

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.

Bank: [REDACTED]

Account No.: [REDACTED]

ID No.: 68378271

Tax ID No.: CZ68378271

(hereinafter the “Buyer”)

and

1.2 Dr Eberl MBE-Komponenten GmbH,

with seat: Josef-Beyerle-Strasse 18/1, 71263 Weil der Stadt (Germany),
represented by: Dr. Karl Eberl,
registered in district court Stuttgart (Amtsgericht Stuttgart).

Bank: [REDACTED]

Account No.: IBAN [REDACTED] / SWIFT CODE: [REDACTED]

ID No.: HRB No. 252157

Tax ID No.: DE 128 221 218

(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 is in the process of implementing a project Reg. No. CZ.02.1.01/0.0/0.0/16_013/0001405 with the title “LNSM – Laboratory of Spintronics” within the framework of the Operational Programme Research, Development and Education (OP RDE) (hereafter the “**Project**”).
- 2.3 The subject matter of this Contract is funded using grant provided to the Project, for which it is destined.
- 2.4 The Buyer wishes to acquire the subject of performance hereof in order to ensure that the Buyer will be able to prepare semiconducting and semimetallic epitaxial layers using the molecular beam epitaxy.
- 2.5 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 “**MBE Apparatus**” (hereinafter the “**Procurement Procedure**”).
- 2.6 The documentation necessary for the execution of the subject of performance hereof consist of
- 2.6.1 Technical specifications of the subject of performance hereof attached as **Annex No. 1** hereto.
- 2.6.2 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.

- 2.7 The Seller declares that it 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 the Seller from supplying the subject of this Contract to the Buyer.
- 2.8 The Seller acknowledges that the Buyer considers the Seller’s participation in the Procedure, provided that the Seller complies with all qualification requirements, as the confirmation of the fact that the Seller is 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 its qualities as the expert or its 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.



- 2.9 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.
- 2.10 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 the delivery and invoicing), is essential for the Buyer. If the Seller fails to meet contractual requirements, it may incur damage of the Buyer.
- 2.11 The Contractual 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 on the part of the Buyer 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:

the MBE Apparatus (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 Elaboration of the project documentation for the Equipment;
- 3.2.2 Formulation of conditions which must be met at the place of Buyer in order to install the Equipment;
- 3.2.3 Demonstration of the functionality of the Equipment at the place of manufacture;
- 3.2.4 Transport of the Equipment incl. all accessories specified in Annexes 1 and 2 of the Contract to the site, un-packaging and control thereof;
- 3.2.5 Installation of the Equipment including connection to installation infrastructure at the site;
- 3.2.6 Execution of the acceptance tests;
- 3.2.7 Delivery of instructions and operating and repair manuals to the Equipment in Czech or English language to the Buyer, in electronic and hardcopy (printed) versions;
- 3.2.8 Training of operators at the site (at least two-day training of 2 operators);
- 3.2.9 Free-of-charge warranty service including service inspections;



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3.2.10 Provision of 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, the submitted bid 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.

3.6 Additional terms and conditions pertaining to the delivery:

3.6.1 The Seller proceeds independently during the manufacture and delivery of the Equipment while respecting all mutually agreed conditions.

3.6.2 The Seller shall be obliged to notify the Buyer, without unnecessary detail, if any instructions issued by the Buyer in connection with the performance hereunder would be inappropriate, provided that the Seller is able to discern the inappropriateness of such instructions using all professional due care.

4. PERFORMANCE PERIOD

4.1 The Seller undertakes to manufacture, deliver, install and handover the Equipment to the Buyer within 12 months of the conclusion of this Contract in the following phases:

4.1.1 Within 3 month of the conclusion of this Contract

- the completed technical documentation to the Equipment shall be handed over for approval,
- the list of technical requirements which must be met by the Buyer prior the installation of the Equipment shall be handed over.

4.1.2 Within 11 months of the conclusion of this Contract the functionality of the Equipment shall be demonstrated at Seller's premises.

4.1.3 Within 12 months of the conclusion of this Contract the Equipment shall be delivered and with Buyer's assistance installed in the premises of the Buyer at Cukrovarnická 112/10, 162 00 Praha 6, Czech Republic, building F, room No. 95.

4.2 The Seller shall not deliver the Equipment to the place of delivery before July 1, 2018.

4.3 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. If this period exceeds 3 months, the Buyer is obligated to transfer the corresponding payment.



5. PURCHASE PRICE, INVOICING, PAYMENTS

- 5.1 The purchase price is based on the Seller's submitted bid and amounts to **930,000.00 € (in words: nine-hundred-thirty-thousand)** 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, installation and handover, and including all other costs of expenses that may arise in connection with creation of an intellectual property creation and its protection.
- 5.3 The Parties agreed that the Seller shall be entitled to invoice the Price as follows:
- 5.3.1 The first part corresponding to 40 % of the total Price in the amount of **372,000.00 €** excl. VAT after the conclusion hereof.
- 5.3.2 The second part corresponding to 50 % of the total Price in the amount of **465,000.00 €** excl. VAT after the demonstration the Equipment's functionality at the manufacturer's facilities based on a signed protocol of the successful demonstration.
- 5.3.3 The third part corresponding to 10 % of the total Price in the amount of **93,000.00 €** excl. VAT after Handover protocol in accordance with Section 12.4 will have been signed between the Parties. In case the Equipment will be handed over with defects and / or unfinished work, the Price will be invoiced after removal of these defects and / or unfinished work.
- 5.4 The invoice issued by the Seller as a tax document 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,
- 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,
- 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 "LNSM – Laboratory of Spintronics", Reg. No. CZ.02.1.01/0.0/0.0/16_013/0001405

and must comply with the double tax avoidance agreements, if applicable.

5.5 The Buyer prefers electronic invoicing, with the invoices being delivered to efaktery@fzu.cz. All issued invoices shall comply with any international treaties prohibiting double taxation, 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 its 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 its 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.

7. PLACE OF DELIVERY OF THE EQUIPMENT

7.1 The place of delivery and handover of the Equipment shall be the premises of the Buyer at Cukrovarnická 112/10, 162 00 Praha 6, Czech Republic, building F, room No. 95.

8. PROJECT DOCUMENTATION AND INSTALLATION CONDITIONS



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- 8.1 The Seller undertakes to hand over the project documentation of the Equipment (hereafter the “PD”) to the Buyer corresponding to the technical specification as defined in Annex No. 1 and 2 hereto.
- 8.2 Within elaborating the PD the Seller shall be bound by the requirements formulated by the Buyer in Annex No. 1 hereto; the Buyer shall have the right to inspect / review the PD.
- 8.3 The Parties shall execute a handover protocol for the PD. The PD handover does not prejudice the continuing Seller’s liability for professional execution of the PD including the responsibility for optimal solution with regard to the purpose of the Equipment.
- 8.4 The Seller undertakes to hand over to the Buyer a list of conditions that must be met in order to properly install the Equipment including all required parameters of electrical connections, gas, air-conditioning, Equipment components’ location, room temperature etc. (hereinafter the “List”).
- 8.5 The List must comply with the PD and must be reasonable in terms of the intended purpose and use of the Equipment.

9. PREPAREDNESS OF THE PLACE OF DELIVERY

- 9.1 The Seller shall notify the Buyer in writing of the exact date of installation of the Equipment at least 14 days prior to such date, ensuring that the deadline for the performance hereunder is maintained.
- 9.2 The Buyer shall be obliged to allow the Seller, once the deadline set forth in Section 9.1 hereof expires, to install the Equipment at the place of performance.

10. COOPERATION OF THE PARTIES

- 10.1 The Seller undertakes to notify the Buyer of any obstacles on its part, which may negatively influence proper and timely delivery of the Equipment.
- 10.2 The Seller shall be obliged to notify the Buyer of any inappropriate method or instruction as may be issued by the Buyer in connection with requirements for the elaboration of the PD. The Seller shall manufacture the Equipment according to an inappropriate method or instruction as may be issued by the Buyer only if the Buyer continues to insist on such inappropriate method or instruction in writing, regardless of the prior notification in writing from the Seller to the Buyer to that effect.
- 10.3 The Buyer shall be entitled to receive information on the progress with the Equipment manufacture.

11. DEMONSTRATION

- 11.1 The Seller shall invite the Buyer to participate in the Equipment demonstration at least 14 days in advance.
- 11.2 The demonstration shall take place at Seller’s premises.
- 11.3 The Parties shall execute an acceptance protocol in case the preliminary testing of the Equipment confirms that the Equipment is functional and complies to technical specifications according to



Annexes No. 1 and No. 2 hereof.

12. DELIVERY, INSTALLATION, HANDOVER AND ACCEPTANCE

- 12.1 The Seller shall transport the Equipment at its own cost to the place of handover. If the shipment is intact, the Buyer shall issue delivery note for the Seller.
- 12.2 The Seller shall perform and document the installation of the Equipment and launch experimental test in order to verify whether the Equipment is functional and meets the technical requirements of Annexes No. 1 and 2 hereof.
- 12.3 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.
- 12.4 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:
- 12.4.1 Information about the Seller, the Buyer and any subcontractors,
 - 12.4.2 Description of the Equipment including description of all components and serial numbers,
 - 12.4.3 Description of executed acceptance tests: type of test, duration, achieved parameters,
 - 12.4.4 List of technical documentation including the manuals,
 - 12.4.5 Confirmation on training, its participants and extent,
 - 12.4.6 Eventually reservation of the Buyer regarding minor defects and unfinished work including the manner and deadline for their removal,
 - 12.4.7 Date of signature of the Equipment Handover Protocol.
- 12.5 Handover of the Equipment does not release the Seller from liability for damage caused by product defects.
- 12.6 The Buyer shall not be obliged to accept the 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 its refusal to accept the Equipment.
- 12.7 Should the Buyer not exercise its 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 and acceptance of the Equipment.



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13. TECHNICAL ASSISTANCE – CONSULTATIONS

13.1 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.

14. REPRESENTATIVES, NOTICES:

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

e-mail: [REDACTED] and [REDACTED]
tel. [REDACTED] and [REDACTED]

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

[REDACTED]
e-mail: [REDACTED]
tel. [REDACTED]

14.3 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 eberl@mbe-komponenten.de in case of the Seller.

14.4 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 14.1 and 14.2.

15. TERMINATION

15.1 The Buyer is entitled to withdraw from the Contract without any sanction on the part of the Seller if the Seller is in delay with the handover longer than 10 weeks after the date pursuant to Section 4.1 hereof. In case the Buyer causes any delay, this clause is void.

15.2 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 invoice due to defect on the delivered Equipment or due to breach of the Contract by the Seller.

15.3 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.



16. INSURANCE

- 16.1 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.
- 16.2 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 its part under this Contract.

17. WARRANTY TERMS

- 17.1 The Seller shall provide warranty for the quality of the Equipment for a period of **24** months. The warranty term shall commence on the day following the date of signing of the Handover Protocol pursuant to Section 12.4 hereof. The warranty does not cover consumable things.
- 17.2 Should the Buyer discover a defect, he shall notify the Seller to rectify such defect using the email address service@mbe-komponenten.de. The Seller shall be obliged to review any warranty claim within 7 business days from receipt and to propose solution, unless agreed otherwise by the Parties.
- 17.3 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.
- 17.4 During the warranty period any and all costs associated with defect rectification / repair including transport and travel expenses shall be always borne by the Seller.
- 17.5 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.
- 17.6 The repaired portion of the Equipment shall be subject to a 6-month warranty for the repaired components.
- 17.7 The Seller declares that it shall ensure post-warranty [out-of-warranty] service for the period of 5 years after the warranty term expires; the service terms shall be identical with provisions of Sections 17.2 and 17.3.
- 17.8 The Seller undertakes to provide the Buyer with updates of the software controlling the Equipment for the entire term of warranty service.

18. CONTRACTUAL PENALTIES

- 18.1 The Buyer shall be entitled to claim a contractual penalty against the Seller in the amount of 0,01 % from the Price for each commenced day of delay with the delivery pursuant to Section 4.1 hereof with a possible grace period of 3 weeks.



18.2 All contractual penalties shall be payable within 30 days from the date claimed.

19. DISPUTES

19.1 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.

20. ACCEPTANCE OF THE PROJECT RULES

20.1 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.

21. FINAL PROVISIONS

21.1 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.

21.2 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.

21.3 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.

21.4 This Contract is drawn up in three (3) counterparts, each of which is deemed to be the original. The Seller shall receive two (2) counterparts, the Buyer shall receive one (1) counterpart.

21.5 The Parties expressly agree that the Contract as a whole, including all attachments and data on the Parties, subject 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



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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.

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

21.7 This Contract becomes valid and effective as of the day of its publication in the Contract Register.

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

Annex No. 1: Technical specification on the subject of performance (the Seller shall fill in all blue fields in columns “Complies YES/NO” and “N”)

Annex No. 2: Technical description of the device as presented in Seller’s bid (the Seller shall present in its bid)

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

In Prague on 16. 11. 2017

In Weil der Stadt on November 6th 2017

For the Buyer:

For the Seller:

RNDr. Michael Prouza, Ph.D.
Director

Dr. Karl Eberl
Chief Executive Officer



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Annex No. 1

Technical specification on the subject of performance as defined by the Buyer

Seller shall fill in all the blue fields in the following table of Technical specifications. Blue fields in column “Complies YES/NO” shall be filled either with YES, or NO. Blue fields in column “N” shall be filled by value of parameter corresponding to column “Equipment surpassing the minimum specification”; values of the parameter are expected to lie within the limits shown in column “Expected range of parameter”. Wherever appropriate, the Seller may add explanatory remarks below the Table referring to the Item reference number from the last column.

