

Compact Stand-alone Laser Plasma Reflectometer for Process Control of EUV Lithography Mask Blank Multilayer Coatings

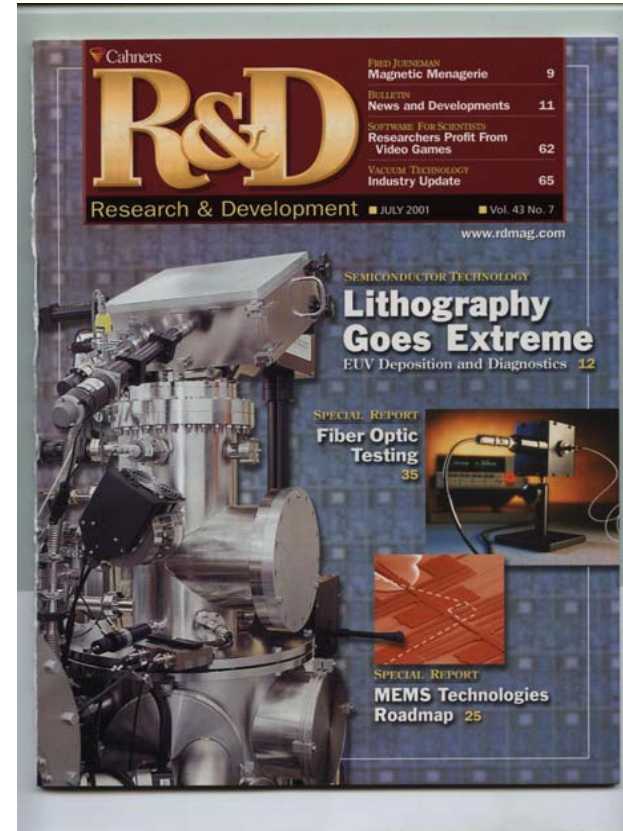
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EUUV Technology

www.euvl.com

About EUV Technology

- **EUV Technology manufactures custom R&D instrumentation for the utilization and analysis of short wavelength EM radiation – soft x-rays & EUV.**
- **We specialize in metrology and calibration tools for EUV lithography.**
- **We have pioneered the approach of providing EUV calibration equipment that can be installed on the shop floor**



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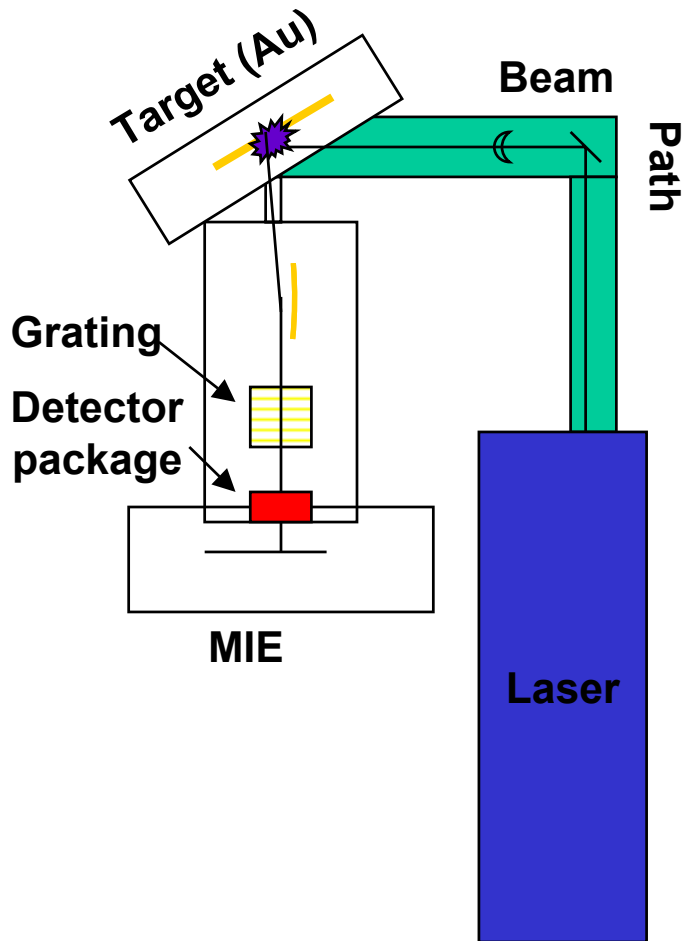
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- **The first LPR1016 Reflectometer was purchased by EUV LLC delivered and installed at Lawrence Livermore National Laboratory in September 2000.**
- **June 2003, EUV Technology was selected by International SEMATECH, to build a stand-alone EUV Reflectometer for the ISMT's NanoFab 1 EUV mask blank facility in Albany, New York.**
- **EUV Technology is one of the few companies with the expertise and intellectual resources to build a tool of this type.**

