursor lines. Each of the lines has its own independent entry in the reaction chamber.
23. Precursor inlets are located at the top of the deposition chamber, enabling the top-down flow of precursors on the sample surface.
24. All vacuum and gas connections in the ALD system are of a metal-to-metal type using metal gasket fittings.
25. Each of the precursor lines has its own mass flow controller (MFC), pulse control valve and pressure gauge that can be fully controlled by a computer.
26. Each precursor line needs to be connected by a by-pass to a carrier gas, enabling line purging by an inert gas.
27. The ALD system needs to be compatible with solid, liquid and gas precursors as well as flambable and corrosive gases, such as NH_3 or H_2.
28. The ALD system contains a minimum of 3 heated precursor lines and 2 plasma gas source lines.
29. The ALD system contains at least 2 heated precursor delivery lines, including valves and dedicated containers, for low vapour pressure precursors that can be controllably heated to a temperature of a minimum of 300°C. All the lines (including valves) in the precursor delivery system needs to be heated to a higher temperature than the maximum temperature achieved in the heated containers with precursors. The precursors need to be carried to the reaction chamber by the flow of carrier gas. The heated containers need to be placed in the vicinity of the ALD reaction chamber to minimise the precursor distance from the reaction chamber.
30. The ALD system contains a minimum of 3 delivery lines for liquid and highly volatile precursors at room temperature and pressure. The precursors need to be carried to the reaction chamber by a flow of carrier gas. The system needs to be supplied with a minimum of 5 high vapour pressure precursor containers. The containers need to be compatible with water and vapour pressures >10 mbar. The container needs to be cooled down by 4-8 °C with respect to the ambient temperature.

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31. High vapour pressure and toxic precursors need to be stored in a separate ventilated precursor cabinet made of stainless steel.

Control system

32. The ALD system is fully controlled by a dedicated control system that includes a computer, monitor, electronics, and software. The control system enables full real-time control and monitoring of ALD deposition processes, recording and saving of all deposition parameters during the deposition, and programming capability for creating complex deposition recipes. The software needs to have a simple and easy operation for first time users, enable remote access service and ALD process control over a network or the internet. The software needs to have an integrated pulsing monitor for each inlet line, individually programmable purging and gas flow rates for each line and fully programmable pulsing sequences suitable for the fabrication of ternary compounds and multilayer heterostructures. There should be a possibility to save log files on a computer hard drive and a USB memory card.
33. All valves, mass spectrometers, and detectors of the ALD system need to be automated and controlled by the control system enabling electrical readout and regulation of their input and output signals, creating programmable pulsing sequences of different gases and precursors.

Other requirements

34. All the electrical appliances of the ALD system needs to be compatible with the electric power supply with a voltage of (nominally) 230/400 V and a frequency of 50 Hz.
35. The ALD system needs to be delivered and installed in the designated ALD laboratory of the FZU. All the delivered items of the ALD system including packaging need to satisfy the size limit of the packages to be transferred through the door width of 78 cm and the height of 1960 cm.
36. Provide ALD setup installation, commissioning and training of our ALD operators.
37. Provide free technical support for a minimum of 2 years.

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Tab. 1. – Evaluation criterion according to paragraph 7.2.2 of the Tender Documentation - Technical level of the Equipment.

The evaluated parameters according to the evaluation sub-criterion (Technical level of the Equipment) are listed in this table:

No.	Description of the minimum requirements of the Equipment as defined by the Buyer	Description and specification of the Equipment offered by the Seller	Complies YES/NO	Points
1	The ALD system must be able to deposit atomically thin layers of these materials: Al_2O_3, HfO_2, ZnO, TiO_2, SiO_2, and Si_3N_4 on different substrates (e.g. Si wafer, glass, graphene, nanostructured materials, etc.). The deposition of these materials in the ALD system needs to be well experimentally demonstrated and reported in the literature.	The ALD system is capable of depositing these materials on different substrates. SiO2 requires plasma process or ozone generator.	Yes	
2	The ALD system is able to deposit continuous and homogeneous atomically thin layers of the above-mentioned materials on flat, structured, porous, and powder substrates.	All materials except the ones requiring plasma can be done for powders, high aspect ratio structured and porous materials. Plasma radicals die before reaching high aspect ratio locations and only work on flat surfaces and in limited aspect ratios.	Yes	
3	The delivery includes the ALD deposition process parameter recipes for successful deposition of Al_2O_3, HfO_2 and SiO_2 in the ALD system.	Yes	Yes	
4	A deposition reactor includes an outer vacuum chamber and an inner reaction chamber made of AISI 304/316L stainless steel or analogous.	Yes	Yes	
5	The reactor chamber can be heated in the whole volume to a temperature of a minimum of 450 °C to avoid unwanted contamination,	System fulfils these requirements	Yes	

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	condensation, and deposition of materials or precursors on the chamber walls. The outer vacuum chamber does not need to be water-cooled.			
6	The deposition reactor is equipped with dedicated vacuum feedthroughs to connect an ellipsometer, quartz crystal microbalance (QCM) and a mass spectrometer/residual gas analyser (RGA).	Yes	Yes	
7	Samples are manually loaded in the deposition reactor using a load lock vacuum chamber.	Yes	Yes	
8	The load lock chamber is equipped with a sample loading port, a pressure gauge and additional feedthrough suitable for connecting an ellipsometer.	Yes	Yes	
9	The load lock chamber is connected to a glovebox, enabling inserting samples into the chamber under an inert gas atmosphere.	Yes	Yes	
10	The system includes a glovebox with a length of a minimum of 1200 mm and a width of a minimum of 650 mm that allows a single person to perform operations in inert nitrogen conditions. The glovebox has got a stainless steel design and pipework. It is equipped with a removable chemically resistant front window and gloves, which are compatible with organic solvents. The glovebox is equipped with small and large transfer chambers (antechambers) and a vacuum pump. The glovebox has got integrated high vacuum feedthroughs (KF40/KF50) for connecting other devices. Automatic oxygen and moisture purification	Yes	Yes	