Minimum specification of the Equipment	Complies YES/NO	Equipment surpassing the minimum specification	Expected range of parameter (N)	N	Formula for weighted partial score (points)	Item ref.
General requirements						
2 growth chambers	YES					1
1 buffer chamber	YES					2
1 dedicated wafer outgassing chamber	YES					3
1 load-lock chamber	YES					4
2-inch sample holder system	YES					5
Growth chamber A						
base pressure less than 8×10^{-11} Torr	YES					6
LN2 cooling shroud	YES					7
10 cell ports, at least 6 of them with DN63CF flange	YES					8
		number (N) of ports with DN63CF flange	$6 \leq N \leq 10$	10	$(N-6) \times 100$	9
at least 4 independent shutter ports	YES					10
		number (N) of independent shutter ports	$4 \leq N \leq 10$	10	$(N-4) \times 100$	11
cryo-pump at least 1500 l/s	YES					12



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		pumping speed (N, in l/s)	$N \geq 1500$	1500	$(N-1500)/6$, max 250	13
ion-getter pump at least 300 l/s	YES					14
substrate manipulator with heater for at least 1000°C	YES					15
RHEED gun and screen	YES					16
beam-flux monitor	YES					17
		quadrupole mass spectrometer	$N = 0 / 1$	0	$N*150$	18
motorized valved cracker source for As with at least 300 cc	YES					19
dual filament cell suitable for Ga	YES					20
cold-lip cell suitable for Al	YES					21
		dual filament cell suitable for In	$N = 0 / 1$	1	$N*400$	22
		Si-filament doping source	$N = 0 / 1$	1	$N*400$	23
		C-filament doping source	$N = 0 / 1$	1	$N*400$	24
at least 4 independent cell shutters mounted	YES					25
		number of mounted shutters	$4 \leq N \leq 10$	6	$(N-4)*80$	26
2 optical ports dedicated for band-edge spectrometer	YES					27
		2 heated windows	$N = 0 / 1$	0	$N*160$	28
Growth chamber B						
base pressure less than 8×10^{-11} Torr	YES					29
LN2 cooling shroud	YES					30
10 cell ports, at least 6 of them with	YES					31



DN63CF flange						
		number of ports with DN63CF flange	$6 \leq N \leq 10$	10	$(N-6)*100$	32
at least 6 independent shutter ports	YES					33
		number of independent shutter ports	$6 \leq N \leq 10$	10	$(N-6)*100$	34
cryo-pump at least 1500 l/s	YES					35
ion-getter pump at least 300 l/s	YES					36
substrate manipulator with heater for 1200°C	YES					37
installation of RHEED gun supplied by the buyer	YES					38
beam-flux monitor	YES					39
implementation of quadrupole mass spectrometer supplied by the buyer	YES					40
dual filament cell suitable for Ga	YES					41
dual filament cell suitable for Cu	YES					42
cold-lip cell suitable for Al	YES					43
GaP decomposition cell with integrated shutter	YES					44
single filament cell suitable for Mn	YES					45
high-temperature cell suitable for Fe	YES					46
Si-filament doping source with integrated shutter	YES					47
		high-temperature cell suitable for Pt	$N = 1 / 0$	1	$N*400$	48



		dual filament cell(s) for medium temperatures	$0 \leq N \leq 2$	1	N*400	49
		source retraction mechanism(s) (N=0/1)	$0 \leq N \leq 2$	0	N*400	50
at least 6 independent cell shutters mounted	YES					51
		number (N) of mounted shutters	$6 \leq N \leq 10$	9	(N-6)*80	52
2 optical ports dedicated for band-edge spectrometer	YES					53
		2 heated windows	N = 0 / 1	0	N*160	54
Buffer chamber with wafer transfer mechanism connecting the growth chambers, outgassing chamber and load-lock chamber						
base pressure less than 2×10^{-10} Torr	YES					55
wafer storage magazine	YES					56
IGP-based pumping system	YES					57
Dedicated wafer outgassing chamber						
heated station	YES					58
implementation of IGP-based pumping system supplied by the buyer	YES					59
Load-lock chamber						
primary bake-out heater	YES					60
implementation of TMP-based pumping system supplied by the buyer	YES					61
Accessories						
at least 5 wafer	YES					62



holders for 2-inch wafers						



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Operational Programme Research,
Development and Education



Annex No. 2

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

It includes the following separate documents:

Quotation Reference No. 2178941/MB, from date August 25th 2017

Attachment-A to Quotation (technical description and drawings)

Attachment-B to Quotation (Training plan and acceptance criteria)



EUROPEAN UNION
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Operational Programme Research,
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QUOTATION

NAME OF THE PUBLIC CONTRACT:
"MBE Apparatus"

Date	25.08.2017 Page 1/16
Reference No.	2178941 / MB
Your VAT	CZ68378271
Our VAT	DE128221218
Our sign	Eberl -218

Pos	Qty.	Description	Price	Total
		Dual MBE System with Linear Transfer Tunnel, Heated Station and Load-Lock Chamber		
		1. MBE Chamber I		
		-		
(1)	1	1.1 OCTOPLUS 400	██████████	██████████ EUR
	1 pc.	Cylindrical deposition chamber, 450mm ID. It has all essential features for high quality MBE growth. The deposition chamber is made from non-magnetic stainless steel 10 source flanges DN 63 CF, radially arranged DN 63 CF flange on bottom 8 to 10 separate flanges DN 63 CF for linear shutters (exact number is fixed during design approval, it depends on additional ports e.g. for ellipsometry etc.) DN100 CF for wafer transfer pump ports as needed for the pump system used Flanges for RHEED, BFM, Pyrometer, mass-analyser. 2 optical ports dedicated for band-edge spectrometer. and view ports for substrate transfer and source insight. Pair of flanges for viewports targetet to substrate for		
			Carried forward	██████████ EUR

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Pos	Qty.	Description	Price	Total
		Brought forward1		████████ EUR
	1 pc.	optical in-situ measurement Top-flange with integrated LN2 cooling shroud and flanges for view ports and substrate manipulator. Large volume LN2 cooling with effusion cells within the LN2 shroud. The cooling shroud is equipped with Vacuum-Barrier adapters		
	1 pc.	System frame, bake-out equipment for uniform bakeout up to 200°C, pre-vacuum channel to load-lock for initial pump down, Water cooling panel with individual flux control. Cooling water lines Blind flanges for unused flanges, nuts bolts and gaskets. Viewports and shutters for transfer and optical ports		
	1 pc.	All effusion cells and other sources are separated by cell dividers made from molybdenum to avoid coverage of and crosstalk between the various effusion cell		
	1 pc.	Manual Transfer gate valve DN100 CF (VAT series 10) between MBE and transfer chamber		
	-			
(2)	1	1.2 PUMPING SYSTEM	████████	████████ EUR
	1 pc.	Cryopump 1500l/s, Flange 200 CF CT8 from Brooks, "low noise" version with 3phase motor UHV-version with over-pressure protection Si-diode as Temperature indikator at 10K-stage incl Compressor, High Voltage Helium Flexline Assembly, 8 meters Cable Assembly, Compressor to Cryopump		
	1 pc.	Pneumatic UHV valve (VAT Series 10) 200, viton for cryo-pump, with position indicator.		
	1 pc.	Ion getter pump (nominal pumping speed 300 l/s) from Gamma Vacuum,		
	1 pc.	Controller channel for IGP including cable set, bake-able		
	1 pc.	All metal valve DN 16 CF for cryo-pump regeneration		
	1 pc.	Pump-Valve emergency closing function. with temperature indicator for the cryo-pump and with emergency cloasing function at power shut-down or at temperature increase above 30K (temperature adjustable)		

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Pos	Qty.	Description	Price	Total
		Brought forward2		████████ EUR
(3)	1	1.3 MANIPULATOR	████████	████████ EUR
	1 pc.	Substrate manipulator for 2" wafer with W heater mounting flange DN150CF (O.D. 8") 2" wafer or substrates < 50mm Mo wafer holder 25mm vertical stroke for substrate transfer water cooled ceramic bearings and magnetically coupled feedthrough for continuous rotation (0-30 RPM) W-wire heater typical max. temperatures up to 1200°C on Si substrate thermocouple type C maximum power 450W/14A		
	1 pc.	Integrated main shutter Rotary feedthrough and Ta-shutter plate		
	1 pc.	DC-Power Supply for substrate heater control 0-5V, manual current limit LED display for voltage and current		
	1 pc.	Pid Controller channel with individual temperature display		
	1 pc.	Manipulator Control Unit includes mounting parts for manipulator, motor and control electronic for continuous rotation 0-30 RPM		
	1 pc.	RSM 90-CCW-1.0 Soft-acting Rotary Shutter Module opening angle 90°, standard CCW rotation, shutter speed 1.0s per action, 8m cable Input voltage 24 V DC Our Part No. 650-012-130-090		
	1 pc.	Power and TC cables		
	5 pc.	Moly wafer adapters for 2inch wafers, or 1/4 wafer. Substrate size to be decided after ordering		
		-		
(4)	1	1.4 IN-SITU CONTROL EQUIPMENT	████████	████████ EUR
	1 pc.	RHEED gun and controller from Staib Instruments, 15keV, including cables, RHEED screen on led glas, view port and viewport shutter		
	1	Implementation of Quadrupol Mass Analyser, in case an adequate QMA is provided by customer		
	1 pc.	Beam Flux Monitor including 150mm z-shift		
		Carried forward		████████ EUR

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Pos	Qty.	Description	Price	Total
		Brought forward3		██████████ EUR
		mounting flange DN40CF (O.D. 2.75") in vacuum diameter O.D. 36,5mm		
	1 pc.	BA-iridium twin filament ion gauge for pressure measurement, high sensitivity $p < 3 \times 10^{-11}$ mbar including controller		
	1 pc.	Cold-cathode pressure gauge atm to 10^{-3} mbar for pre-vacuum line		
		-		
		MBE SOURCES		
(5)	1	1.6 EFFUSION CELLS for Ga, In, Al	██████████	██████████ EUR
	2 pc.	Effusion Cell WEZ (for Ga and In) mounting flange DN40CF 35ccm PBN crucible Dual Ta-wire filament Type C WRe 5/26% thermocouple bakeable up to 300 °C maximum temperature 1400 °C (outgassing 1500°C) electrical parameter: 400W/11A dimensions under UHV: O.D. 37mm, length 287 mm		
	1 pc.	Liquide Ga collection tray mounted in shutter flange		
	1 pc.	Effusion Cell WEZ (for Al) mounting flange DN40CF 35ccm PBN crucible Cold lip Ta-wire filament Type C WRe 5/26% thermocouple bakeable up to 300 °C maximum temperature 1400 °C (outgassing 1500°C) electrical parameter: 400W/11A dimensions under UHV: O.D. 37mm, length 287 mm		
	5 pc	Implementation of Delta Elektronika power supplies ES 030-10, and Eurotherm 2408 PID controllers provided by customer		
	5 pc.	Cables for power and TC		
	3 pc.	Linear Soft Acting Shutter Module magnetically coupled feedthrough mounting flange DN40CF (O.D. 2.75") 100mm maximum stroke shutter speed 0.2s per action Ta shutter plate and Mo shutter rod		
		Carried forward		██████████ EUR

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Pos	Qty.	Description	Price	Total
		Brought forward4		████████ EUR
(6)	1	-		
	1 pc.	1.7 VALVED CRACKER SOURCE Valved As-Cracker Source VACS DN100CF (O.D. 6") valve flange for 300cc As reservoir cell with integrated water cooling t max=500°C /600W/9A cracker for As-cracking t max= 1200°C /300W/7A	████████	████████ EUR
	1 pc.	VADP 100-63-K-LxxxD57-ID41 Valve Adaptor Flange for valved sources valve flange DN100 CF (O.D. 6") water cooled mounting flange DN63 CF (O.D. 4.5") XL=90mm, I.D. 41mm Injector/Cracker cooling length 150-400mm Our Part No. 156-002-110-000		
	1 pc.	MVCU-230V Motorized Valve Control Unit Use with valved sources VACS and VGCS includes servo motor and mounting kit includes 6m cable set for connection of MVCU to motor 3HE / 19" rack / manual and remote control (0-10V analog in) automatic zero calibration step power input 230V AC / 300W Our Part No. 650-033-000-230		
	2 pc	Implementation of Delta Elektronika power supplies ES 030-10, and Eurotherm 2408 PID controllers provided by customer		
	2 set	Cables for power and TC, bakeable		
(7)	1	1.7 DOPING CELLS for Si and C	████████	████████ EUR
	1 pc.	Silicon Doping Source - SUSI-D2 40-LxxxD36 mounting flange DN40CF (O.D. 2.75") full Ta construction without hot ceramic parts source material: high purity As doped silicon stripe two independent silicon filaments self sensing operation mode possible fast ramping to stable value in about 10s electrical data per filament: 150W/ max. 30A 75W/22A 1E19/cm ³ @ 1µm/h GaAs		
		Carried forward		████████ EUR

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Pos	Qty.	Description	Price	Total
		Brought forward5		██████████ EUR
	1 pc.	300°C bakeable Carbon Doping Source SUKO-D Base flange DN 40CF (O.D. 2.75-Inch), Source Material: PGR (Pyrolytic Graphite) WRe 5/26% Thermocouple Graphite Filament is totally shielded with PGR-parts water cooled current fedthrough electrical data: 500W/ max. 65A 300°C bakeable Dimensions under UHV: O.D. 36mm Length of Cell: 250-400mm		
	2 pc.	DC-Power Supply with manual current limit, LED display for voltage and current Cable set for connecting controller and power supply Input wide range 90-265V AC		
	2 pc.	Pid Controller channel, with individual temperature display		
	2 pc.	Cable set for power and TC, bakeable		
		-		
	3 pc.	Linear Soft Acting Shutter Module magnetically coupled feedthrough mounting flange DN40CF (O.D. 2.75") 100mm maximum stroke shutter speed 0.2s per action Ta shutter plate and Mo shutter rod		
		Remark: 1 additional linear shutter is included In total there are 6 linear shutters mounted in MBE chamber I - 2. MBE CHAMBER II -		
(8)	1 pc.	2.1 OCTOPLUS 400	██████████	██████████ EUR
	1 pc.	Cylindrical deposition chamber, 450mm ID. It has all essential features for high quality MBE growth. The deposition chamber is made from non-magnetic stainless steel 10 source flanges DN 63 CF, radially arranged DN 63 CF flange on bottom		

Carried forward ██████████ EUR

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Pos	Qty.	Description	Price	Total
		Brought forward6		██████████ EUR
		8 to 10 separate flanges DN 63 CF for linear shutters (exact number is fixed during design approval, it depends on additional ports e.g. for ellipsometry etc.) DN100 CF for wafer transfer pump ports as needed for the pump system used Flanges for RHEED, BFM, Pyrometer, mass-analyser. 2 optical ports dedicated for band-edge spectrometer. and view ports for substrate transfer and source insight. Pair of flanges for viewports targetet to substrate for optical in-situ measurement		
	1 pc.	Top-flange with integrated N2lq cooling shroud and flanges for view ports and substrate manipulator. The cooling shroud is equiped with Vacuum-Barrier adapters Short version, substrate surrounded by LN2 cooling, sources with separate water cooling.		
	1 pc.	System frame, bakeout cover, fan heaters, blind flanges, screws, gaskets view ports and view port shutters etc.		
	1 set	All effusion cells and other sources are separated by cell dividers made from molybdenum to avoid coverage of and crosstalk between the various effusion cell		
	1 pc.	Manual gate valve DN100 CF (VAT series 10) between MBE and transfer chamber, -		
(9)	1	2.2 PUMPING SYSTEM	██████████	██████████ EUR
	1 pc.	Cryopump 1500l/s, Flange 200 CF CT8 from Brooks, "low noice" version with 3phase motor UHV-version with over-pressure protection Si-diode as Temperature indikator at 10K-stage incl Compressor, High Voltage Helium Flexline Assembly, 8 meters Cable Assembly, Compressor to Cryopump		
	1 pc.	Pneumatic UHV valve (VAT) 200, viton, series 10, with position indicator, for cryo-pump		
	1 pc.	Pump-valve emergency closing function. with temperature indicator for the cryo-pump and with emergency cloasing function		