Goal

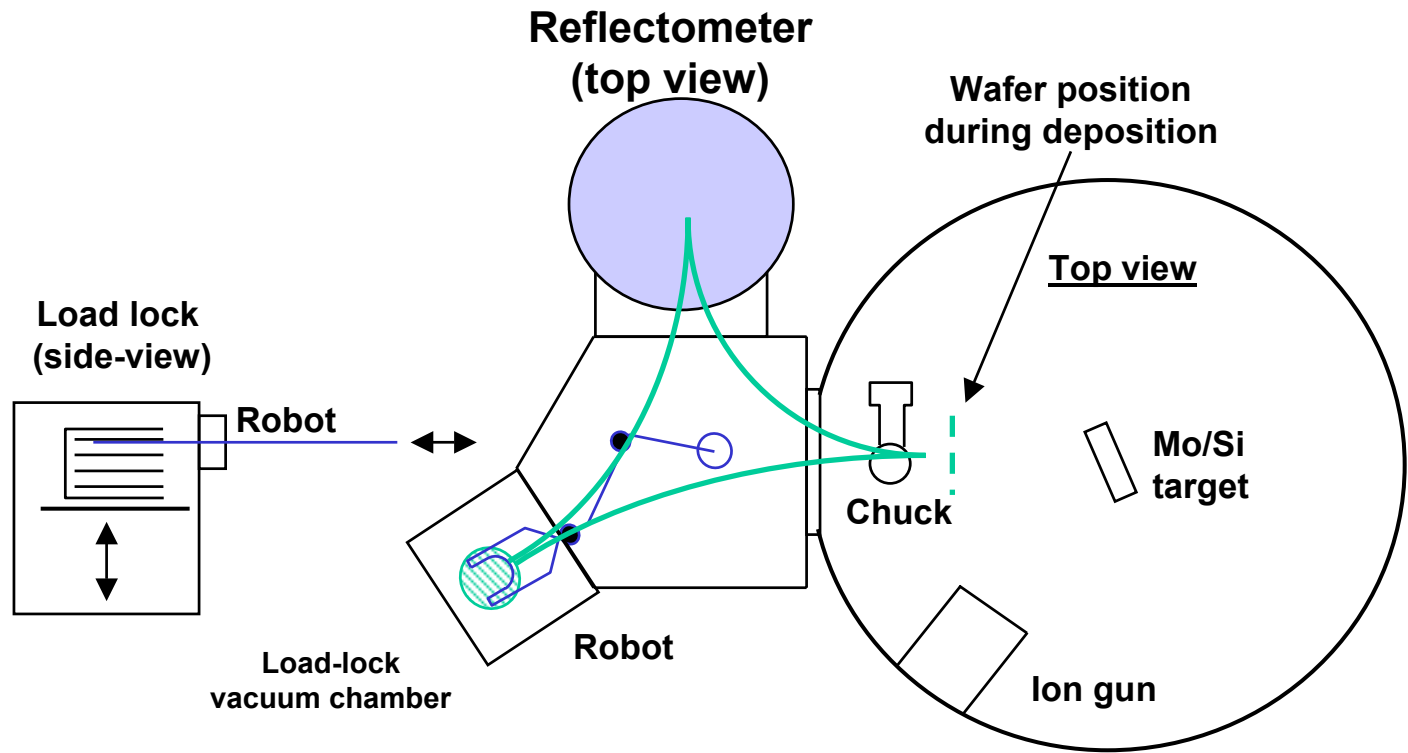
- **To provide a method of quality control of mask blanks by defining a process monitoring concept that meets the needs of mask blank production.**
 - **Test, calibration and quality control equipment that can be installed and used on the shop floor.**
 - **Accuracy sufficient to monitor and evaluate the entire coating process at the customers manufacturing facility without the mask blank ever having to leave the clean environment.**
 - **Difficult to achieve high yield without fast feed back.**
 - **No printable defects**
 - **Wavelength control**
 - **Reflectance uniformity across the wafer**

