De Zaale 20, 5612 AJ
PO Box 6336, 5600 HH
Eindhoven, The Netherlands
+31 (0)40 3334 999
www.differ.nl

European Market Consultation

Pulsed Laser Deposition (PLD) system

Dutch Institute for Fundamental Energy Research (DIFFER)

AUT-Kenmerk: DIFFER-21-45

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1 CLIENT: DIFFER

DIFFER is the Dutch Institute for Fundamental Energy Research. Its mission is to perform leading fundamental research on materials, processes, and systems for a global sustainable energy infrastructure. We host unique user facilities for energy and materials research. We work together with universities, universities of applied sciences, research institutes and companies that can further develop the technology of our energy research into commercially scalable solutions. In addition, we play an active national and international role in bringing together various parties within the energy community. We believe that it is only through collaboration that we can realize groundbreaking energy solutions for the future.

We are focusing on four main actions in the coming years (strategy report 2023-2028):

1. We strengthen our focus on the DIFFER mission. Our research was, is and will be focused on materials, processes, and systems in the fields of solar fuels and fusion energy. Within this context, we extend our research to other energy applications.

2. We open our facilities to more users. Our flagship facilities are Magnum-PSI and Upgraded Pilot-PSI for fusion research, the Ion Beam Facility for materials research for nuclear fusion and fission, and solar fuels. These facilities are highly relevant to academic and private partners in solar fuels and fusion research.

3. We invest in new facilities. Those investments focus on research into materials for energy. They are centered around fabrication and characterization of high-performing materials for energy applications. The results will be fed-back to advanced materials modelling which will provide better selections of candidate materials. At present we are realizing the Liquid Metal Shield Lab to investigate liquid metal walls in fusion reactors. We have decided to realize a Pulsed Laser Deposition (PLD) facility with multiple in-situ diagnostics, a system for in-situ and operando ion beam measurements, and a Compact X-ray Facility.

4. We enhance our relations with academia, applied research, industry and society. We valorize our science in co-development with industry and through technology transfer. We foster the interaction with academia, applied research institutes, society, and private nuclear fusion endeavours, where these are in line with our own scientific interests and strategy.

For more details about DIFFER, please refer to our webpage: www.differ.nl

2 MARKET CONSULTATION

Introduction

High quality thin films show promising potential in increasing the performance of electrodes, electrolytes, catalysts and membranes for a large variety of applications. Thin films can therefore play a vital role in realizing the energy transition. However, there are two major challenges:

1. Well-controlled deposition and growth of high quality, well-tuned, and reproducible thin films on large and imperfect substrates are complex processes that are not fully understood yet. As a consequence, the application of PLD for producing large area thin films is still highly empirical.
2. In light of the energy transition, metal oxide thin film materials are of major interest. The combination of several metals in an oxide composition yields several millions of possible

combinations. Most of them have never been investigated before. As such, much (academic) ground work has yet to be done.

DIFFER has the ambition to overcome these challenges and has therefore initiated the development of a PLD user facility consisting of a PLD cluster line. The PLD cluster line is to be composed of a small and a large area PLD chamber that include various in-situ diagnostics, a sputter chamber, an XPS/UPS system, and an (optional) in-situ storage which are all attached to a linear transfer line with a load lock.

The market consultation is for the purchase of the two PLD chambers with ablation laser system, the sputter chamber, and the linear transfer line with load-lock. Most of the various in-situ diagnostics, the XPS/UPS system and in-situ storage are to be added by DIFFER in a later stage. Hence, it is of the utmost importance that the design of the PLD chambers and transfer-line shall enable the integration of these tools in a later stage.

The PLD facility is to be used as a user facility. That is, a facility that will be used in a multi-user environment (researchers, students and industrial partners) for a wide range of applications. Therefore, robustness, user-friendliness, flexibility and applicability range are important factors besides accurateness and reproducibility of the experimentation results.

In Appendix 1, the requirements of the PLD cluster line are presented. In-situ diagnostic tools and in-situ storage are not within the scope of this document.