Carried forward ██████████ EUR

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Pos	Qty.	Description	Price	Total
		Brought forward7		████████ EUR
		at power shut-down or at temperature increase above 30K (temperature adjustable)		
	1 pc.	Ion getter pump (nominal pumping speed 300 l/s) from Gamma Vacuum,		
	1 pc.	Controller channel for Ion getter pump including bakeable cables		
	1 pc.	All metal valve for cryo-pump regeneration		
		-		
(10)	1	2.3 SUBSTRATE MANIPULATOR	████████	████████ EUR
	1 pc.	Substrate manipulator for 2" wafer with W heater mounting flange DN150CF (O.D. 8") 2" wafer or substrates < 50mm Mo wafer holder 25mm vertical stroke for substrate transfer water cooled ceramic bearings and magnetically coupled feedthrough for continuous rotation (0-30 RPM) W-wire heater max. substrate temperatures up to 1200°C thermocouple type C maximum power 450W/14A		
	1 pc.	DC-Power Supply control 0-5V, manual current limit LED display for voltage and current		
	1 pc.	PID control channel with individual temperature display		
	1 pc.	Cables for power and TC		
	1 pc.	Manipulator Control Unit includes mounting parts for manipulator, motor and control electronic for continuous rotation 0-30 RPM		
	1 pc.	Integrated manual rotary main shutter with Ta plate		
	1 pc.	RSM 90-CCW-1.0 Soft-acting Rotary Shutter Module opening angle 90°, standard CCW rotation, shutter speed 1.0s per action, 8m cable Input voltage 24 V DC		
	5 pc.	Moly wafer adapters for 2inch wafers, or 1/4 wafer. Substrate size to be decided after ordering		
		-		
(11)	1	2.4 IN-SITU CONTROL EQUIPMENT	████████	████████ EUR
	1	Implementation effort for RHEED system with screen and		
		Carried forward		████████ EUR

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Pos	Qty.	Description	Price	Total
		Brought forward8		██████████ EUR
		viewport, and shutter. The new RHEED system is provided by customer		
	1	Implementation of Quadrupol Mass Analyser. The new QMA is provided by customer		
	1 pc.	Beam Flux Monitor (BFM) including 200mm z-shift mounting flange DN40CF (O.D. 2.75") in vaccum diameter O.D. 36,5mm Including controller channel and bake-able cables Remark: The customer my exchange the BFM against a quartz microbalance during the design approval after ordering without additional cost.		
	1 pc.	BA-iridium twin filament ion gauge for pressure measurement, high sensitivity $p < 3 \times 10^{-11}$ mbar including controler		
	1 pc.	Cold-cathode pressure gauge atm to 10^{-3} mbar for pre-vacuum line		
		-		
		MBE SOURCES		
		-		
(12)	1	2.5 EFFUSION CELLS	██████████	██████████ EUR
	2 pc.	Effusion Cell WEZ (for Ga and Cu) mounting flange DN40CF 35ccm PBN crucible Dual Ta-wire filament Type C WRe 5/26% thermocouple bakeable up to 300 °C maximum temperature 1400 °C (outgassing 1500°C) electrical parameter: 400W/11A dimensions under UHV: O.D. 37mm, length 287 mm		
	1 pc.	Liquide Ga collection tray mounted in shutter flange		
	1 pc.	Effusion Cell WEZ (for Al) mounting flange DN40CF 35ccm PBN crucible Cold lip Ta-wire filament Type C WRe 5/26% thermocouple bakeable up to 300 °C maximum temperature 1400 °C (outgassing 1500°C) electrical parameter: 400W/11A dimensions under UHV: O.D. 37mm, length 287 mm		
		Carried forward		██████████ EUR

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Pos	Qty.	Description	Price	Total
		Brought forward9		████████ EUR
	1 pc.	Effusion Cell WEZ (for Mn) mounting flange DN40CF 35ccm PBN crucible Standard Ta-wire filament Type C WRe 5/26% thermocouple bakeable up to 300 °C maximum temperature 1400 °C (outgassing 1500°C) electrical parameter: 400W/11A dimensions under UHV: O.D. 37mm, length 287 mm		
	6 pc.	DC-Power Supply manual current limit, LED display for voltage and current Cable set for connecting controller and power supply Input wide range 90-265V AC		
	6 pc.	Pid Controller channel, with individual temperature display		
	6 pc.	Cable set for power and TC		
	4 pc.	Linear Soft Acting Shutter Module magnetically coupled feedthrough mounting flange DN40CF (O.D. 2.75") 100mm maximum stroke shutter speed 0.2s per action Ta shutter plate and Mo shutter rod -		
(13)	1 pc.	2.6 GaP DECOMPOSITION SOURCE	████████	████████ EUR
	1 pc.	GaP Decomposition Source DECO mounting flange DN63CF Ta-wire heater 35ccm PBN crucible and PBN CAP-System for decomposition of GaP - estimated working temperatures for doping in Si MBE 600°C-800°C growth in III-V MBE 800°C-1000°C WRe 5/26% Thermocouple bakeable up to 300°C Maximum temperature: 1400°C, maximum outgassing temperature: 1500°C electrical parameter: 450W/10A for maximum temperature, <180W/7A at 1000°C		
	1 pc.	Integrated manual rotary shutter O.D.<40mm with couple Ta-plate design. Remark:		

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Pos	Qty.	Description	Price	Total
		Brought forward10		████████ EUR
		An integrated rotary shutter is used for this source for better on/off ratio		
	1 pc.	DC-Power Supply manual current limit, LED display for voltage and current		
	1 pc.	Pid Controller channel, with individual temperature display		
	1 pc.	Cable set for power and TC		
	1 pc.	Soft-acting Rotary Shutter Module opening angle 90°, standard CCW rotation, shutter speed 0.2s per action Input voltage 240 V AC		
	-			
(14)	1	2,7 DOPING SOURCES	████████	████████ EUR
	1 pc.	Silicon Sublimation Source - SUSI 40 Base flange DN 40CF (O.D. 2.75-Inch), Source Material: High purity As-doped Silicon WRe 5/26% Thermocouple Silicon Filament is totally shielded with silicon parts electrical data: 300W/ max. 55A 300°C bakeable Dimensions under UHV: O.D. 36mm Length of Cell: 250-450mm Remark: it allows Si doping and thin Si layer deposition		
	1 pc.	DC-Power Supply manual current limit, LED display for voltage and current Cable set for connecting controller and power supply Input wide range 90-265V AC		
	1 pc.	Pid Controller channel, with individual temperature display		
	1 pc.	Set of cables for power and TC, bakeable		
	1 pc.	Linear Soft Acting Shutter Module magnetically coupled feedthrough mounting flange DN40CF (O.D. 2.75") 100mm maximum stroke shutter speed 0.2s per action Ta shutter plate and Mo shutter rod		
	-			
(15)	2	2.8 HIGH TEMPERATURE SOURCE for Fe and Pt	████████	████████ EUR
	2 pc.	High Temperature Effusion Cell w/o Cru mounting flange DN63CF (O.D. 4.5")		
		Carried forward		████████ EUR

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Pos	Qty.	Description	Price	Total
		Brought forward11		██████████ EUR
	2 pc.	free-standing W-heating filament - cell price without crucible - Type C WRe 5%/26% thermocouple maximum temperature 1700°C / 1900°C (depends on crucible and evaporation material) bakeable up to 300°C max. electrical data : 1050W / 15A (1900 °C) 500W/ 12A (1700 °C)		
	2 pc.	10cc crucible for high temp. Cell 1x Al2O3 for Fe, 1x PG for Pt (low evaporation rate) or other depending on material to evaporate to be discussed and decided after ordering		
	2 pc.	DC-Power Supply manual current limit, LED display for voltage and current Cable set for connecting controller and power supply Input wide range 90-265V AC		
	2 pc.	Pid Controller channel, with individual temperature display		
	2 pc.	Cable set for power and TC, bake-able		
	2 pc.	Linear Soft Acting Shutter Module magnetically coupled feedthrough mounting flange DN40CF (O.D. 2.75") 100mm maximum stroke shutter speed 0.2s per action Ta shutter plate and Mo shutter rod		
	-	-		
(16)	1 pc.	Dual-Filament Effusion Cell WEZ (for spare) mounting flange DN40CF 35ccm PBN crucible Dual Ta-wire filament Type C WRe 5/26% thermocouple bakeable up to 300 °C maximum temperature 1400 °C (outgassing 1500°C) electrical parameter: 400W/11A dimensions under UHV: O.D. 37mm, length 287 mm	██████████	██████████ EUR
	2 pc.	Set of cables for power and TC, bakeable Remark: power supplies and PID controlers provided by customer		

Carried forward	██████████ EUR
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Pos	Qty.	Description	Price	Total
			Brought forward ¹²	██████████ EUR
	1 pc.	Linear Soft Acting Shutter Module magnetically coupled feedthrough mounting flange DN40CF (O.D. 2.75") 100mm maximum stroke shutter speed 0.2s per action Ta shutter plate and Mo shutter rod Remark: In total there are 9 source shutter modules mounted in MBE chamber II (8x linear, 1x rotary for GaP source) -		
(17)	1	3. BUFFER AND TRANSFER CHAMBER	██████████	██████████ EUR
	1 pc.	UHV buffer chamber with flanges for transfer rods, ion gauge, view ports, Ion pump and wafer lift. The base pressure is 2×10^{-10} mbar. It is a linear tunnel transfer chamber with magnetic driven wafer trolley, which runs on mono-rail. Exact length will be fixed within approval process. It allows attachment of 2 MBE chambers, heated station and adapter exchange station. The buffer chamber allows modular expansion for later system extension by simply adding another transfer module (see attachment).		
	1 pc.	System frame, bake-out equipment, blind flanges for un-used chamber flanges and view ports, required bellows. Integration with MBE controll system		
	1 pc.	Bellow unit to compensate for thermal expansion where needed		
	2 pc.	Ion getter pump (nominal pumping speed 300 l/s) with a NW 150 CF (8" OD) inlet flange		
	2 pc.	Controller channel for IGP, incl. cables		
	3 pc.	Transfer rod for substrate transfer from buffer chamber to MBE chamber I and II, and to heated station. Including wafer carrier and adjustment units.		
	3 pc.	Vertical lift for substrate transfer (2x MBE chamber, 1x heated station)		
	1 pc.	Wafer trolley for 5 substrate adapters to be moved manually on mono-rail by magnetically coupled handle Remark: This magazine can be moved to load-lock chamber for		
			Carried forward	██████████ EUR

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Pos	Qty.	Description	Price	Total
		Brought forward ¹³		████████ EUR
(17)	1 pc.	wafer loading in and out BA-iridium twin filament ion gauge for pressure measurement, high sensitivity p<3x10 ⁻¹¹ mbar including controler		
(18)	1	4. FAST ENTRY CHAMBER	████████	████████ EUR
	1 pc.	Fast Entry load lock chamber with flanges for transfer pressure gauge, view port, pumping etc. UHV linear tunnel transfer system, with mono-rain and magnetically coupled trolley movement.		
	1 pc.	Frame incl. UHV assessories, view port and bake-out jacket		
	1	to perform outgassing of loaded substrates up to 150°C Implementation of pump: Remark: New Turbo pump Edwards EXT240D (CF100) with controller provided by customer.		
	1 pc.	Diapragm pump for pre-vacuum		
	1 pc.	Wide range cold cathod pressure gauge for pressure measurement from atm to 5x10 ⁻⁹ mbar,		
	1 pc.	Manual gate valve (VAT series 10) 150 CF, between Load-lock and buffer chamber		
	1 pc.	Quick-Access-Door Viton-sealed, The quick loading door can be replaced by cupper gasket sealed DN 150 CF flange for cell degasing.		
(19)	1	5. HEATED STATION FOR WAFER DEGASING	████████	████████ EUR
	1 pc.	UHV chamber for heated station with flanges for transfer, additional pumping, pressure gauge, view port Water cooling shroud integrated		
	1 pc.	Frame extention, blind flanges, view port, bake-out equipment		
	1	Implementation of one 200l/s Ion Getter pump provided by customer. It includes the adaption of the frame.		
	1 pc.	Wafer heater for 2 inch substrates Ta heater with PBN diffusor, 25mm vertical lift max substrate temperature 500°C		
	1 pc.	Power supply for the wafer heater		
	1 pc.	PID control channel with individual temperature display		
		Carried forward		████████ EUR

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Pos	Qty.	Description	Price	Total
		Brought forward ¹⁴		████████ EUR
	1 pc.	Cable set for power and TC		
	-			
(20)	1 pc.	6 MBE CONTROL SYSTEM	████████	████████ EUR
	2 pc.	MBE growth process software including hardware interface control of:		
		- substrate manipulator (temp. rotation, shutter)		
		- up to 16 effusion cells (temperature, shutter)		
		- 2 valved sources cracker sources		
		- 18 shutters in total		
		- H2 cracker source temperature (if included)		
		- heated station in prep-chamber (if included)		
		- Ion Gauges		
		- pyrometer input (if included)		
		- flux measurement (for BFM)		
		- interfaces and hardware as needed		
		- including manual,		
	2 set	Cables set		
	2 pc.	PC for MBE control software		
	3 pc.	19" instrumentation rack and electronic switch cabinet for control electronics.		
	1 pc.	Beckhoff system controller including PC with touch screen integrated in 19inch instrumentation rack It includes bake-out control, water cooling flux control and vacuum system integrity. It also includes control of the pneumatic valves, and automated chamber venting function for the different UHV chambers. with VPN router for remote system access. It also includes a separate electronic cabinet for the electrical power management.		
	1 pc.	UPS for powering critical system components in the event of a power failure for about 10 min. It operates the IGP pump and the Ga and Al sources		
	2 pc.	Shutter control unit, 12 channels (all sources and main shutter) incl. implementation effort and cables		
	2 set	Shutter cable set (cells + mainshutter)		
	-			
		7. OTHERS		

Carried forward	████████ EUR
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Pos	Qty.	Description	Price	Total
		Brought forward ¹⁵		██████████ EUR
(21)	1	Factory training for 3 days, few weeks before delivery, for 2 researchers from the customer in our laboratory. Travel expense and hotel is not included	██████████	██████████ EUR
(22)	1	Transportation to customer laboratory, packing and insurance	██████████	██████████ EUR
(23)	1	System installation, training, and acceptance test performed at customers site Acceptance criteria see Attachment B to this quotation	██████████	██████████ EUR
Amount				██████████ EUR
Discount				██████████ EUR
Total invoice amount				930.000,00 EUR

Terms of Payment:

40 percent of the system price by T/T prepayment within 4 weeks after signing the purchase contract.
50 percent to be paid after approved factory training and pre-acceptance test in our assembly laboratory
10 percent to be paid after shipping, installation and passing the final acceptance test

Delivery:

Technical approval drawings provided about 3 month after signing the purchase contract
The factory training and pre-acceptance in our laboratory will be performed within 11 month after ordering
Time of delivery is not before July 1st. 2018, but within 12 months after ordering

Quotation valid 3 months after date of quotation.