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	system with auto purge and regeneration function with attainable purity at O2 <1 ppm, and H2O <1 ppm. The glovebox is equipped with an oxygen and moisture analyser for real-time purity monitoring. The internal solvent removal system includes a unit for organic contaminants removal (e.g. activated carbon filter).			
11	The deposition reactor is equipped with a sample heating stage enabling a temperature control up to 450 °C with the precision of ±1°C or better.	Yes, up to 650°C	Yes	
12	The ALD system is supplied with sample holders of different lateral dimensions: 200 mm (8") diameter, 100 mm (4") diameter, 20×20 mm, 10×10 mm, a set of holders for small and porous samples of different sizes, and a capsule holder for powder samples containing a porous lid. The deposition reactor should enable deposition on samples with a minimum sample thickness (height) of 50 mm.	Yes	Yes	
13	The deposition reactor is equipped with accessories for depositing ALD films on porous three-dimensional (3D) materials and powders by forcing the precursors to flow through substrates.	Yes	Yes	
14	The ALD system allows conformal deposition on high aspect ratio pore structures using diffusion enhanced technology.	Yes	Yes	
15	The ALD system includes plasma-enhanced ALD (PEALD) mode, enabling deposition of improved film properties at lower temperatures. The deposition reactor has its own gas inlet for the PAELD and is equipped	Yes	Yes	

	with a remote plasma source which is at least 40 cm away from the sample to avoid any possible damage to the films. The plasma source has a power in the minimum range of 100-3000 W and a frequency of 2-3 MHz. The PEALD can be performed up to deposition temperatures of 450 °C. The plasma ignition can be realized at standard deposition pressures (i.e. it does not require lowering of the pressure in the reaction chamber).			
16	A vacuum in the deposition chamber is maintained by a dry vacuum pump (oil backstreaming is unacceptable). The pump is equipped with a vacuum booster delivering a minimum pumping speed of 500 m^3/h. The vacuum pump is compatible with corrosive gases and can be placed remotely from the ALD system.	Yes	Yes	
17	The exhaust of the ALD system must be equipped with a scrubber and a particle filter designed for the abatement of all toxic gases and remaining particles to eliminate any risk for operators and the environment.	Yes	Yes	
18	The load lock chamber has its own high vacuum pumping system and venting. The vacuum pump needs to deliver a base pressure below 50 Pa.	Yes	Yes	
19	The ALD system contains an in situ thickness monitor using a quartz crystal microbalance (QCM) as the sensor, enabling continuous thickness monitoring during the ALD deposition with the sensitivity of 0.1 nm or better.	QCM cannot be used same time with heated sample stage.	Yes	
20	The construction of the ALD system must enable future installation of an ozone generator.	Yes, room is left for the system for installation of Ozone generator and related gas lines	Yes	

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21	The deposition reactor contains a minimum of 6 independent precursor lines. Each of the lines has its own independent entry in the reaction chamber.	Yes	Yes	
22	Precursor inlets are located at the top of the deposition chamber, enabling the top-down flow of precursors on the sample surface.	Yes	Yes	
23	All vacuum and gas connections in the ALD system are of a metal-to-metal type using metal gasket fittings.	all gas connections metal VCR (yes), but not all vacuum connection, for example in a pumpline there are o-rings (Viton, Kalrez etc.)	Yes	
24	Each of the precursor lines has its own mass flow controller (MFC), pulse control valve and pressure gauge that can be fully controlled by a computer.	Yes	Yes	
25	Each precursor line needs to be connected by a by-pass to a carrier gas, enabling line purging by an inert gas.	Yes	Yes	
26	The ALD system needs to be compatible with solid, liquid and gas precursors as well as flammable and corrosive gases, such as NH_3 or H_2.	Yes	Yes	
27	The ALD system contains a minimum of 3 heated precursor lines and 2 plasma gas source lines.	Yes	Yes	
28	The ALD system contains at least 2 heated precursor delivery lines, including valves and dedicated containers, for low vapour pressure precursors that can be controllably heated to a temperature of a minimum of 300°C. All the lines (including valves) in the precursor delivery system needs to be heated to a higher temperature than the maximum temperature achieved in the heated containers with	Yes	Yes	