Procurement department
The provision of professional procurement support for the processes and projects of DIFFER is the province of the Procurement Department of DIFFER. The Procurement Department implements project-based procurement processes and (European) tenders, which means it is involved in this process - and in this market consultation - right from the start.

Market consultation explanation
A market consultation is the process of exchanging information with interested parties about a proposed invitation to tender, organized by the contracting authority, based on which the latter can determine the feasibility and the preconditions of the contract to be awarded. A market consultation could also be about obtaining information on - or insight into - possible solutions to a problem. Market parties may also actually be asked for ideas. For the contracting authority, the consultation could also provide insight into how best to design the tender procedure.
Market consultation can take one of a variety of forms: closed or open consultation, written or verbal, interactive or non-interactive or a combination of both.

Objective & Scope
This is the market consultation for a Pulsed Laser Deposition (PLD) system.
Please note that this is a market consultation and not an invitation for a Tender.
DIFFER wants to start a market consultation before proceeding to tender.

With this market consultation DIFFER wants to find out:
- the number of possible suppliers in the market
- if the possible suppliers can deliver the described equipment, meeting the demanded technical specifications and requirements.
- an indication of the price for the specific PLD system.

Motivation of the Investment
One major bottleneck for the (inter)national energy materials community is the lack of a suitable research infrastructure that allows the processing of complex (metal oxide) thin films with high-quality, well-controlled, and tunable compositions and structures, including fast and reliable process development. We therefore want to build a PLD user facility which enables such studies and accelerates progress in this

field. The specific objectives for the requested PLD user facility with several vacuum chambers and multiple *in-situ* diagnostics (plasma, surface, structure and composition) are:

- Gaining a better understanding of the triangle 'film growth, materials properties, and functions' by combining multiple *in-situ* diagnostics in one single tool. This will enable new strategies to develop optimized materials and structures, tailored processing of energy materials, and better selection of materials for specific energy applications, such as fuel cells, electrolyzers, and batteries
- Fabricating high-quality, well-controlled thin films for
  a. *in-situ* and operando investigation of reaction mechanisms
  b. demonstrator size applications with commercial substrates and larger deposited areas than typically used in PLD research devices
- Enabling component development for characterization of functional properties and integration in industrial systems by additional *in-situ* processing tools
- Generically investigating upscaling from small to larger deposition areas to find the parameters and characteristics needed to enable fast process transfer from small to wafer-size areas (Science Question 4). The unique RI with a small and a large area deposition chamber connecting to the same *in-situ* diagnostics will enable this.

The PLD cluster line is to be composed of a small and a large area PLD chamber that include various in-situ diagnostics, a sputter chamber, an XPS/UPS system, and an (optional) in-situ storage which are all attached to a linear transfer line with a load lock. This research cluster shall enable state-of-the art research on deposition of metal oxide thin films for academic and industrial applications on substrates up to 10 cm in diameter. This will lay the ground for integration of PLD thin films in demonstrator systems and for fast and straightforward upscaling of PLD processes from small to large deposition areas.

Purpose of the questionnaire

Many choices have to be made in preparing for a possible future tender procedure. DIFFER would like to put the questions to the market by means of this market consultation. Suppliers who want to reply on this consultation, need to send in the completed Declaration of compliance with Schedule of Requirements (Appendix 1) by the message (berichten) module of Tenderned **before 10 July 2023 12.00 pm CET**.

Technical questions in relation to the Tendering Platform can be posed by contacting the service desk of Tenderned, which can be reached by the telephone number given below every working day between 08:30 and 17:00.
Tel.: +31 (0)800 836 33 76

Planning

Only through Tenderned you can ask questions related to this document through the message (berichten) module. It is not allowed to contact any other person at DIFFER about this Market Consultation.