Warrenty: 24 month after installation and approved acceptance testing, but not more then 26 month after delivery

See Purchase Contract for futher details

with best regards
Dr. Karl Eberl



MBE

KOMPONENTEN | DR. EBERL



Attachment – A to the Quotation 2017-08-25

"MBE Apparatus,,

Academy of Sciences of the Czech Republic

Institute of Physics

RNDr. Michael Prouza, Ph.D., Director

Na Slovance 1999/2

182 21 PRAHA 8 (CZECH REPUBLIC)

Dr. Karl Eberl

MBE-Komponenten GmbH

71263 Weil der Stadt

Germany

www.mbe-komponenten.de



Main features of the Dual-MBE System

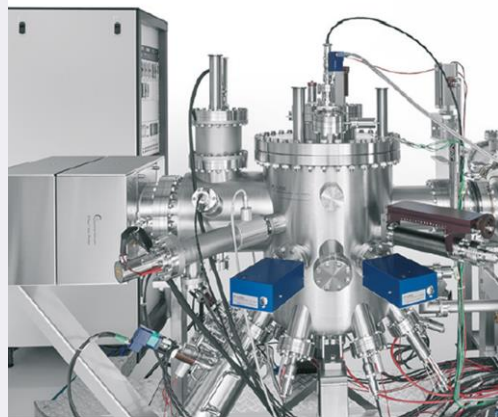
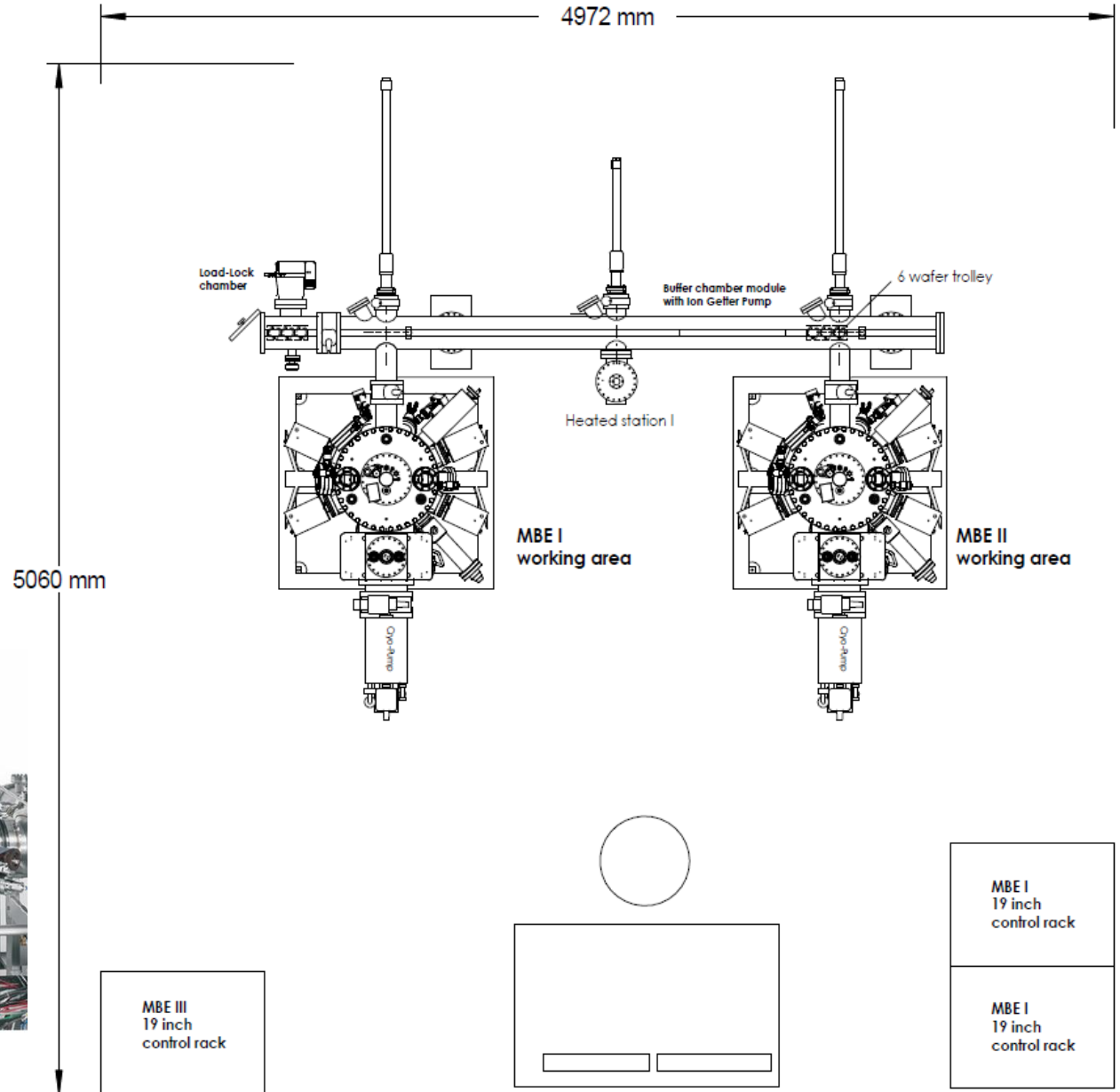
Confidential information

1. MBE chamber I for III-V: Octoplus 400
LN2 main cooling shroud
2inch GaAs substrate heater, 10 source flanges (DN 63 CF)
up to 10 linear shutters
1x Cryopump 1500 l/s and Ion getter pump
2. MBE chamber II: Octoplus 400
2inch substrate heater, 10 source flanges DN 63 CF
up to 10 linear shutters
1x Cryopump 1500 l/s, Ion getter pump 300l/s
3. Buffer chamber for storage and transfer:
Ion getter pump with TSP
Magazine for 5 substrates (2 inch wafers)
4. Heated station for wafer degassing up to 500°C
with optional atomic H source
water cooling shroud
5. Fast-entry load-lock, with turbo pump
5-wafer magazine, wafer bake-out at 150°C



Example of system layout

Confidential information



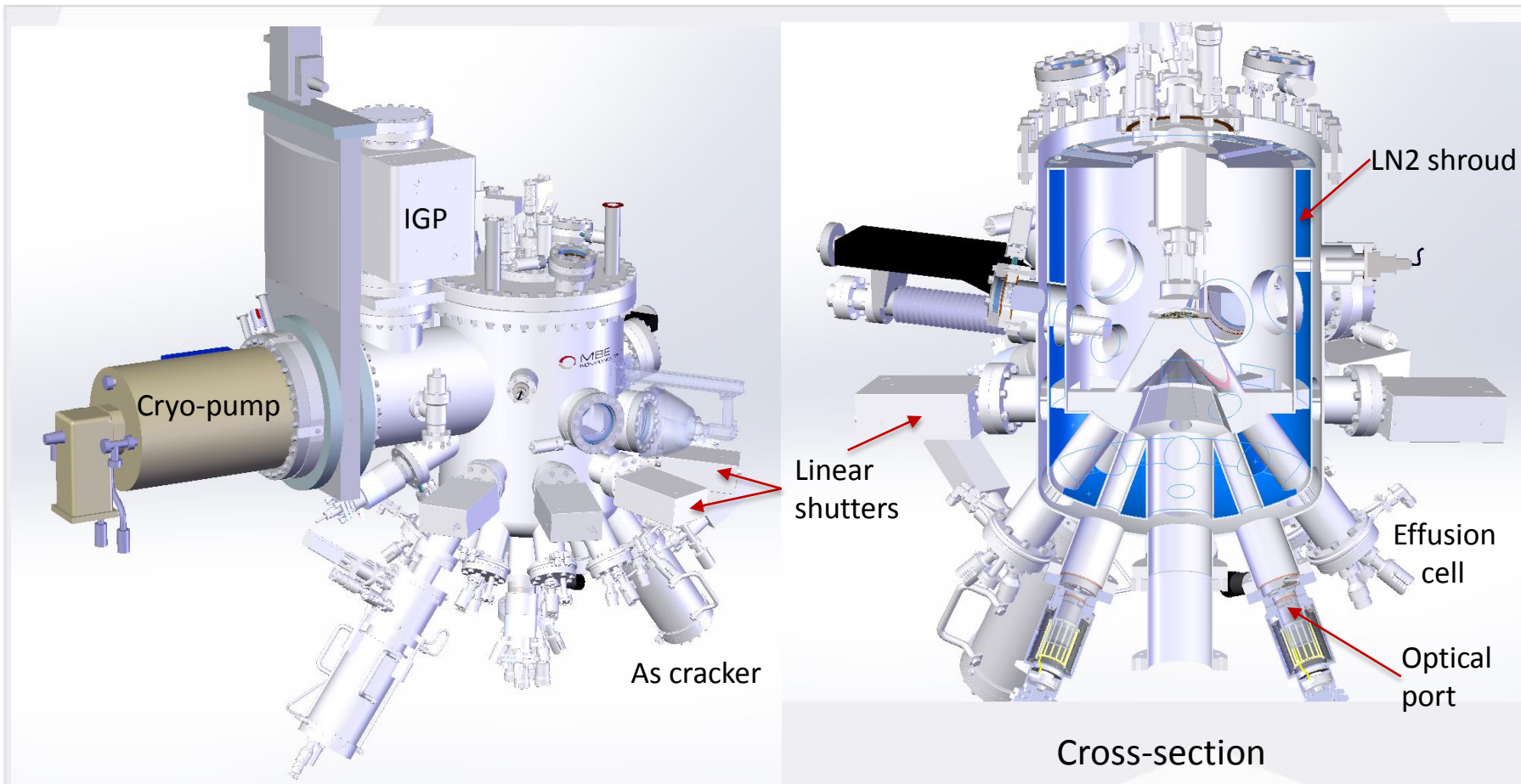
Octopus 400 MBE System

Octopus 400 for III-V MBE

(example: similar system)

Final drawings will be provided in the design approval process.

**Confidential
information**



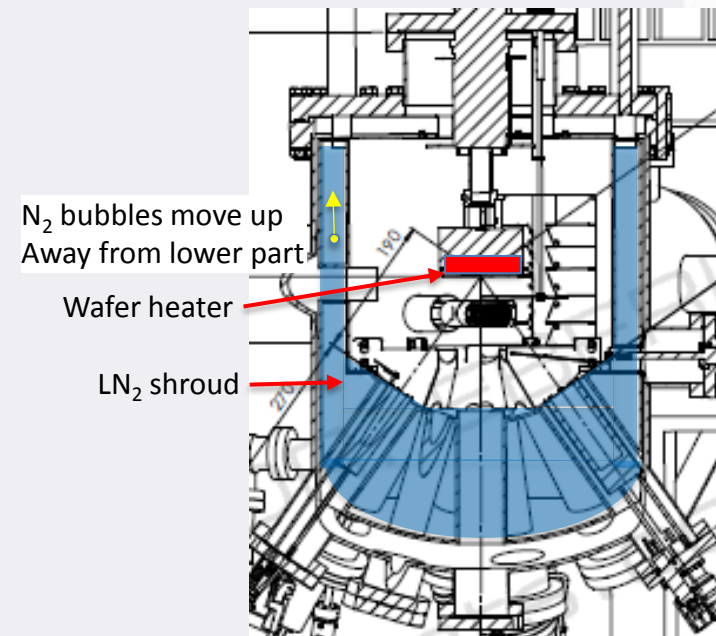
Information to the design of the LN2 cooling shroud

**Confidential
information**

Key Features:

- The LN2 cooling shroud is designed such, that the hot wafer can see mostly LN2 cooled areas all around on it's side and below.
- The hot sources are surrounded by LN2 cooling
- The LN2 is by design one large volume unit to ensure uniform LN2 cooling without creation of Nitrogen bubbles on hot areas. This is most important to avoid hot spots.
- N2 bubbles created in the area of the hot sources can raise up to an area which is behind the wafer – “most important”.