Operating principle of our EUV Reflectometer Model No. LPR1016 purchased by EUV LLC



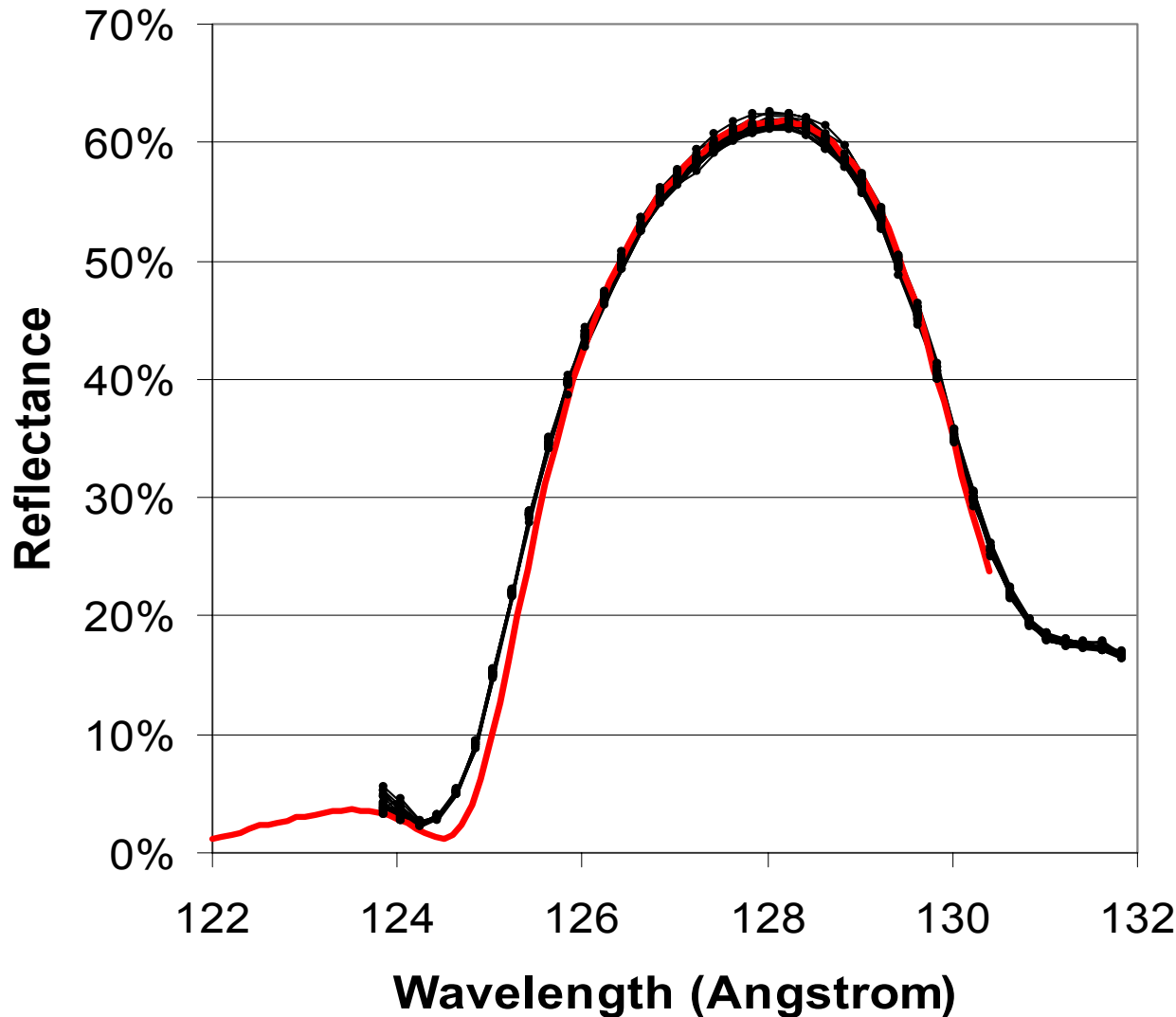
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Reflectometer is installed on a spare port of the LLNL LDD cluster tool to allow tight integration and automated measurement