Nr.	Process step	Deadline
1.	Publication of the public market consultation	9 June 2023
2.	Closing date for submitting questions	23 June 2023 12.00 hours pm CET
3.	Final date for responding to questions	4 July 2023
4.	Final date for submitting a response on the market consultation	10 July 12.00 hours pm CET

Preconditions

The following preconditions apply to this market consultation:

- This document is intended solely for market consultation purposes; the market consultation is not part of a European tender or procurement process;
- The market consultation is not an invitation to submit a tender for a possible European contract nor a request for a quotation. This market consultation is a form of preparation;
- Participation in the market consultation is entirely voluntary and free of obligation and has no consequences whatsoever on participation in a possible European tender or procurement

process. This means that market parties who do not participate in the market consultation are not excluded from participating in a possible European tender. Nor will market parties who participate in the market consultation be in any way excluded from - or receive preferential treatment in - any European tender or procurement process;
- The parties have no right to reimbursement of any costs that may be incurred within the framework of this market consultation;
- Claims relating to the use of information, confidentiality, or requests for reimbursement in connection therewith, will not be honored. Documents submitted by participating market parties will be regarded as public documents and thus as free of copyright;
- No rights whatsoever may be derived from information supplied within the context of the market consultation;
- Information supplied during the market consultation may differ from information supplied during a later stage within the context of a possible European tender or procurement process;
- In case of a possible European tender, responses to - and the global results of - the market consultation will be recorded in a market consultation report in a fully anonymized form. The market consultation report will be included in the tender documents, thereby respecting the fundamental principles of transparency, objectivity and equality;
- DIFFER retains the right to terminate, either entirely or partially, the process of market consultation;
- DIFFER retains the right to adjust its plans, as recorded in this document, as it sees fit;
- Communication during this market consultation will be in the English language;
- Questions can be send through the message (berichten) module of Tenderned;
- By participating in this market consultation, participating market parties indicate their unconditional agreement with the conditions as stipulated in this market consultation document.

APPENDIX 1: Declaration of compliance with Schedule of Requirements

The supplier is to declare compliance with the Schedule of Requirements. All requirements, except some exception clearly marked, have to be available upon ordering. Proof-of-compliance should be given, e.g. by references.

Mandatory requirements overall research cluster

1. The research cluster is to be a 'user facility' that is open to non-DIFFER researchers as well. As such, multiple people should be able to use the research cluster in parallel without interfering with each other (where the usage of the ablation laser is an exception).
2. The base pressure for the whole research cluster should be at least 10^{-8} mbar.
3. The main components of the research cluster, being the small and large area PLD chambers, the sputter chamber, and the transfer-line, shall all be supplied by the same supplier. For maintenance and support reasons, sub-contracting is not allowed for these components.
4. The main components of the research cluster, being the small and large area PLD chambers, the sputter chamber, and the transfer-line, shall allow bake out, like with a heating tent.
5. The research cluster should support the transfer of substrates to other research infrastructure, such as DIFFER's Ion Beam Facility, under vacuum conditions means of a vacuum suitcase.
6. The research cluster shall be integrated into the DIFFER's lab safety system.
7. All components that impose a possible safety risk, such as fire, have to be CE certified or similar.
8. The research cluster shall enable DIFFER's CODAC system read-access to process parameters, such as chamber pressures and pump speeds (only integration concept needs to be available upon ordering).

Mandatory requirements small and large area PLD chambers

1. The small and large area PLD chambers should at least enable deposition on silicon, silicon dioxide, glass, FTO, zirconia (YSZ), sapphire, and porous oxide (e.g., Ni-YSZ cermet) substrates.
2. The small and large area PLD chambers are to be used for the deposition of metal oxides in first instance.
3. Three repeated depositions should result in three samples where the sample to sample thickness variation is not more than 1% (for both small and large area PLD, consecutive depositions).
4. The small and large area PLD chambers shall ensure thickness uniformity in minimum of state-of-the-art research tools, while other material properties are not affected by the scaling to larger substrate areas.
5. The small and large area PLD chambers shall guarantee a stable, reliable and repeatable process.
6. The small and large area PLD chambers should enable multiple in-situ diagnostics and should therefore have flanges available for attaching the below in-situ diagnostics a) to h). The in-situ diagnostics are not allowed to interfere with the main PLD cluster and to interrupt the operation of the PLD cluster.
    a. Reflection High-Energy Electron Diffraction (RHEED)
    b. Mass Spectroscopy (MS)
    c. Optical Emission Spectroscopy (OES)
    d. Intensified Charge Coupling Device (ICCD)
    e. Low Angle X-ray Spectroscopy (LAXS)
    f. Phase-Modulated Infrared Reflection Absorption Spectroscopy (PM-IRRAS)
    g. Multi Beam Optical Stress Sensor (MOSS)
    h. Spectroscopic Ellipsometry (SE)