Comment: These are the design rules, which are used in all the high mobility MBE systems



MBE System Control

Main features:

- Industrial PLC control
- System status visualization with touch screen operation
- Vacuum pump controller
- Vacuum pressure interlock
- Cooling water flow monitor and interlock
- DC power supply monitor
- Automatic pump down and venting procedures
- Valve control with device safety check
- Automatic bake-out controller with timer and monitor
- I/O interfaces for the MBE process control software (e.g. pressure, vacuum, cooling water and power supply interlock)
- Options:
 - Field bus interface instead of I/O interfaces
 - Motor controller for automated substrate transfer

Example for
MBE control rack

touch screen PC
for system control

Separate PC for
MBE process software



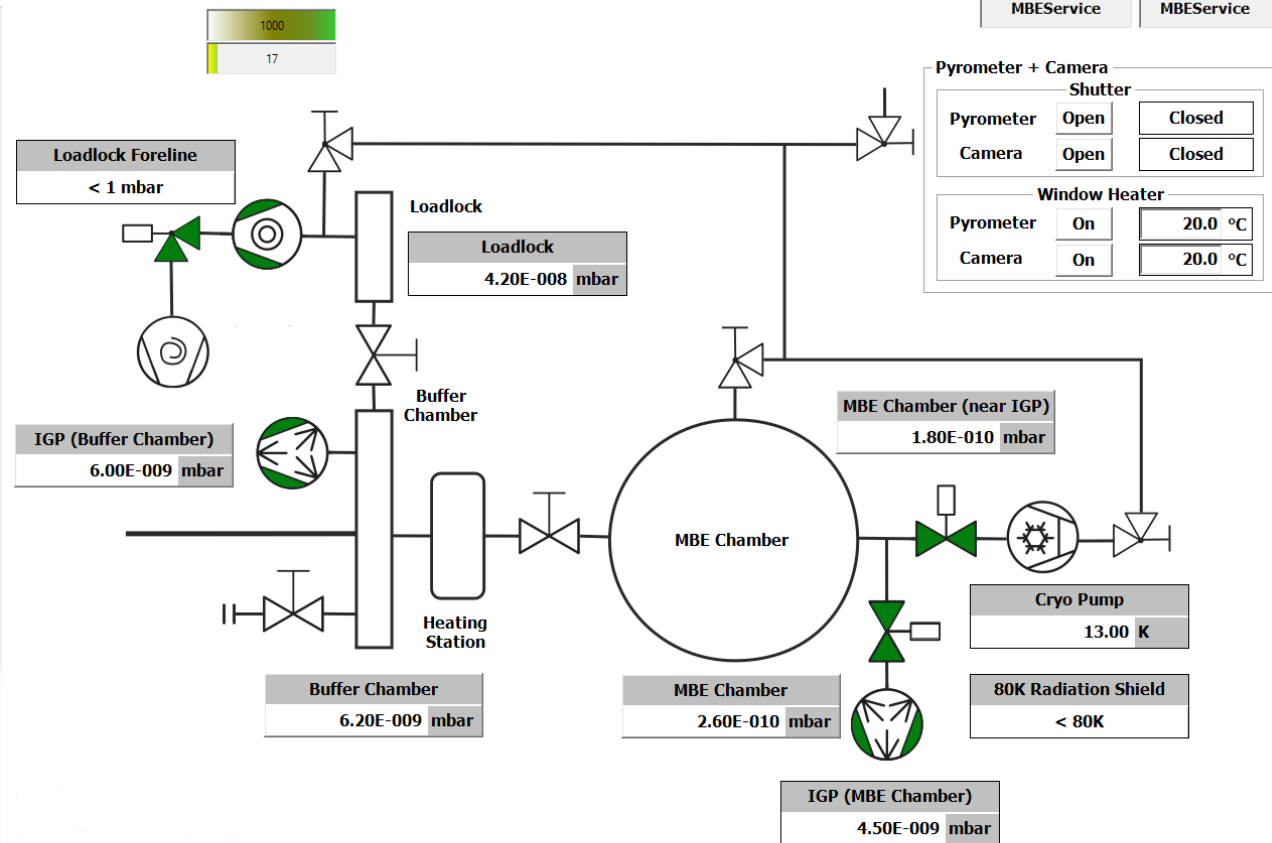
MBE System Control (Example)

Page 1: Process Diagram

Information:

- Pressure in each chamber
- Overview of all components
- View port heaters
- Pump status

Time: 03/30/2016 08:46:39 AM	Code: KW17	Text: Cooling Water Warning : Circuit 1 Low Water	03/30/2016 08:47 AM
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MBE System Control (Example)

Page 2: System Overview

Information:

- Pressure in each chamber
- Overview of all components
- View port heaters
- Pump status



MBE
KOMPONENTEN | DR. EBERL

Time: 03/30/2016 08:46:39 AM Code: KW17 Text: Cooling Water Warning : Circuit 1 Low Water

03/31/2016 10:11 AM

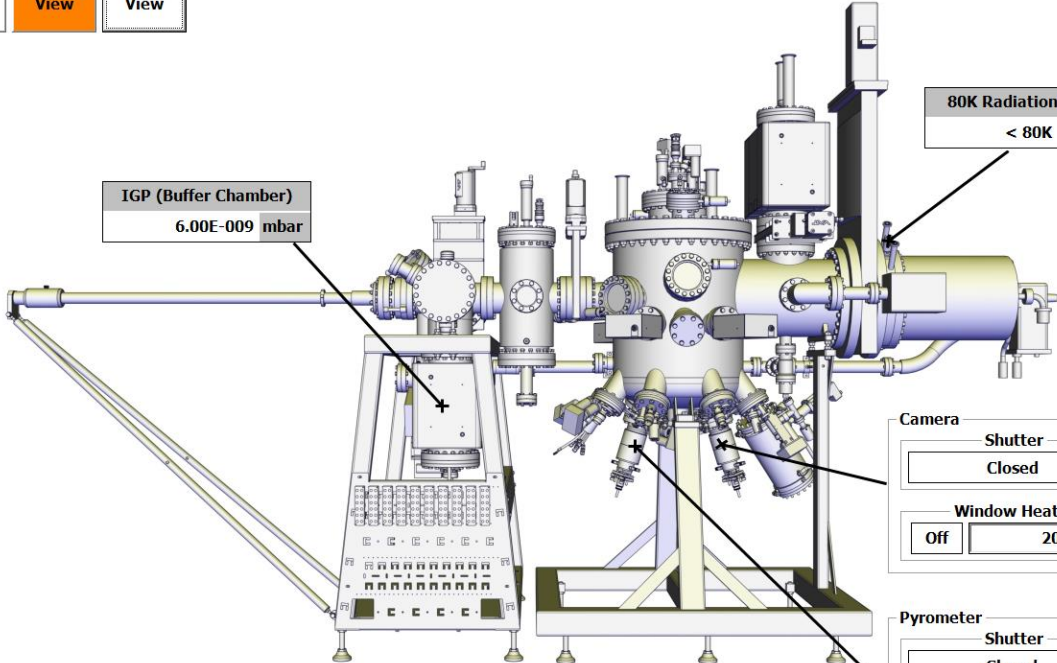
Top View

Front View

Rear View

MBEService

MBEService



IGP (Buffer Chamber)

6.00E-009 mbar

80K Radiation Shield

< 80K

Camera

Shutter

Closed

Window Heater

Off 20.0 °C

Pyrometer

Shutter

Closed

Window Heater

Off 20.0 °C

Process Diagram

System Overview

Manipulator

Cooling Water

Power Supply

Alarmlist

Bakeout

Pyrometer

Config

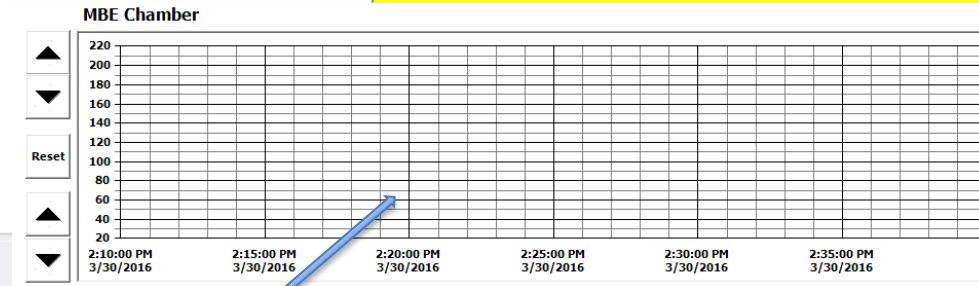
LED

MBE System Control (Example)

Page 7: Bakeout

Information:

- Pressure in each chamber
- Bakeout time and temperature for each system part
- Opening of trend charts



MBE
KOMponenten | DR. EBERL

Time: 03/30/2016 08:46:39 AM
Code: KW17
Text: Cooling Water Warning : Circuit 1 Low Water

03/30/2016 10:51 AM

MBE Chamber 2.60E-010 mbar	Buffer Chamber 6.20E-009 mbar	Loadlock 4.20E-008 mbar	Cryo Pump 13.00 K
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Bakeouttrendcharts

1: Loadlock Turbo Pump

On Heating

Setting: 160.0 °C

2: Loadlock

On Heating

Setting: 160.0 °C

3: IGP Buffer Chamber

On Off

Setting: 20.0 °C

4: Valve Loadlock Buffer Chamber

On Off

Setting: 20.0 °C

5: Transfer

On Off

Setting: 20.0 °C

6: Buffer Chamber

On Off

Setting: 20.0 °C

7: Heating Station

On Off

Setting: 20.0 °C

8: MBE Chamber

On Off

Setting: 20.0 °C

Process Diagram

System Overview

Manipulator

Cooling Water

Power Supply

Alarmlist

Bakeout

Pyrometer

Config

LED

MBE System Control – Example dual MBE

Page 5: Cooling Water

Information:

- See status for each water circuit
- Change alarm levels
- Activate / deactivate each circuit
- Define action in case of alarm e.g. cell ramp down

MBE
KOMPONENTEN | DR. EBERL

Time: 05/28/2015 09:09:20 AM
Text: BaseThread(AsyncJobs) Exception Ads-Error 0x7 : Target machine could not be found.

05/28/2015
09:12 AM

Cooling Water Interlock

Active	Active
<input checked="" type="checkbox"/> circuit 1 :SiGe (1_Sub)	<input checked="" type="checkbox"/> circuit 8 :GaAs (1_Sub)
<input checked="" type="checkbox"/> circuit 2 :SiGe (2_Si)	<input checked="" type="checkbox"/> circuit 9 :GaAs (3_Sb, 4_As)
<input checked="" type="checkbox"/> circuit 3 :SiGe (optional 3_Si)	<input checked="" type="checkbox"/> circuit 10: GaAs (7_C)
<input checked="" type="checkbox"/> circuit 4 :SiGe (4_Ge, 5_B)	
<input checked="" type="checkbox"/> circuit 5 :SiGe (9_GaP)	
<input checked="" type="checkbox"/> circuit 6 :SiGe (10_Sn)	
<input checked="" type="checkbox"/> circuit 7: SiGe (QCM)	
	<input checked="" type="checkbox"/> circuit 11: HiPace300 and HiPace800M
	<input checked="" type="checkbox"/> circuit 12: Transfer IGP
	<input checked="" type="checkbox"/> circuit 13: -
	<input checked="" type="checkbox"/> circuit 14: -

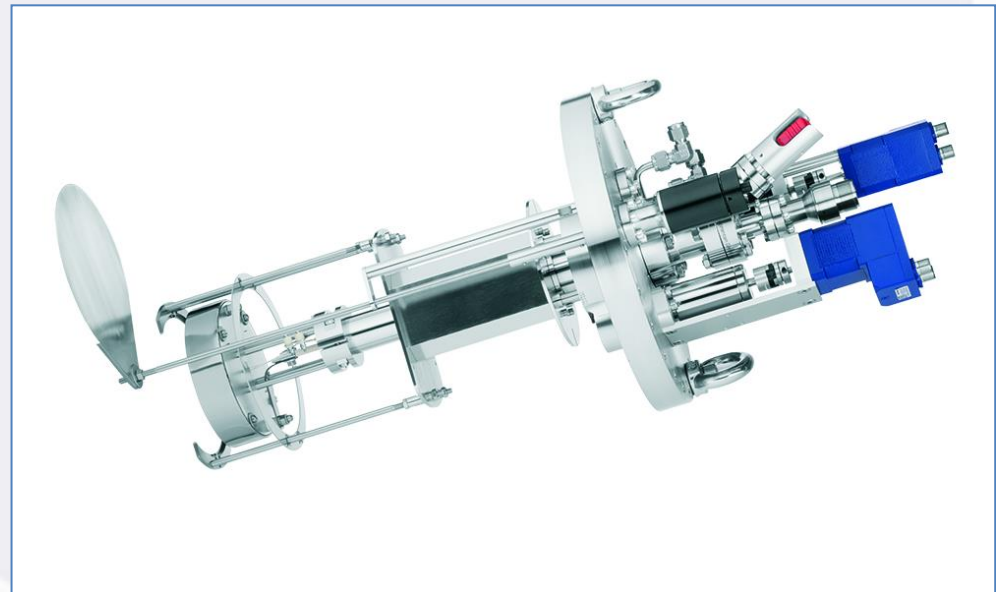
Water panel with individual flux sensors



Substrate manipulator

Features

- Temperature up to 1200°C wafer temp.
- continuous rotation,
- ceramic bearings
- vertical lift for transfer
- shutter option
- W heater
- wafer holder modified to allow heating of GEN II type 2inch moly block



MBE – Chamber A: Material information

Material	T _{melt}	T @ 10 ⁻³ mbar)	recommended crucible	source / filament type
Ga	30	995	PBN	WEZ: dual filament cell – 35ccm
In	157	823	PBN	WEZ: dual filament cell – 35ccm
Al	660	1076	PBN	WEZ: effusion cell cold lip – 35ccm
Si doping			sublimation source	SUSI-D: low power, fast reaction
C doping			sublimation source	SUKO-D: low power fast reaction

Note:

All recommendations are to the best of our knowledge but without guarantee.
 No responsibility is taken for damages arising by erroneous information.

MBE Chamber B: Material information

Material	T _{melt}	T @ 10 ⁻³ mbar)	recommended crucible	source / filament type
Ga	30	995	PBN	WEZ: dual filament cell / 35ccm
Cu	1085	1117	PBN	WEZ: dual filament cell / 35ccm
Al	660	1076	PBN	WEZ: effusion cell cold lip / 35ccm
Mn	1246	823	PBN	WEZ: hot lip effusion cell / 35ccm
P			-	DECO: GaP compound source /35ccm
Fe	1538	1302	Al ₂ O ₃	HTEZ: high temperature cell / 10cc
Pt	1768	1889	PG	HTEZ: high temperature cell / 10cc
Si doping			sublimation source	SUSI:

Note:

All recommendations are to the best of our knowledge but without guarantee.
 No responsibility is taken for damages arising by erroneous information.