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	precursors. The precursors need to be carried to the reaction chamber by the flow of carrier gas. The heated containers need to be placed in the vicinity of the ALD reaction chamber to minimise the precursor distance from the reaction chamber.			
29	The ALD system contains a minimum of 3 delivery lines for liquid and highly volatile precursors at room temperature and pressure. The precursors need to be carried to the reaction chamber by a flow of carrier gas. The system needs to be supplied with a minimum of 5 high vapour pressure precursor containers. The containers need to be compatible with water and vapour pressures >10 mbar. The container needs to be cooled down by 4-8 °C with respect to the ambient temperature.	Yes	Yes	
30	High vapour pressure and toxic precursors need to be stored in a separate ventilated precursor cabinet made of stainless steel.	Yes	Yes	
31	The ALD system is fully controlled by a dedicated control system that includes a computer, monitor, electronics, and software. The control system enables full real-time control and monitoring of ALD deposition processes, recording and saving of all deposition parameters during the deposition, and programming capability for creating complex deposition recipes. The software of the control system needs to have a simple and easy operation for first time users, enable remote access service and ALD process control over a network or the internet. The software	Software meets the specification but the ALD process control over a network or the internet is disabled due the security reasons	Yes	

	needs to have an integrated pulsing monitor for each inlet line, individually programmable purging and gas flow rates for each line and fully programmable pulsing sequences suitable for the fabrication of ternary compounds and multilayer heterostructures. There should be a possibility to save log files on a computer hard drive and a USB memory card.			
32	All valves, mass spectrometers, and detectors of the ALD system need to be automated and controlled by the control system enabling electrical readout and regulation of their input and output signals, creating programmable pulsing sequences of different gases and precursors.	Yes	Yes	
33	All the electrical appliances of the ALD system needs to be compatible with the electric power supply with a voltage of (nominally) 230/400 V and a frequency of 50 Hz.	Yes	Yes	
34	All the delivered items of the ALD system including packaging need to satisfy the size limit of the packages to be transferred through the door width of 78 cm and the height of 1960 cm.	No Glovebox meets all technical requirements but the minimal width of the glovebox with KF flanges exceeds the width of the door opening	No	
35	Technical service is available in the Czech Republic.	Technical service is available in Czech language from Poland and closes support office to the installation site is in Dresden, Germany, 150km from Czech republic.	No	

(Bidder shall fill in values)

Annex No. 2

The Seller's bid in the extent it describes technical parameters of the Equipment

SHORT DESCRIPTION OF THE TOOL

Table 1. The content of the offered PICOSUN™ R-200 Advanced ALD tool.

ITEM	QTY	DESCRIPTION
Reactor	**1**	PICOSUN™ R-200 Advanced ALD reactor with six separate precursor inlets, each with own MFC, pulsing valve and PT. Maximum deposition temperature of the ALD reactor is 450 °C. The Product includes: ✓ Vacuum chamber (AISI304) *Stainless steel vessel with KF connection flanges* ✓ Reaction chamber (AISI316L) RC-200 deep (6 inlets) *Chamber and lid with top flow precursor distribution geometry* ✓ Sample holder SH-200 for max 200mm wafers ✓ Powder cartridge POCA 100/200 for coating of powders ✓ Heated sample stage HS-650 for up to 650°C ✓ Through porous substrate holder ✓ Advanced source control and electronics system ✓ Leak tight covers for safer operation with hazardous chemicals *Loading chamber for integration of plasma generator and load lock*
Software	**1**	Advanced software with a touch panel PC *Touch panel PC and electronics cabinet used for operating the ALD reactor with ALD-software and electronics. Can also monitor the tool during deposition and store recipes and logs.*
Precursor sources	**8**	**3** Picosolution™ 100 source systems for high vapour pressure liquid precursors for e.g. Al_2O_3 and TiO_2. Total **5** containers **2** Picohot™ 300 heated source system for low vapour pressure precursors. Total **2** containers. **1** Picohot™ 200 heated source system for low vapour pressure precursors Total **1** container. **2** Picogas™ connections for plasma gas precursors (NH3 & O2) **1** External cabinet for Picosolution™ sources Each precursor line is connected to a carrier/purge nitrogen line.
Vacuum pump	**1**	1 Hanbell PS602 dry vacuum pump, afterburner and a mechanical foreline particle trap included.

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		1 Edwards nXds10i dry scroll vacuum pump for the load lock
Plasma generator	**1**	Picoplasma™ inductively coupled remote plasma source system. Tunable power 100 – 3000 W, frequency 1.7 – 3 MHz.
Ports for ellipsometer	**2**	Viewports and holders for ellipsometer integration in chambers for in-situ measurement and in load lock
QCM	**1**	Quartz crystal microbalance for in-situ measurements
Diffusion enhancer	**1**	Picoflow™ diffusion enhancer
Substrate handler	**1**	Picoloader™ manual substrate handler with a load lock
Glove box integration	**1**	2-glove glovebox integrated to the load lock
Abatement system	**1**	Picoscrubber PS-200 exhaust gas treatment system
Port for RGA	**1**	Port for residual gas analysis
Remote support	**1**	Picoline™ remote connection for faster troubleshooting and Picosun support
Power supply	**1**	400V, 50Hz-60Hz; 3 phase
Warranty	**1**	24 months warranty.
Commissioning, installation and user training	**1**	Commissioning (installation, including acceptance tests). User training for the equipment during installation, for any number of people is included in the price.

Facilities requirements, supplied by the Buyer: Electricity, leak tester with helium, chemicals, pump exhaust line, gas lines, compressed dry air (4-5.5 barg pressure), cooling water (for the plasma generator and dry pump), argon line (for plasma generator) and nitrogen line (min. 50 slm flow, 99.999 % min. purity (99.9999 % for nitrides), 1-2 barg pressure for the ALD unit and the dry pump, ventilation line.