- Can measure one wafer while the next is coated.
- Automated measurement of every blank possible.
- Small footprint, self contained system: Fab compatible.

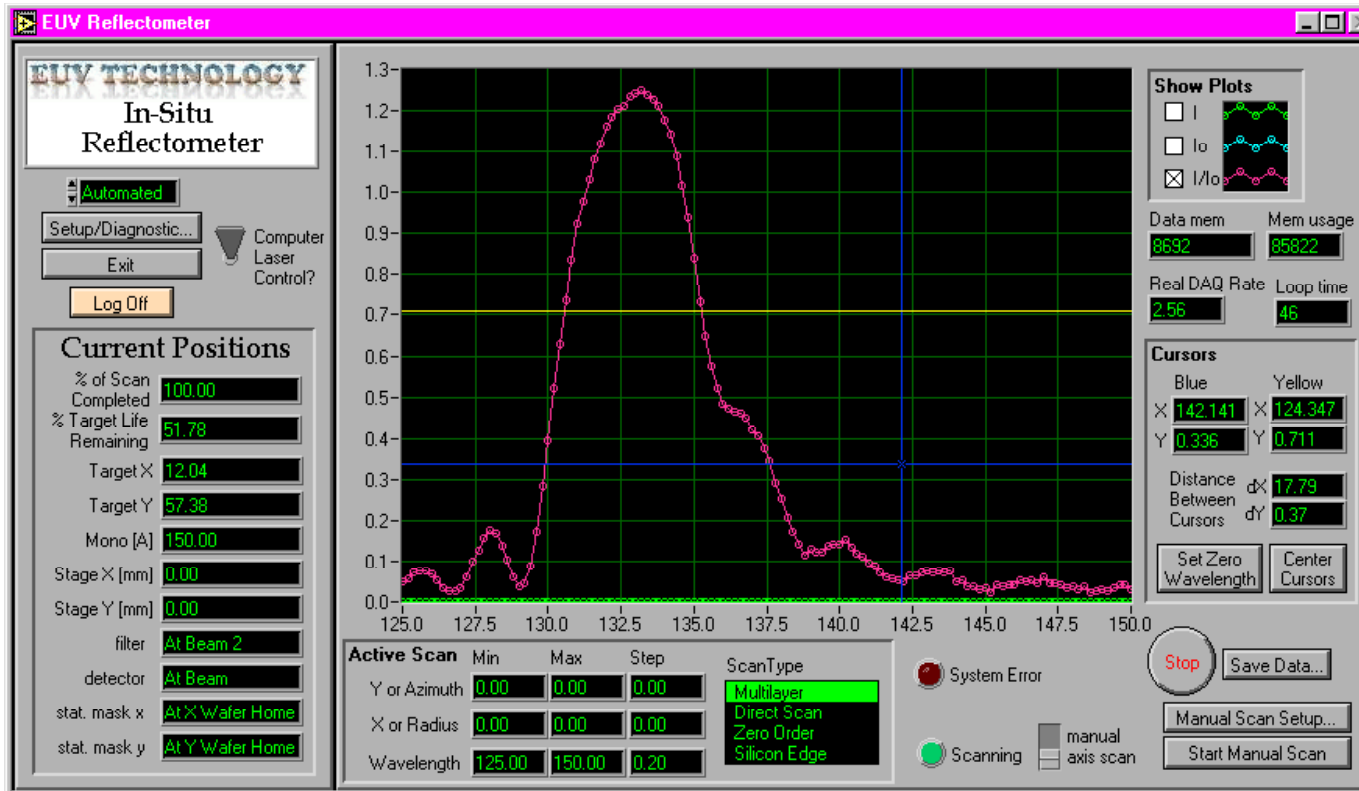
EUV Reflectometer Model No. LPR1016 reflectance measurements agree with the ALS:



- 20 LPR scans
 - ALS
- Measurement area: 200 mm
 - Data rate – about 2 points/sec
 - Data to be obtained at 1 laser shot per point
 - Less than 30 sec per measurement.

User friendly software was designed to be used in a cluster tool

- Written in LabView.
- Fully integrated with LDD control system.
- Measurement recipe is wafer selectable just like deposition recipe is.
- Allows both full automation and manual control.



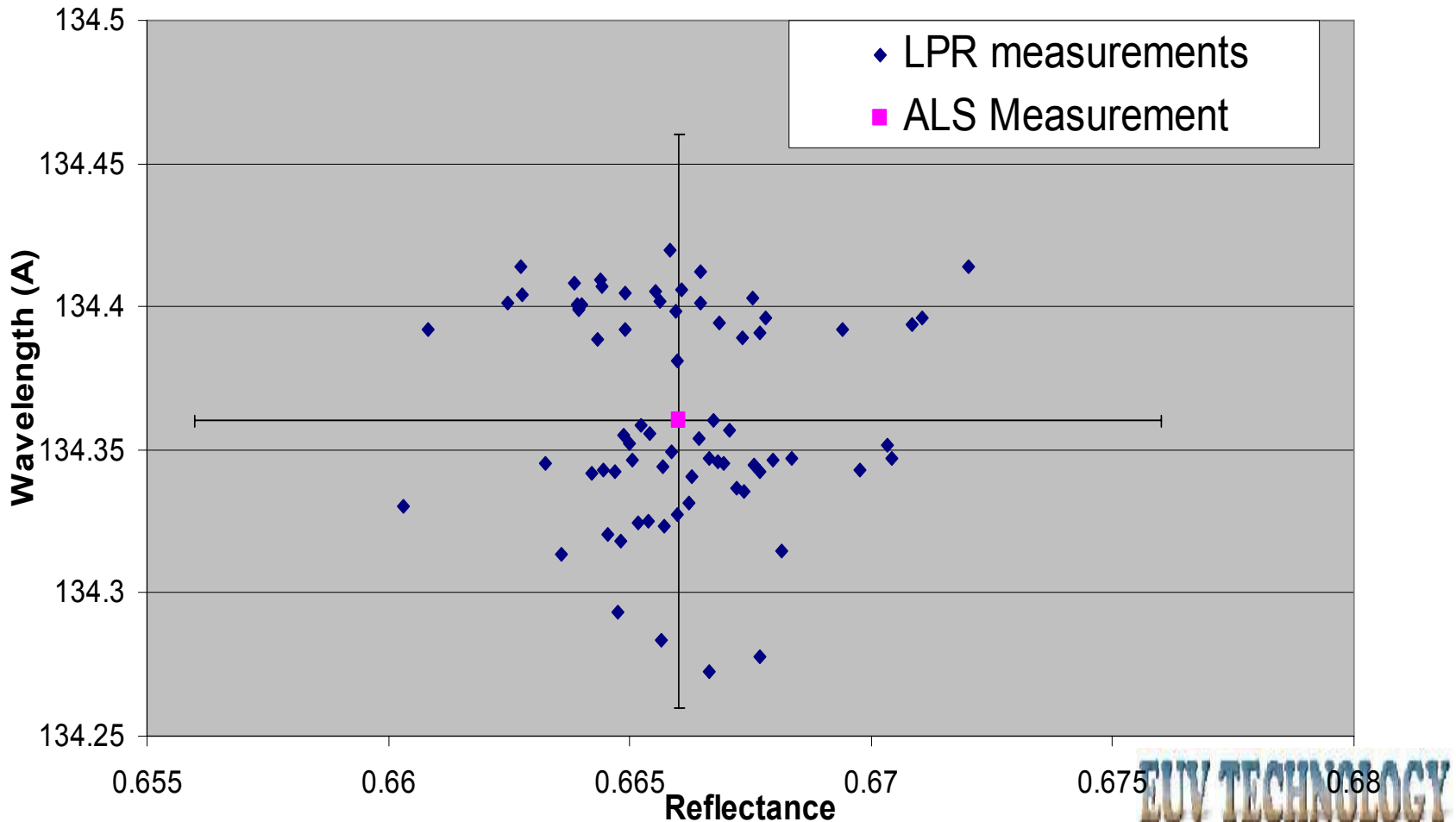
Only EUV reflectivity measurement facility in the world “clean” enough for mask blanks