Effusion Cells:



Effusion Cells WEZ / NTEZ:

- Evaporation of: In, Ga, Al
- Very robust wire Heater
- All feedthroughs exchangeable
- Very stable flux
- Double dual filament / hot lip / cold lip
- crucible size 35 ccm

High Temperature Source HTEZ

- Compatible with all MBE systems
- crucible sizes 10 ccm and varios materials,
- Self-supporting tungsten wire heater filament
- Clean operation in UHV up to 2000°C
- High reliability and long lifetime

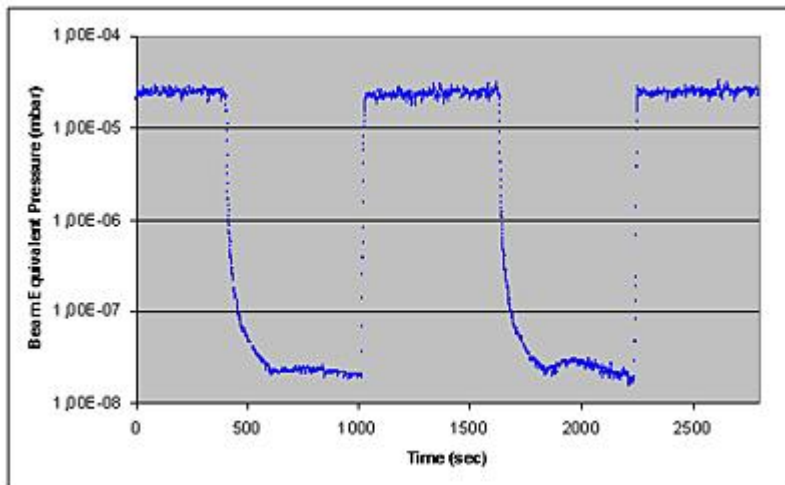


Crucibles for HTEZ made of Al_2O_3 , BeO and refractory metals (W, Ta), sizes 1.5 and 10 cm³



As valved cracker source

- Precise and fast As flux control
- Large capacity 300ccm or 500ccm
- As loading in one single piece of As
- Large opening cross section valve mechanism / no needle valve
- cooling shroud integrated



BEP vs. time, with valve on and off
cell temp. 390°C / cracker temp. 600°C
The motorized valve control allows to adjust and switch the As_2 flux within seconds within about 3 orders of magnitude



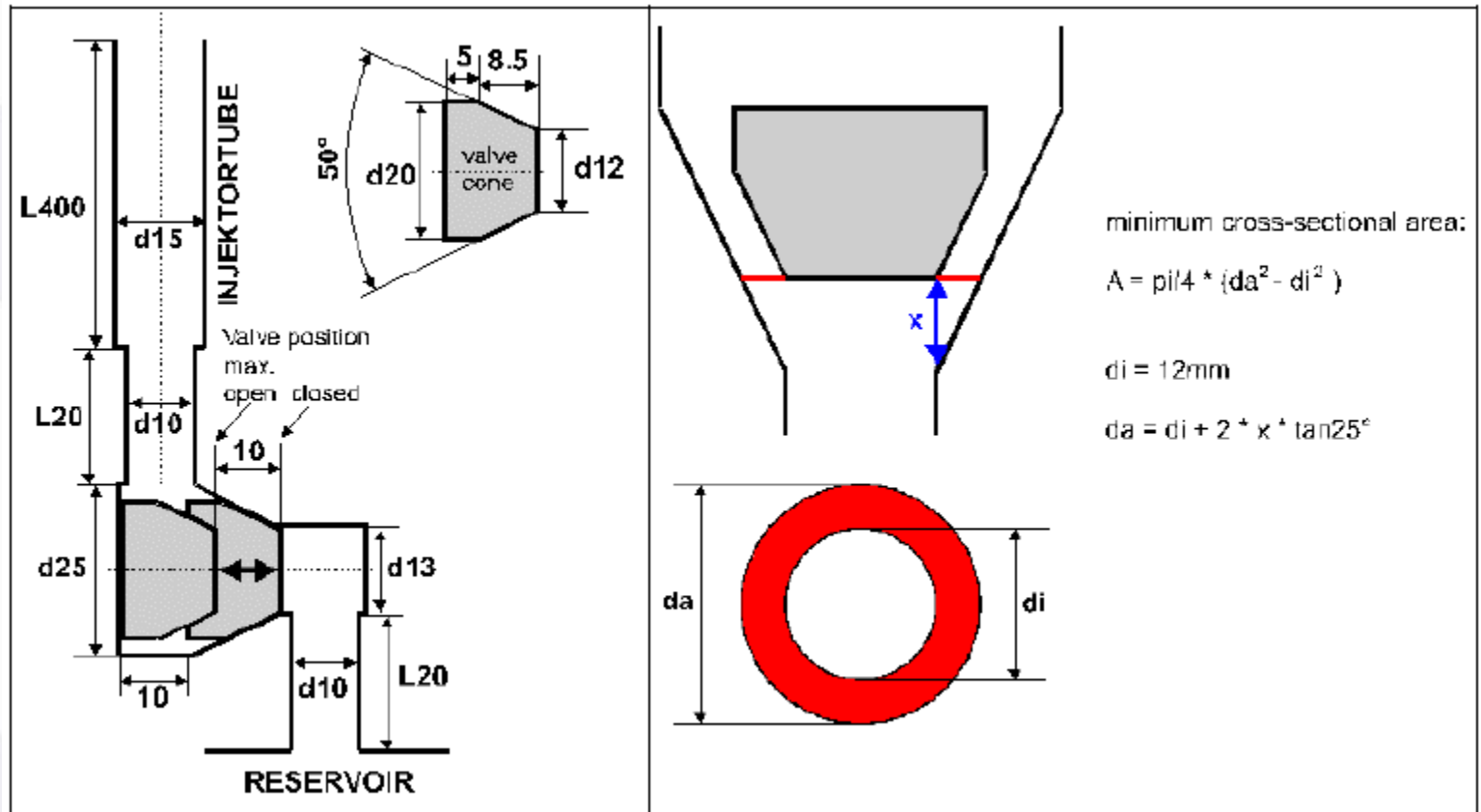
VACS 100-300 valved arsenic cracker with DN63CF (O.D. 4.5") mounting flange (using a VADP 100-63 adapter), 300 cm³ crucible, cooling shroud and motor drive



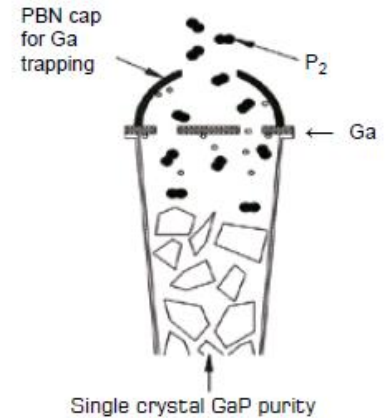
Motorized Valve Control Unit and DC power supplies

VACS 300 / 500: sketch of valve mechanism

- Large opening cross section valve mechanism / no needle valve
 -> the valve can not get stuck by design
 and, better pump out is possible as compared to needle valve design used by competitors
- large opening cross-section about 2cm², linear with valve position



GaP Decomposition Source



Schematic sketch of the Ga-Trapping-Cap

GAP COMPOUND SOURCE DECO

- Compatible to all MBE systems
- Doping and MBE growth applications
- Ultra high purity P₂ beam
- Reduced White Phosphorus deposition
- Simple operation
- High reliability
- Precise and fast flux control



Silicon Sublimation Source: SUSI

Features:

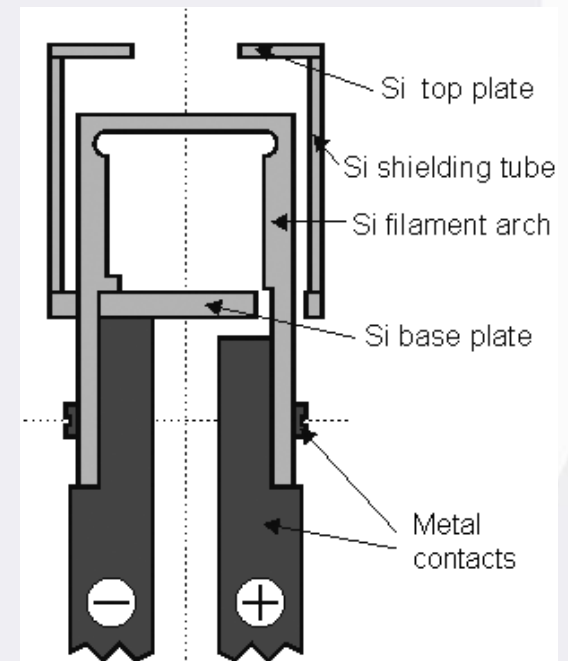
- High purity Si source for MBE
- Thermal sublimation of Si from high purity intrinsic or highly doped Si filament
- Excellent growth of thin silicon layers
- Compatible with most MBE systems
- Water-cooled electrical contacts
- Inner filament shielding with pure silicon parts
- No ceramic parts in the hot zone

Applications:

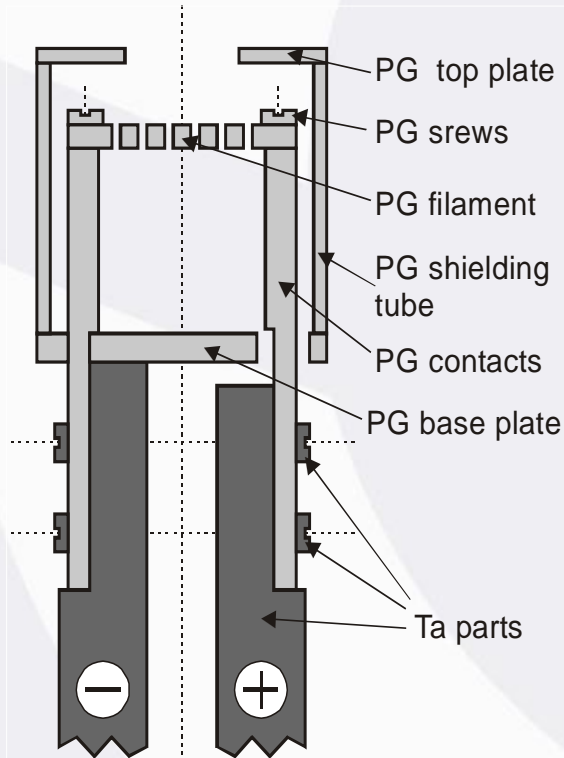
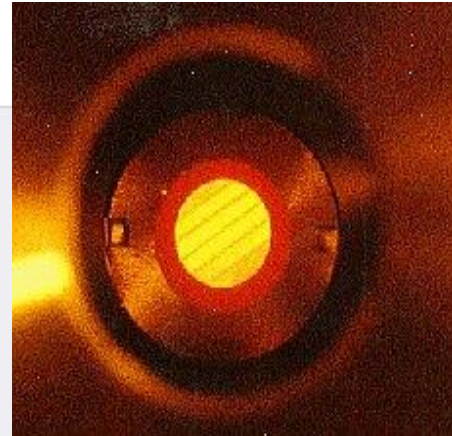
- high purity n-type doping in III-V MBE
- Thin layer Si growth: 1-4 Å/min.

See web-page for more info:

<http://mbe-komponenten.de/products/mbe-components/effusion-cells/susi.php>



**C-doping source: SUKO 40-D
(option, not included now)**



Main features and applications:

- High purity C source for MBE
- p-type doping in III-V semiconductors
- Thin layer C or SiC growth
- Graphene preparation
- low power consumption
- fast reaction

Ref. W. Wegscheider, W. Dietsche,

Longitudinal and Hall resistance at <30 mK for C-doped GaAs / AlGaAs Heterostructure

Hall bar length 1 mm, width 200 μm

Mobility $1.2 \times 10^6 \text{cm}^2/\text{Vs}$ at a density of $2.3 \times 10^{11} \text{cm}^{-2}$

Inset:

Low magnetic field ($-0.5 \text{ T} < B < 1 \text{ T}$)
 Shubnikov-de-Haas oscillations
 and Hall measurement

SUKO-D:

optimized for min. heat load
 and shielding

Ref.:

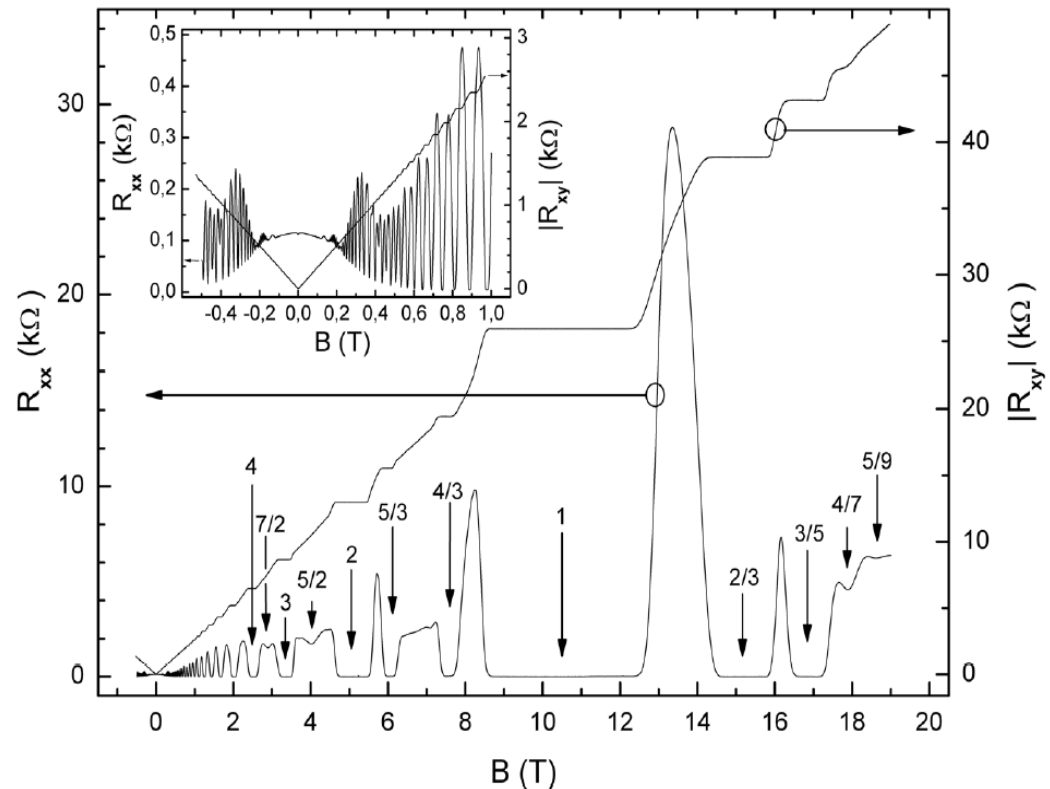
High Mobility MBE system

Prof. W. Wegscheider,

Univ. Regensburg

Prof. W. Dietsche

Prof. H. Sakaki ...