EXAMPLE OF THE SOURCE CONFIGURATION OF THE PICOSUN™ R-200 ADVANCED ALD TOOL

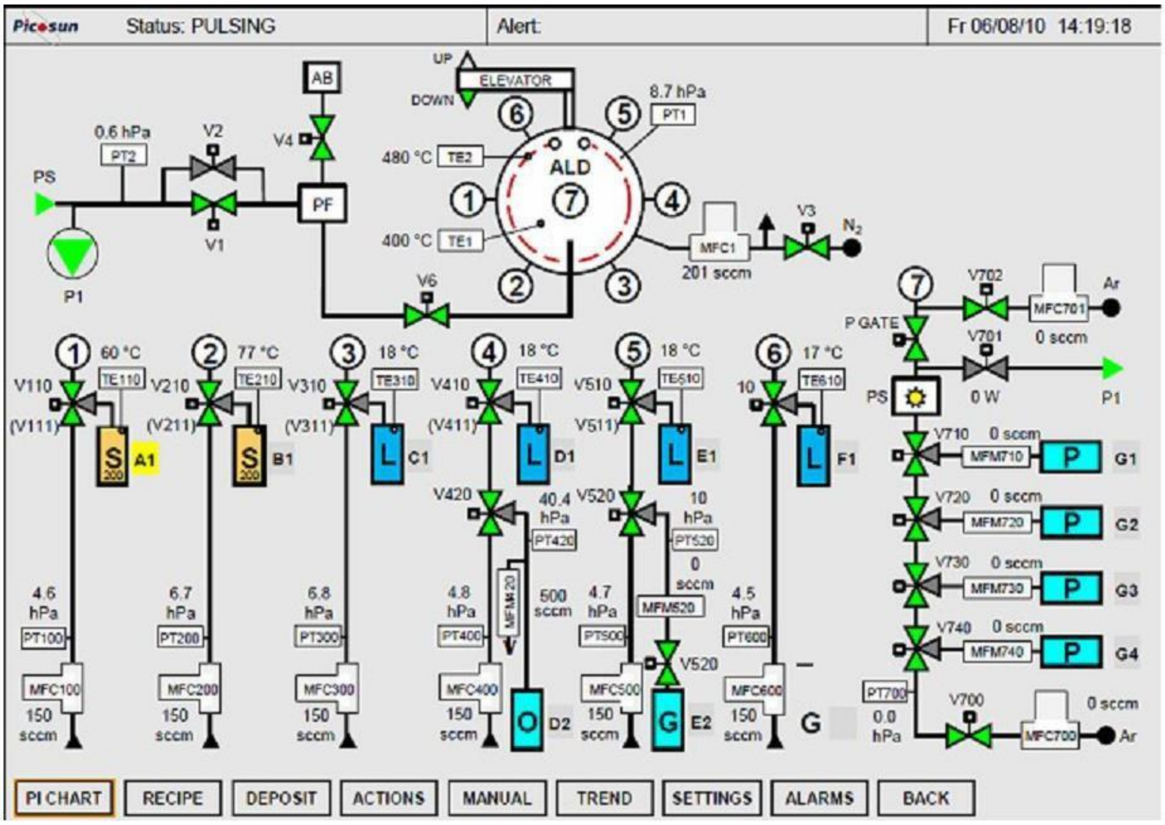

Figure 2. Example of the software and separate source line configuration of PICOSUN™ R-200 ALD reactor (image is indicative).

Picosun ALD tools are capable of making extremely uniform oxide, nitride, and metal films thanks to the symmetrical top-flow precursor distribution geometry. Even particles and through-porous samples with high aspect ratios can be coated. Our heated source systems are proven to be reliable in R&D and production, and to be able to deliver the precursor vapour at very low temperatures. Moreover, our ALD tools are compatible with chloride precursors, with the help of in-situ passivation of chambers and sources. ALD films can be easily processed as a nanolaminate during one continuous process run without changing the source containers or chamber lid parts. Even combining thermal and plasma processes in a single recipe is possible.

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SPECIFICATION OF THE QUOTED ALD REACTOR AND CONTENTS OF DELIVERY

1.1 Vacuum chamber

- AISI 304 stainless steel vacuum vessel with one (1) NW40KF, six (6) NW25CF, and six (6) NW16CF connection flanges with VITON® / metal seals
- Flange for electrical connections to reaction chamber
- Air cooled cold wall vacuum chamber

1.2 Automated flow control

- Exhaust line is equipped with a computer-controlled pneumatic valve, and the reaction chamber is evacuated and vented by the computer
- Flow of nitrogen gas to the intermediate space is adjusted with a computer-controlled mass flow controller (MFC)

1.3 Source lines

- Six separate, individual source lines are included in the thermal ALD reactor
- Separated mass flow controllers for carrier/purge nitrogen gas and six three-way pulsing valves for controlling precursor vapour near room temperature
- Each source line is connected to carrier/purge nitrogen line, the minimum recommended purity of the nitrogen gas being 99.999% or 99.9999% for nitride processes
- The source lines have metal sealed VCR fittings

1.4 Reaction chamber RC-200 deep

- Hot wall reaction chamber (within the cold wall vacuum chamber)
- Six separate, individual inlets pre-installed for precursor source conduits
- Vertical flow of precursors perpendicular to the substrate (top-flow configuration)
- Computer controlled standard deposition temperature range up to 450°C with an accuracy of ±1 °C
- The reaction chamber is made from AISI 316 stainless steel

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1.5 Loading chamber

- Loading chamber above the reaction chamber and vacuum chamber to allow integration of plasma generator and manual substrate handler

1.6 Extra sealing

- ALD reactor covers are made leak tight for extra protection during using of harmful substances (such as sulphides)

1.7 Substrate holders

1.7.1 Powder cartridge POCA-200

- Glass sinter cartridge and steel adapter plate for holding powder
- Suitable for RC-200 deep reaction chamber
- Flow-through static cartridge assembly for coating powder substrates
- Various powder cartridge sinters available for the different grain sizes of the powder

1.7.2 SH-200 substrate holder

- SH-200 substrate holder for one up to 200 mm wafer/sample
- Suitable for RC-200 reaction chamber
- The substrate holder is made from AISI 316 stainless steel

1.7.3 HS-650 heated sample stage

- SH-200 substrate holder for one up to 200 mm (about 8”) wafer heated up to 650°C
- The holder is made from AISI 316 stainless steel.