    Diagnostics a) through b) are to be supplied with the research cluster. Diagnostics c) through h) are to be added by DIFFER in a later development stage. The cluster supplier should be willing to discuss with in-situ diagnostics suppliers for the integration of the in-situ diagnostics in the research cluster.
7. The ablation laser should be shared among the two PLD chambers.
8. The ablation laser beam path shall be enclosed and purged and guarantee stable and reproducible beam delivery, ease of maintenance and laser control.
9. The large and small area PLD chambers should have an identical flange layout, such that, if needed, the two chambers can be (in time) equipped with the same diagnostics at the same position to study upscaling and to provide flexibility in usage of diagnostics on both chambers.
10. The small and large area PLD shall have separate operating and control systems that shall include preprogrammed process recipes (process modules). Recipe settings must be easily configured by the operator for customization of processes.

Mandatory requirements small area PLD specific

1. The small area PLD shall enable the heating of 1 inch substrates to at least 1000 degrees Celsius using laser heating.

Mandatory requirements large area PLD specific

1. The large PLD shall enable the heating of 4 inch substrates to at least 900 degrees Celsius using radiative heating.
2. The large PLD shall enable the in-situ diagnostics of the full substrate surface. Hence, one should be able to do measurements at any position on the substrate surface. (concept needs to be available before ordering)
3. The large area PLD chamber should be equipped with a means to reduce the amount of target particles/droplets that contaminate the substrate with 99.8%.
4. The research cluster should support materials screening experiments. That is, it should support the creation and characterization of multiple discrete films on a four inch wafer which are sufficiently large to enable film characterization. This is considered to be a desirable feature to reduce cost per film and to reduce the time to obtain the right process conditions ('sweet spots')

and material combinations for detailed studies. Both are essential to ensure high quality cost effective research output. (concept needs to be available before ordering)

Mandatory requirements sputter chamber specific

1. The sputter chamber should enable sputtering on substrates up to 4 inch in diameter and of up to three different materials.
2. The sputter chamber should be equipped with a Quartz Micro Balance (QMB)
3. The sputter tool should enable the usage of a mask to do selected thin film deposition.

Mandatory requirements linear transfer-line with load-lock specific

1. The linear transfer-line shall enable the simultaneous transportation of at least three four inch substrates and at least five one inch substrates.
2. The linear transfer-line shall be extendable in case DIFFER wants to add additional vacuum chambers to the cluster line in the future.

Mandatory requirements for engineering support during the system life-cycle

1. Onsite physical engineering support with qualified PLD expertise within 48 hours during regular working hours.
2. At least 2 years of free software updates after the last acceptance test
3. At least 1 year of replacement warranty on all major components of the research cluster after the last acceptance test

Preferred requirements regarding experience of the supplier

1. Experience with PLD systems in which the PLD laser is shared among multiple PLD chambers.
2. Experience with the inhouse design and realization of custom vacuum chambers.
3. Experience with the inhouse design and realization of substrate and target motion stages.
4. Experience with the design and realization of linear transfer lines.
5. Experience with laser heating of 1 inch targets.
6. Experience with small and large area deposition.
7. Experience with particle/droplet reduction in large area deposition.
8. Experience with integration of RHEED in PLD.
9. Experience with support and maintenance of a PLD cluster line over the entire life cycle of such cluster line for both hardware and software.

The supplier also gives a price indication for the PLD system as described in this document, delivery duty paid in Euro (excl. VAT).

Name of undersigned	
Position	
Supplier	
Signature	
Town/city and date	