Conclusion:

Our unique high purity Si and C sublimation doping cell, are used by high mobility GaAs MBE experts. Record highest mobility of p-type and n-type doping are achieved by our unique doping cells

Example of application for the SUKO-D:

Graphene grown on biotite mica substrates using the SUKO

Gunther Lippert et. al. IHP Microelectronics Frankfurt Oder Germany

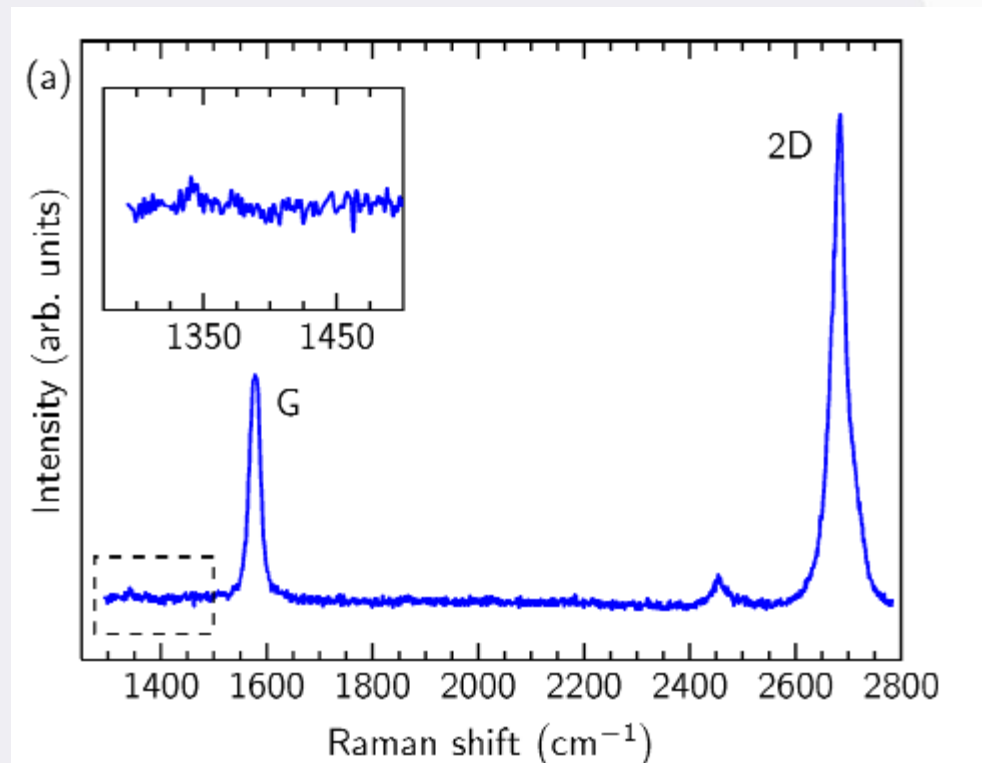
J. Cryst. Growth 2012

Raman spectra of MBE-grown graphene on mica acquired with 532 nm laser Excitation wavelength.

The inset shows the D-peak region, where no defect-induced peak can be observed

Remark:

The C sublimation source allows Very high quality Graphen layer deposition in MBE

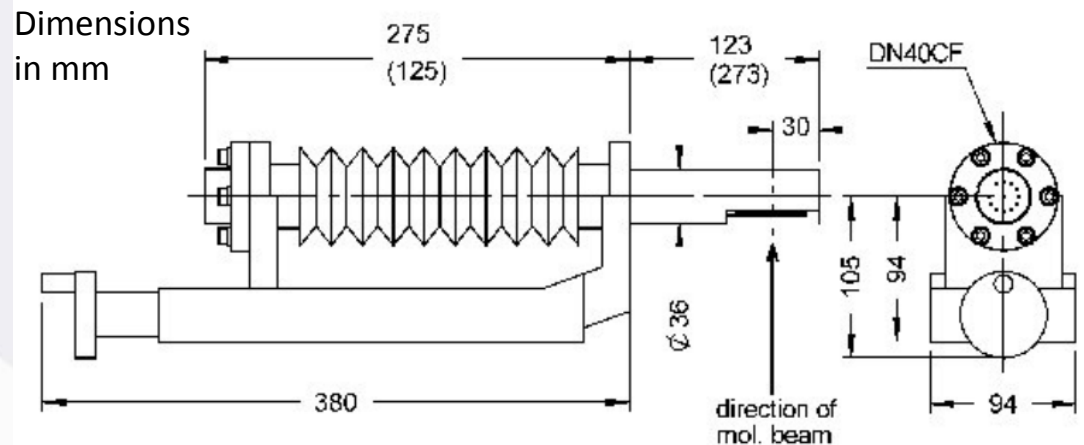


Beam flux monitor

BFM 40-150

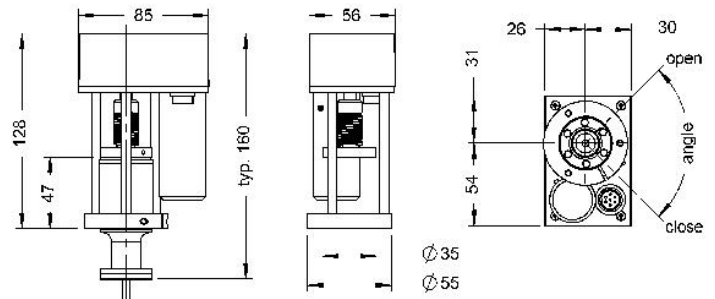
Features:

- Bayard-Alpert type ionization gauge
- Compatible with AML gauge controllers
- Mounting flange DN40 CF (O.D. 2.75")
- Linear gauge head positioning
- Standard linear travel 150mm
- Bakeable up to 250°C



1) **Soft-acting rotary shutter**

integrated in source cooling shroud
easy to remove and cleaning of the whole assembly
0.2 sec open and closing time



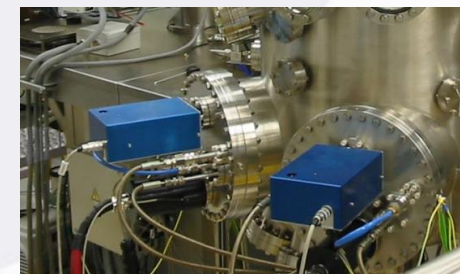
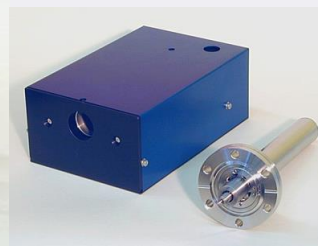
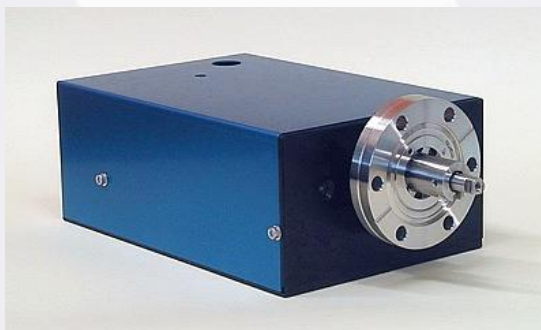
Soft acting Rotary shutter drive: RSM xx-CCW

Shutter control unit SCU12:

The SCU allows manual control (CLOSE / OPEN), and remote control. Two LEDs indicate the actual shutter position (CLOSE / OPEN) when under either manual or remote control

2) **Soft-acting linear shutter**

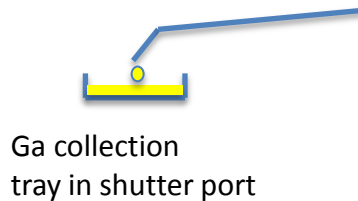
very long life-time, no welded bellows
0.2sec open and closing time



Shutter design:

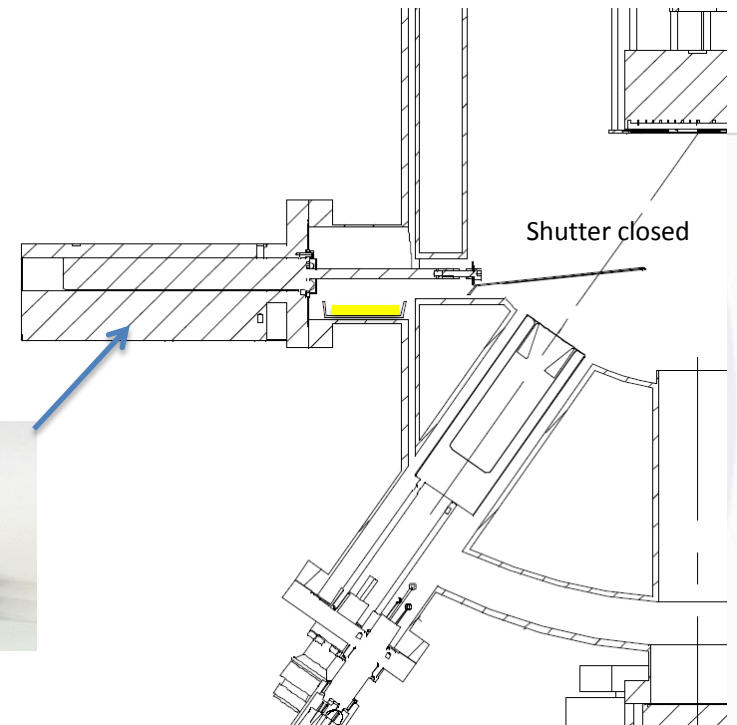
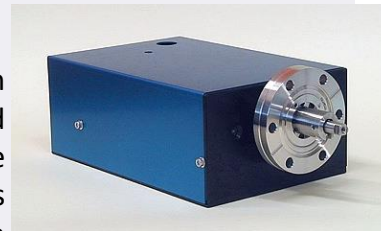
Tilted shutter design
for low transient, with
Ga drop down nose

Shutter open



Ga collection
tray in shutter port

Soft acting shutter motor with
horizontal position and
Sinus-motion to move
slowly into end-positions
to avoid particle drop down



Shutter closed

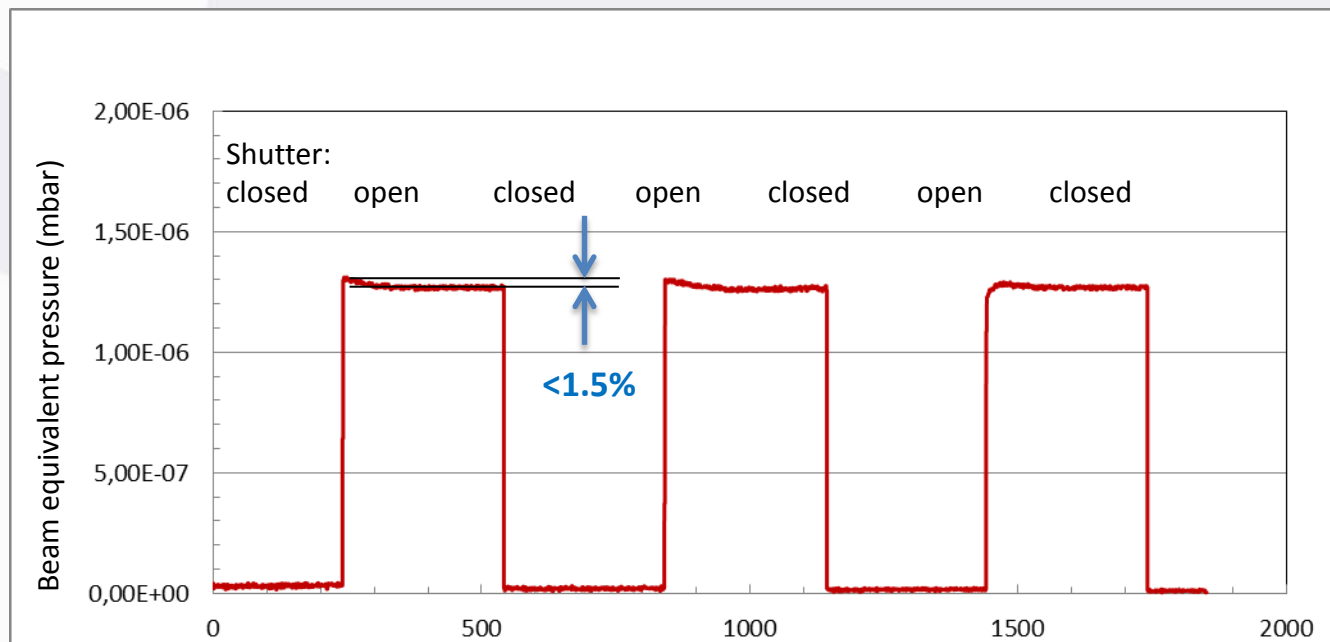
Summary:

- The design avoids drop down of liquid Ga and In onto the cell, due to the tilted design with drop-down nose.
- Due to the nose, the liquid Ga or In are collected during backwards movement within a specially designed collection tray
- The soft-acting (sinuodal motion) avoids particle drop down.
- Horizontal shutter position much better than vertical shutter. Shutter from bottom flange have frequently problems with particles dropping into the shutter drive which results in shutter blocking.

Flux transient measurement result:

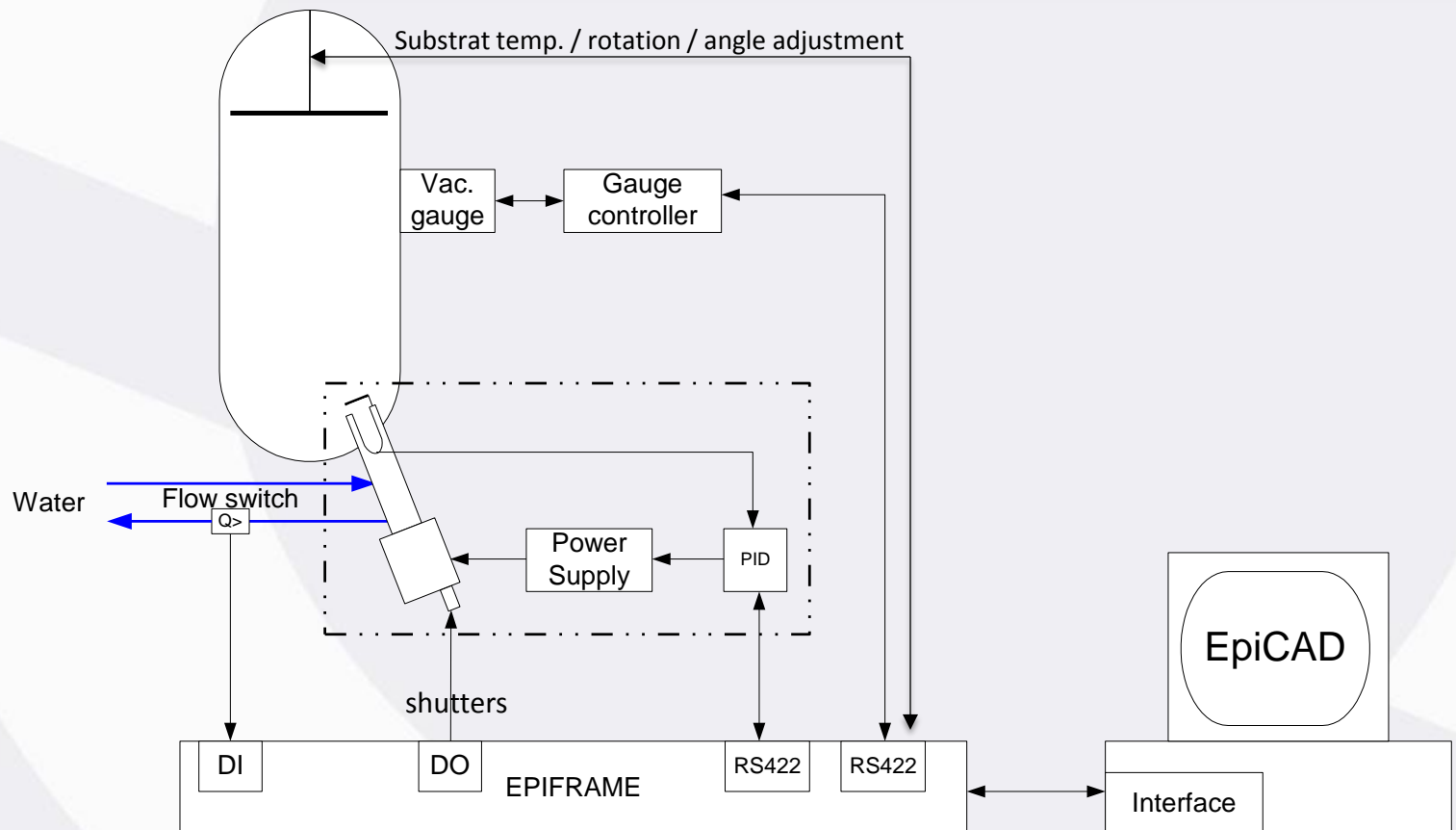
Shutter transient measured for Ga evaporation with linear shutter by using beam flux monitor (Bayard Alpert pressure gauge in substrate position).