1.7.4 Through porous substrate holder

- Holder for forcing precursors to flow through the sample.

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1.7.5 Mesh basket

- Basket for holding 3D objects

1.8 Software and electronics

- 12-pack control program and control electronics upgrade suitable for the deposition of e.g. nanolaminates, doped thin films, and ternary thin films
- Human Machine Interface (HMI) PLC with a Windows touch panel PC
- PC data logging. Possibility to save log files on a USB stick or a flash card memory
- User levels
- Alarm levels for scheduled maintenance
- Integrated pulsing monitor for each inlet line
- Individually programmable purge gas flow rate for both independent source lines
- Fully programmable pulsing sequences for ternary compounds and nanolaminates
- Electronics package for handling the electrical power feeds and input/output signals related to the instrumentation of the precursor sources

1.9 Precursor sources

Notice: Both metallic precursor sources and non-metallic reactant sources are counted together as precursor sources.

Notice: Precursor sources described in this purchase offer are compatible only with the Seller's ALD Product.

1.9.1 Picosolution™ source system for high vapour pressure liquid precursors

Notice: Source chemicals are not included.

- Suitable for source chemicals having a vapour pressure of at least 10 mbar at source temperature
- One (1) complete container assembly with conduits and a pulsing valve
- Compatible with high vapour pressure (>10 mbar) liquid chemicals, such as water
- Integrated manual isolation valve
- Computer-controlled three-way pneumatic valve for pulsing
- VCR all metal sealed gas flow system
- Temperature stabilized ~5 °C below ambient temperature.

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- Precursor chemicals shall be bought separately
- Total 5 containers: AISI 316 stainless steel container of liquid precursor

1.9.2 Boosted Picohot™ 200 source system

- Suitable with source chemicals having a vapor pressure of at least 3 mbar at source temperature
- Source heating temperature range up to 200 °C
- Compatible with thermally stable metal chemicals including metal halides, metal-organic compounds and organometallic chemicals
- One complete container assembly with temperature controlled conduits, a pulsing valve and heat insulators
- Computer-controlled three-way pneumatic valve for pulsing
- Integrated software boosting
- VCR metal sealed gas flow system
- Stainless steel container certified for transport

1.9.3 Picohot™ 300 Heated source system

- Suitable with source chemicals having a vapor pressure of at least 1 mbar at source temperature
- Source heating temperature up to 300 °C
- Compatible with thermally stable metal chemicals including metal halides, metal-organic compounds and organometallic chemicals
- One complete container assembly with temperature controlled conduits, a pulsing valve and heat insulators
- Two computer-controlled three-way pneumatic valves for pulsing
- VCR metal sealed gas flow system
- Stainless precursor container certified for transport

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1.9.4 Picogases™ connection for plasma gas source lines

Notice: Source chemicals are not included.

- Connection point for an external gas cylinder
- Equipped with a mass-flow controller and tubing
- Essentially VCR metal sealed gas flow system
- Gas leak sensor and gaseous precursors are not included

1.10 Picoplasma™ plasma source

- Commercial Matching Network, plasma generator and power supply integrated in one compact system, weight 22.2 kg mounted on the loading chamber with connection to reaction chamber
- Up to 4 different gases
- Commercial RF plasma generator with adjustable 100 – 3000 W power, 1.7 – 3 MHz RF frequency
- AC Power 208 VAC (optional 400 VAC and transformer), 35 A, 3 phases, AC input current 16 A max
- Cooling water flow 5.71 lpm, T < 35 °C
- Analog (25 pin) and RS-232 (AE Bus) interfaces
- Chemraz® O-ring sealing
- Generator MTBF > 100 000 h without chemicals
- Generator compliant with the following certifications: CE 73/23/EEC & 89/336/EEC, IEC/EN 61010-1, CSA C22.2 No. 1010.1, ANSI/ISA-82.02.01, NRTL/C, SEMI S2-0302, SEMI F47, EN 55011, EN61326 and 47 CFR

1.11 Diffusion enhancer

- Picoflow™ PF-200 diffusion enhancer
- Extra stop-valve and tubing in the pump line for restricting the gas flows
- Possibility for increased precursor diffusion and reaction times without a risk of back-diffusion of the precursor chemicals into inlet lines of the reaction chamber
- Software sequence for additional process control
- Optimal for coating of porous substrates with extremely high aspect ratios

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1.12 Dry vacuum pump Hanbell PS602

- Mechanical foreline particle trap and afterburner included
- Drypump speed 500/600m3/h
- Weight 450 kg
- Requires facility nitrogen (not possible to run with bottle nitrogen)

1.13 Dry vacuum scroll pump Edwards nXds 10i

- Oil free dry vacuum pump size 11,4 m3/h
- Electricity 230V
- Weight 25,8 kg
- Size L= 432 mm x W = 265 mm x H= 303 mm
- Noise level 52 db (A)