Result: -> Flux transient is smaller 1.5%



EPI-Soft Software

Schematic Illustration to EpiSoft



EPI-Soft

Features:

1. Data logging with user-defineable intervals
2. Logged data can be exported in ASCII format:
The user can define what data to export as well as how the data is to be exported to best fit in with spreadsheet programs.
- export of the epi-list (run number, layer sequence including flux rates, shutters, comments etc.)
- export of the process data, e.g.: substrate and source temperatures, pressure, system status, etc.
3. Alarm processing for safe system operation
4. Calibration data editor with curve fitting functions and protected zones
5. Essential settings may be protected by password
6. Comfortable recipe editor with error explanations and functionalities to write composite, doping or single material growth recipes

Set-up window for ASCII export file:

```

File Edit Format View Help
NAME: calibration structure 1034      RUN:
Ga(A)InAs
0.5 µm  0.5µm/h x=0.5315
InP
EpiStep  Type  Nesting Level  Periods  Thickness(µm)  Time  Tsub(°C)
1  EpiList Setp  0  0  -  At Run Time  530.00  0
2  EpiList Power  0  0  -  At Run Time  530.00  0
3  EPILIST START...
4  + SUSPEND &As  0  0  -  0:00:05++  530.00  >>  520.
5  Matrix &As  0  0  0.0417  0:10:40  520.00  >>  510.00
6  Matrix &As  0  0  0.0417  0:10:40  510.00  >>  500.00
7  Matrix &As  0  0  0.1000  0:25:37  500.00  0  GaA
8  Growth Interrupt &As  0  0  -  0:02:00  500.00  >>  200.
9  ...EPILIST END
10 EpiList End  0  0  -  (t=0:00:20)  200.00  0
    
```

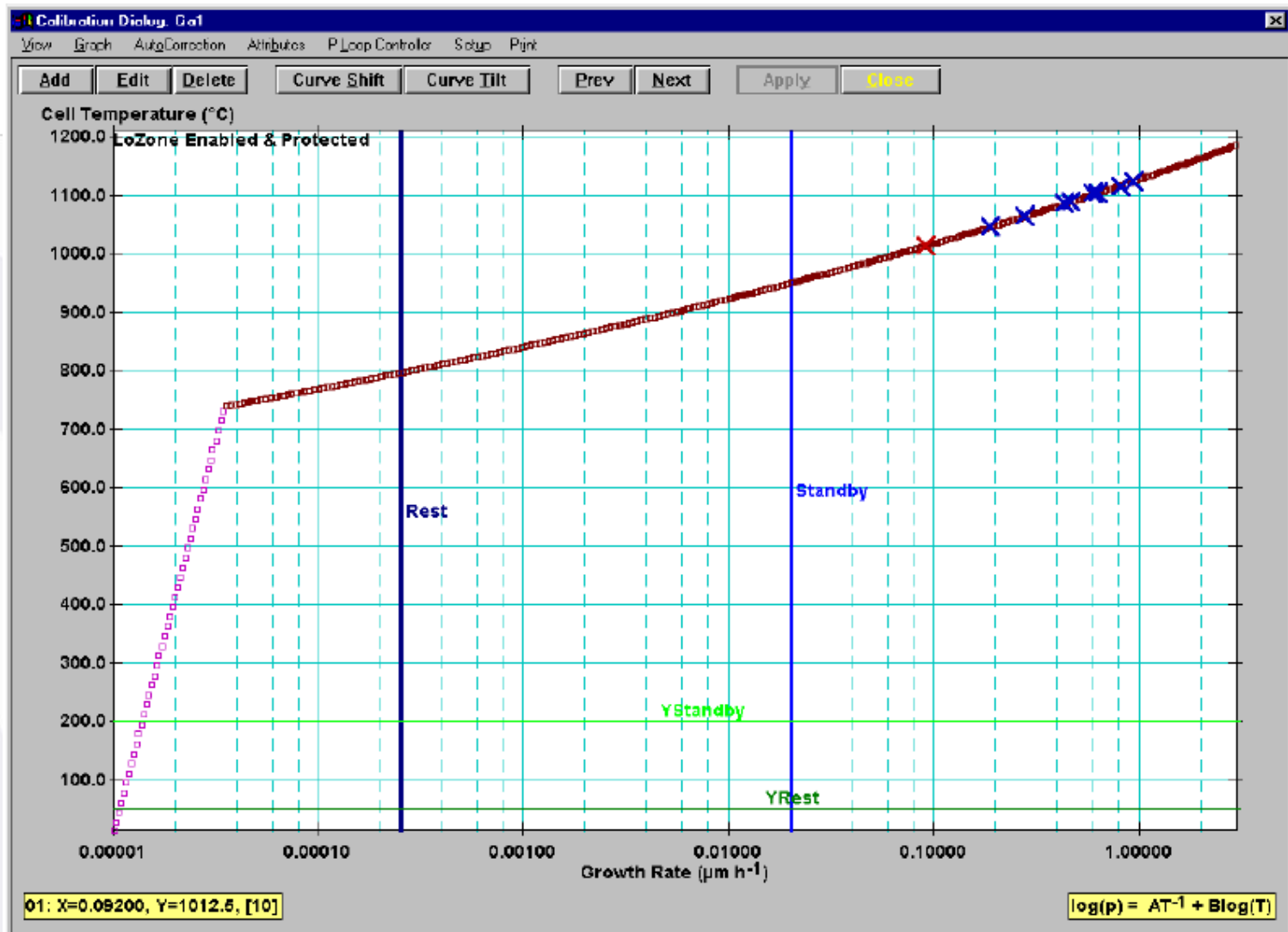
Example of data file:

Glossary

- Alarm Actions: Errors that the P-Loop should react upon like Sensor alarms or Alarm conditions by other P-Loops
- Alarm Conditions: Errors that occur within the P-Loop like Temperature deviation, Controller errors
- Process Data: Data consisting of Setpoint (Setp) and process value (Procv) that is derived from the calibration data and used for process control
- P-Loop: A Process Loop (P-Loop) consists of
 - Controller (PID, Control unit)
 - Power supply (may be integrated into the control unit)
 - Device (Evaporation source, measurement device)
- Calibration data: Data that is derived by calibration measurements and is used by EpiSoft to calculate $Y_{setp} = f(\text{Setp})$ and $\text{Procv} = f(Y_{Procv})$
- EpiCad: Software package to control the P-Loop actions and interlocks
- HiZone: Zone within the calibration data that shouldn't be used for growth due to excessively high evaporation rates
- LoZone: Zone within the calibration data that shouldn't be used for growth due to low evaporation rates that might not result in sufficient growth rates
- Y-Data: Internal data consisting of Setpoint (Y_{Setp}) and process value (Y_{Procv}) for the P-Loop controller (Temperature, voltage signal)

EPI-Soft Software

Example for evaporation material flux calibration data graph:



EPI-Soft Software

Epi-List:

Example of layer sequence for an AlGaAs alloy layer structure

It includes a periodic multi-layer structure with 20 periods of AlGaAs/GaAs

PROCESS EPI LIST EDITOR -- JDCTEST <EpiStep List + Data>* 16:12					
File View Control EpiList Edit Add Integrity Run					Window Z4LogOut Help
8	Matrix Al _{40.0} Ga _{160.0} AsVC	T _S 765.0°C +10.0rpm	T=0.0400µm	n _{6.0} ×10 ¹⁷ cm ⁻³	t=0:01:26.4
		Al:0.66667(1); Ga1:1(1); (Ga2:0.03(1)); AsVC:4(1); Si:1×10 ¹⁸ (1)			
9	Matrix Al _{28.6} Ga _{171.4} AsVC	T _S 765.0°C +10.0rpm	T=0.5000µm	undoped	t=0:19:42.6
		Al:0.4(1); Ga1:1(1); (Ga2:0.03(1)); AsVC:4(1); (Si:1×10 ¹⁸ (1))			
10	Superlattice structure...				
	P-Loop Mismatch Error				
11S1	Start of 20 period Repeat Sequence...				
	Mismatched P-Loops: Si				
12S1	Matrix Al _{28.6} Ga _{171.4} AsVC	T _S 765.0°C +10.0rpm	T=0.0500µm	undoped	t=0:02:08.6
		Al:0.4(1); Ga1:1(1); (Ga2:0.03(1)); AsVC:4(1); (Si:1×10 ¹⁸ (1))			
13S1	Matrix Ga1AsVC	T _S 765.0°C +10.0rpm	T=0.0400µm	n _{1.5} ×10 ¹³ cm ⁻³	t=0:02:24.0
		(Al:0.4(1)); Ga1:1(1); (Ga2:0.03(1)); AsVC:4(1); Si:1.5×10 ¹³ (1)			
14S1	...End of Repeat Sequence				
15	...EPI LIST END				
16	Excess AsVC	T _S 100.0°C +10.0rpm		undoped	t=0:07:00.0
		(Al:0.0042(1)); (Ga1:0.0004(1)); (Ga2:0.03(1)); AsVC:4(1); (Si:1.5×10 ¹³ (1))			

Remark to warranty, maintenance, service

Warranty

We offer 24 months warrenty from the date of acceptance or delivery (as agreed).

MBE Komponenten warrents that the goods delivered to the Purchaser will conform to the relevant technical specifications.

In the event that any goods delivered by MBE Komponenten do not meet the foregoing warranty, such shall be deemed defective and MBE Komponenten will give an appropriate credit for the defective good(s) to Purchaser or, repair or replace the defective good(s).

The claims regarding any defective goods must be made in writing to MBE Komponenten within 2 weeks after the defect occurs, and defective goods shall not have been manipulated, damaged or destroyed by Purchaser or its personnel.

MBE Komponenten shall be allowed a reasonable period to investigate any claim relating to defective goods and shall be given access to Purchaser's relevant records and data for this purpose.

Service and maintenance:

We guarantee that servicing (parts and labor) will be possible for a period of ten years after the date of acceptance.

MBE Komponenten implemented a well defined procedure for technical customer support and for processing of customer complaints. It is part of your internal quality management system according to the ISO 9001.

The procedure includes the following:

- The customer can contact us by telephone or email (German and English) on working days Mo to Fr from 8:30 to 16:00.
- Feedback by MBE expert is ensured by email or telephone within two working days.
- We are well know for our fast reaction and support in case of repair of our products and delivery of spare parts.
We offer in-house repair and support at customer site within a few days (< 10 working days).
- We provide detailed failure mode analysis in order to improve our products continuously and to avoid it to happen again.
An FMA report is provided.
- We provide clear and well arranged user manuals in order to avoid failures.

In this context see also our web-seite: <http://www.mbe-komponenten.de/customer-info-and-service/return-policy.php>

For the customer issue form see: http://mbe-komponenten.de/about-us/failure-description_declaration-of-contamination.pdf

Dr. Eberl MBE Komponenten has a very good reputation as fare as product quality and customer service is concerned.

- Wide range of MBE systems and evaporation sources
- Customized designs and simulation of evaporation
- MBE Komponenten offers high product quality and very professional service

- 1) Final acceptance test at customer site after system installation in customer laboratory
High-purity source materials and adequate epi-ready 2inch GaAs (SI) (100) and Si (100) wafers must be provided in time by the customer.

Protocol for final acceptance test for the MBE system: (At customer site, performed after shipment and installation)	Ok y/n	Date	Name
All components in place and mounted as agreed			
He leak test performed, no leak detected, in MBE chambers, transfer chamber, degassing chambers and load-lock, Measurement of rest-gas spectrum in UHV chamber where mass analyser is installed.			
<i>Functional Testing:</i>			
Demonstrate sample transfer, and show that the sample transfer between all the chambers operates safely and smooth			
Demonstrate the system control software and the interlock functions, ensure the communications between the software and hardware works well, ensure the interlocks work well			
Show power shut down safety functions			
Demonstrate system bake-out – check if all bakeout features work well			
Base pressure MBE Chamber I: The chamber pressure shall be <8E-11 mbar after bakeout			
Base pressure MBE Chamber II: The chamber pressure shall be <8E-11 mbar after bakeout			
Base pressure Transfer Chamber: The chamber pressure shall be <2E-10 mbar after bakeout			
Load source materials and start second bakeout process followed by outgassing of the sources loaded with material.			
Show how to adjust PID parameters for one source. Demonstrate the temperature control accuracy is $\pm 0.5^\circ\text{C}$, for all sources the stability of the temperature better than $\pm 1^\circ\text{C}$			
<i>Epitaxial growth and related final acceptance criteria</i>			
For MBE chamber I Demonstrate operation of some sources (high purity materials provided by customer): - heat up Ga and Al effusion cell and As valved cracker - adjust As flux rate and Ga flux rate using beam flux monitor - Introduce and deoxidize GaAs (100) by heating it up to $> 580^\circ\text{C}$ under As vapor pressure. - Observe RHEED pattern and oscillations for GaAs and AlGaAs set up initial flux calibration curve for Ga, Al and As			
Demonstrate how to use the Beam flux monitor to measure flux			
Demonstrate use of MBE process software: - Show how to adjust cell temperatures: Substrate heating and rotation demonstrated. Effusion cell heating and shutter operation demonstrated - Show how to write a recipe for layer deposition			
For MBE chamber I: Deposit GaAs/AlGaAs multi-layer on 2inch GaAs wafer to check layer thickness and uniformity better $\pm 1.5\%$ (except for the 5 mm to the edge). Remark: the XRD measurement and evaluation has to be performed by customer within few days. - Deposit 6-10 μm GaAs layer, check background doping $< 8 \times 10^{14}$ ccm; - On request: Growth of generic HEMT structure: 30nm to 40nm AlGaAs spacer. Carrier density and mobility: n-type $\approx 2 \times 10^{11}$ cm $^{-2}$, $\mu > 1.6 \times 10^5$ cm 2 /Vs at 77K. HALL measurement and evaluation to be performed by customer			