1.14 Picoline remote support connection

- Secure connection module for remote connection
- Extra fast support and troubleshooting functionality available through Picosun support team

1.15 Ports for ellipsometer

- Modification of the vacuum chamber and reaction chamber for ellipsometer integration
- Ellipsometer windows in load lock for ex-situ observations

1.16 Picoloader™ Handyman PL-200 substrate handler

- Manual substrate handler for a single substrate with a loader chamber, a gate valve and a wafer load lock
- The reaction chamber is isolated from room atmosphere during the loading and unloading of the substrate
- Suitable for installing in R-200 reactors. Shall be configured at purchase according to the used wafer size.
- Pump connection to scroll pump

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1.17 Picoscrubber™ PS-200 exhaust gas treatment system

- Suitable for cleaning exhaust gases of a dry vacuum pump
- To be connected to the exhaust line after the vacuum pump

1.18 Glove box integration, loadlock, 2 gloves

- 2-glove glovebox
- Large main antechamber
- Gas purification system with a vacuum pump
  - Gas purification system for closed cycle circulation of glovebox
  - Removal: oxygen and moisture < 1 ppm
- Shelves (adjustable)

1.19 Quartz crystal microbalance

- QCM for in-situ observation of the deposition
- Using same port as heated chuck, so cannot be used same time (use with standard holder instead)
- Colnatec phoenix Includes:
  - Eon-LT™ PC-Based Film Thickness Monitor withTemperature Measurement Capability
  - Phoenix™ Sensor with Temperature Measurement
  - User Software
  - Cables and Power Supply
  - User Manual, Quick Start Guide

1.20 Clean room compatibility

- System is at least class 10 (Euro 4) clean room compatible

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APPENDIX II

PICOSUN ALD SYSTEM HIGHLIGHTS

1. DETAILED DESCRIPTION OF THE PICOSUN ALD REACTORS

We would like to use the opportunity to highlight some particular details of our ALD reactors. Picosun has a long experience in ALD, which will be useful for you in the future, no matter what you will decide to study next. Picosun has unparalleled experience and understanding of ALD technology. Our CTO Sven Lindfors is the designer of the first ALD reactors back in 1975. PICOSUN™ R-series ALD reactors represent the 15th generation of ALD systems for us. Dr. Tuomo Suntola, the inventor of the ALD method, is a Member of Board of Directors of Picosun. Our employees have contributed to more than 100 patents on ALD. We have several Doctors with background in ALD Chemistry ready to support you in your research. We are working in close co-operation with other universities around the world and have installed over 200 PICOSUN™ ALD reactors on four continents for both research and mass production since 2004. Please notice that we can offer PhD level process and tool support from our main headquarters and factory from Finland and locally around the world.

The key technical issues that ensure the best quality films for your applications are:

1. Hot-wall reaction chamber, mounted inside a larger, cold wall vacuum chamber. This willgive you some certain advantages:

- ✓ Avoiding temperature gradients at the reactor walls, thus more exact process conductions are possible. Especially difficult processes with very narrow process window can be performed securely.
- ✓ Additional safety against over-heating of the frame
- ✓ Protects operator personnel against injuries from heat.
- ✓ Note that our outer vacuum chamber is air cooled, and therefore do not require cooling water.

2. Truly separated independent precursor inlet lines which do not mix before the substrate and the hot-wall reaction chamber ensure excellent particle performance, fast process, conformal high-quality films and prolonged maintenance cycles.

3. Modular system with the possibility of changing of sources and source types at any later point in time quickly by the user (Figure 1). Upgrades can be made any later time. The tool can be tailored to meet your requirements for different substrate types/sizes, processes and characterization needs. The tool can also be upgraded with different loading systems. If you have any plans to upgrade your system later on, it is useful to mention it as soon as possible.

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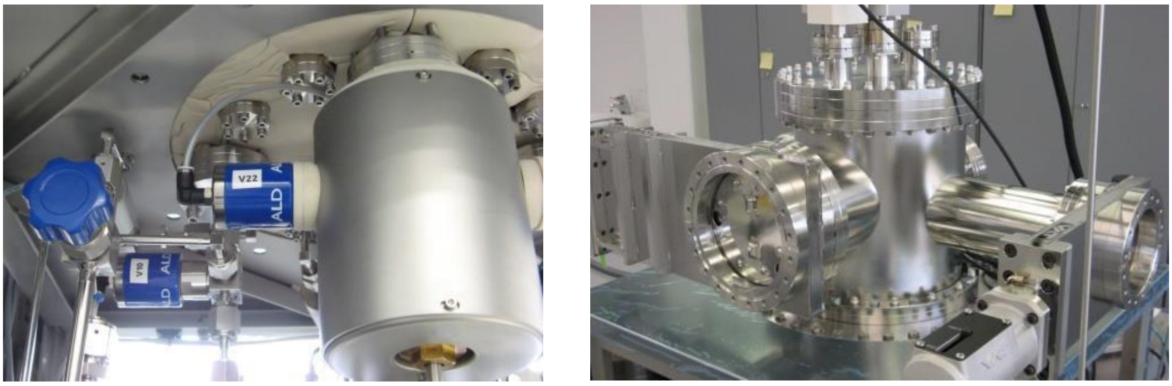

Figure 1 Your ALD reactor is a modular system, so it can be modified, upgraded or integrated to other tools later.

4. Software with automatic process data retrieval (Figure 2). Integrated pulsing monitoring by software is made available by separated source inlets and instrumentation. The software allows creation of complex process runs with multiple materials (nano-laminates), varying layer thicknesses and even process temperature and type of process (plasma/thermal) can be changed. This allows you to create sophisticated layers without need to sit by the tool all the time.

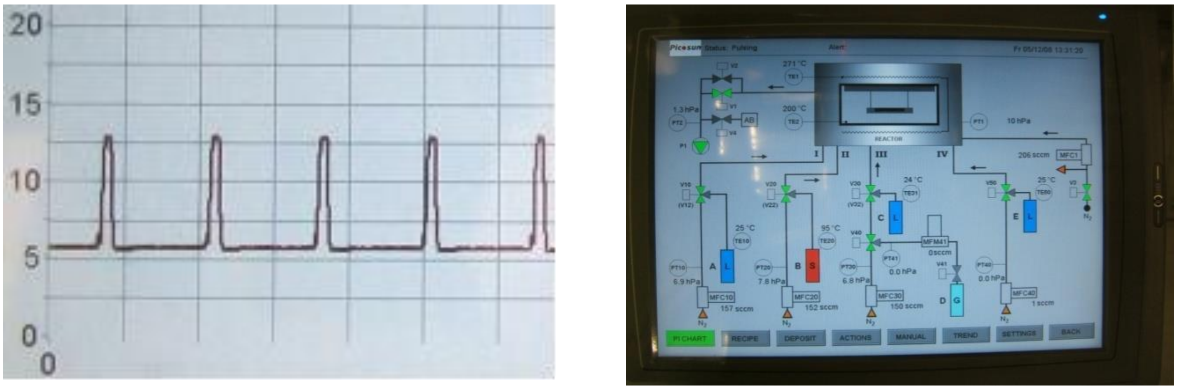

Figure 2 Your ALD reactor has automatic process data retrieval with user-friendly interface.

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2. COATING MATERIAL POSSIBILITIES

By using Picosun ALD tools it is possible to reliably manufacture films from various materials on many kinds of substrates. Some examples are summarized in the figures below. Picosun has experienced applications team that can support you with your processes. The team consists of > 10 PhD level ALD experts. We also work closely with chemical suppliers and some of them are using our tools for developing new precursor materials. For more information about the film possibilities, please be in contact with the contact persons mentioned in this quotation.

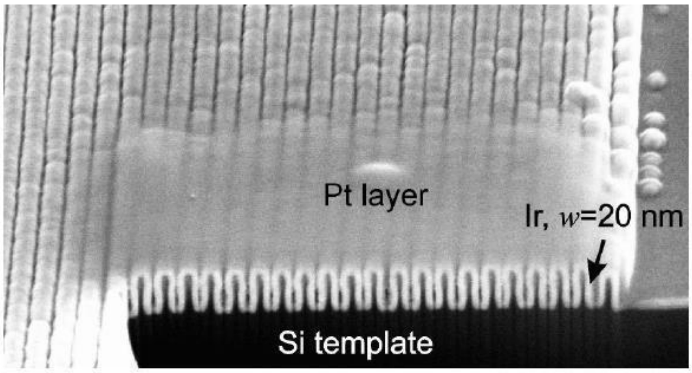

Figure 3 Metal coatings into trench structures.

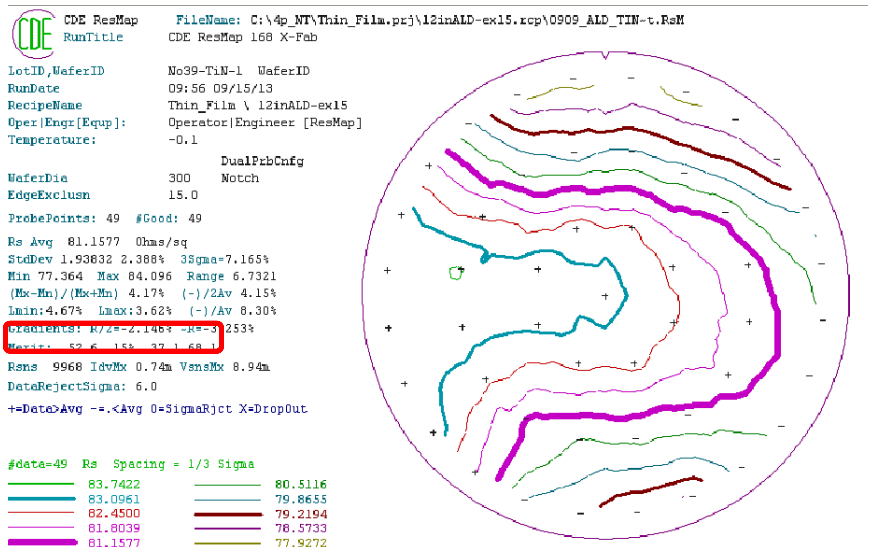

Figure 4 12" TiN wafer deposited at customer site showing uniformity of 2.4% proving the deposition of high quality TiN

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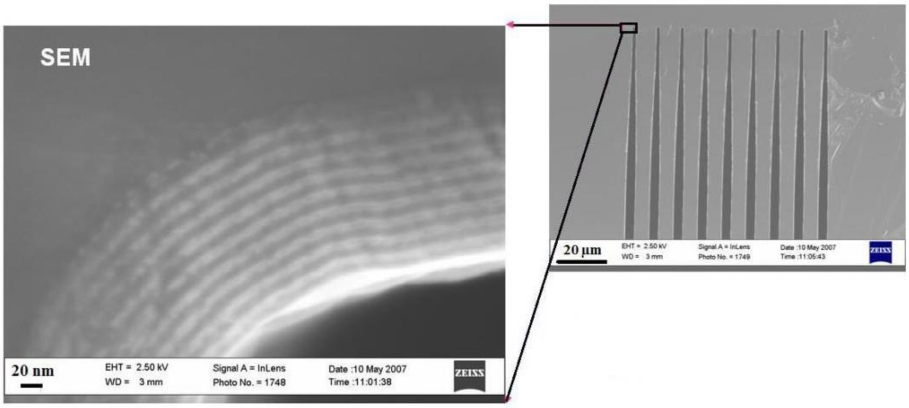

Figure 5 Multilayer structures of metal oxides even on the bottom of trenches. Coatings are done at 110 °C with standard pulsing sequence. The aspect ratio of the sample is > 25 and the conformalility of the coating is > 96 %.

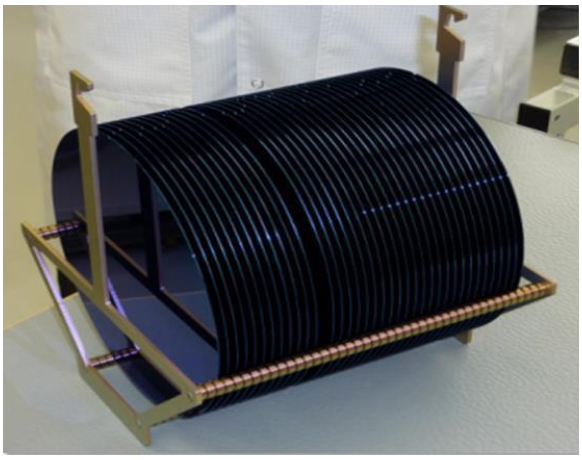

Figure 6 With Picosun ALD tools it is possible to do batch processing as well, if you need to upscale your processing through-put. Most of the processes are also possible to be transferred from single wafer R&D tool to production tool.

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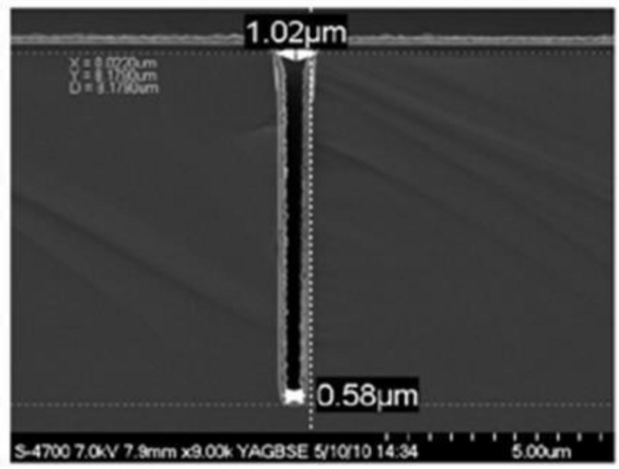

Figure 7 Ta2O5/TiN/Ru film stack with aspect ratio of ~8-13 deposited by PICOSUN™ R-200 ALD reactor in Picoplatform™ Automated Vacuum Cluster Tool (source Fraunhofer Institute, Germany).

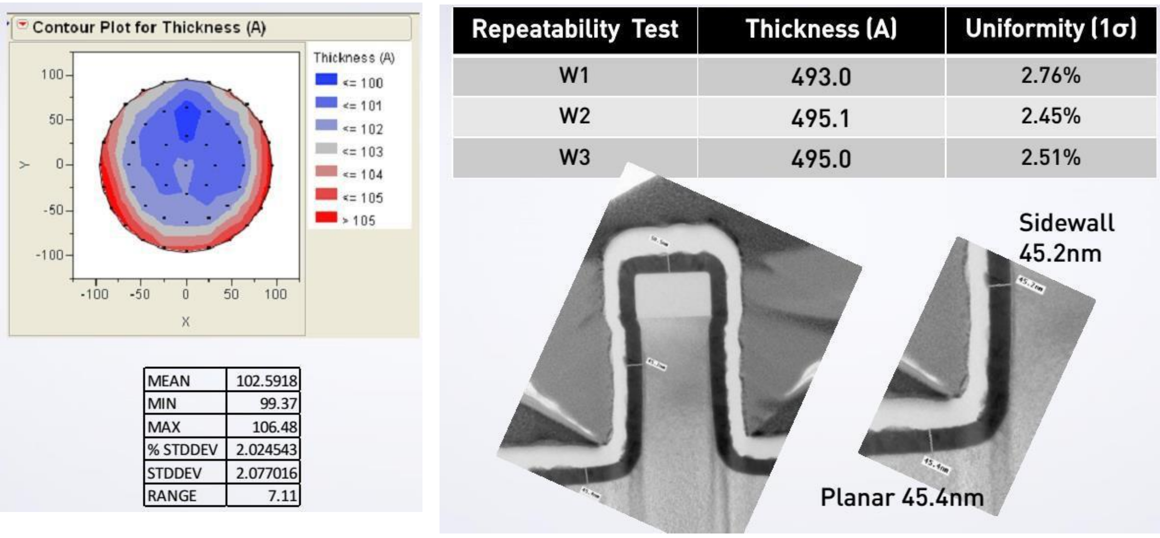

Figure 8 Deposition of HfO_2 from TEMAHf and H_2O on silicon and on 3D-structures showing excellent uniformity and reproducibility of the Picosun ALD tools.