- Mask blanks do not leave the clean environment for measurement.
- Defect levels on wafers with both single and multiple (20×) wavelength scans were statistically indistinguishable from samples that remained in the load-lock.
- They all had average added defect levels of 0.004 cm^{-2} (1 added defect).

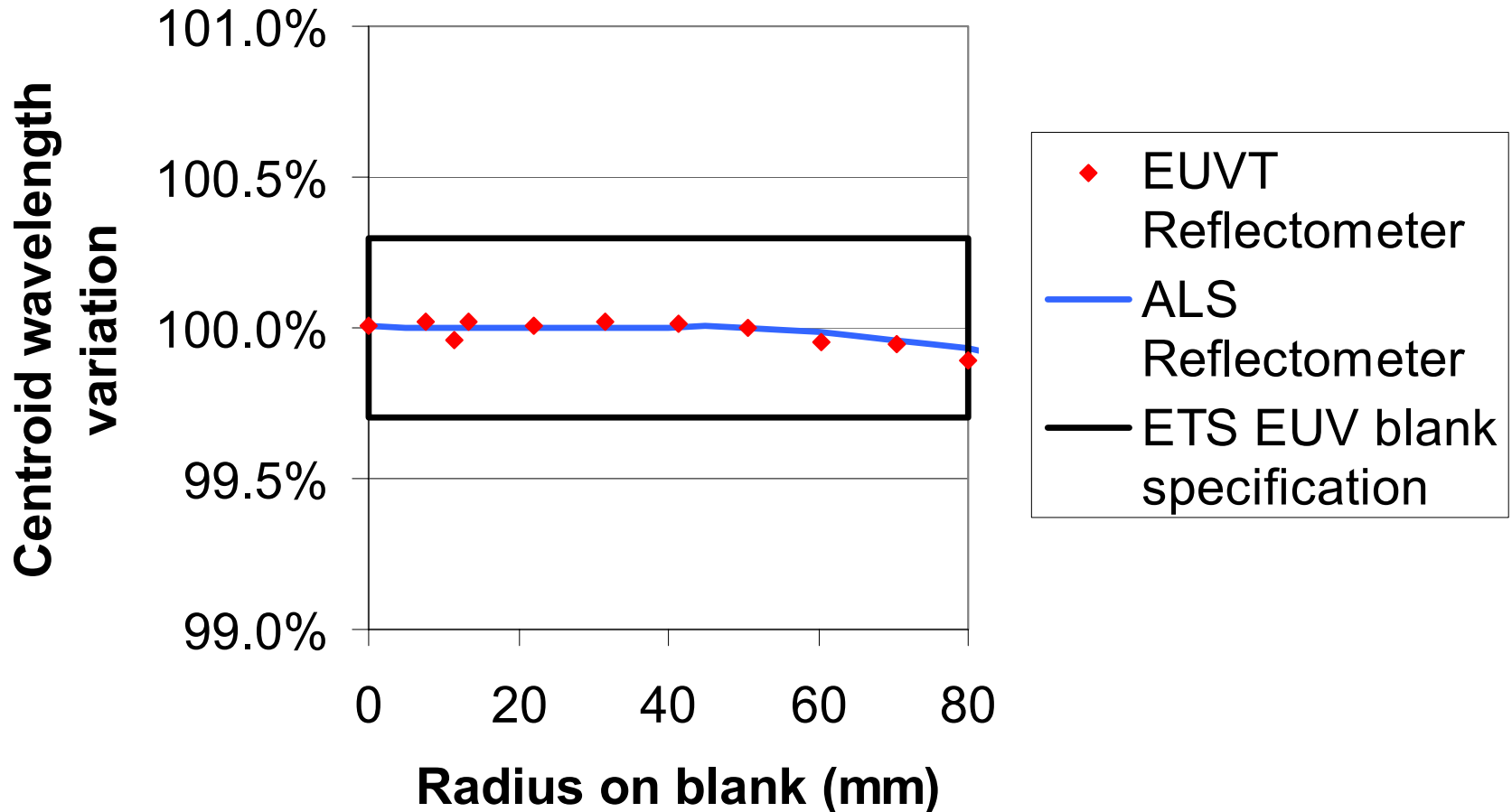


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Recent results from LPR1016: 72 consecutive multilayer reflectivity measurements - P. Kearney (LLNL) 10/02



The first EUV reflectance measurement of a standard square mask blank produced in LLNL's LDD tool were made with our Reflectometer – They agreed well with later measurements at the ALS



Summary of Recent results from LPR1016:
72 consecutive multilayer reflectivity
measurements - P. Kearney (LLNL) 10/02

- Wavelength accuracy and reproducibility (1σ): 0.0037 nm (0.028%)
- Reflectivity precision (1σ): 0.22% (absolute); 0.33% (relative)
- No added defects

Specifications of the EUV Reflectometer

Model No. LPR1016-FS1515

- Substrate dimensions- 152 mm x 152 mm x 6.25 mm.(6” sq.)
- Measurement area – 147 mm x 147 mm of the mask blank.
Positioning accuracy of 0.1 mm to mask edges.
Reporting accuracy of 0.1 mm to mask edges.
- Measurement spot size – 3 mm diameter.
- Wavelength range – 10 to 16 nm.
- Wavelength resolution – 500
- Wavelength precision & accuracy (1σ) – < 0.005 nm (0.04%)
- Peak Reflectivity Resolution(absolute) – < 0.1%
- Reflectivity precision absolute (1σ) – less than 0.5% compared to a reflectivity standard measured at ALS.
- Peak reflectivity capability – 10 to 100 %



Specifications of the EUV Reflectometer

Model No. LPR1016-FS1515

- Data rate – 1 point/sec or greater at 1 laser shot per point.
Capable of data averaging over several pulses.
 - Multiple measurements on a single reticle.
- Can obtain a complete reflectance measurement in 30 seconds.
- Over 2500 reflectance measurements without changing the laser target.
- Laser target can be replaced in less than 30 minutes.
- Throughput for 10 measurement sites per mask – more than 4 masks/hr.
- Footprint of the instrument is about 2.0 m by 2.5 m.



Specifications of the EUV Reflectometer

Model No. LPR1016-FS1515

- User friendly LabView based software to control the instrument and to analyze the reflectance measurements so that a less skilled personal can operate it.
- Recipe handling, manual parameter setup from GUI and remote accessible.
- Out put – peak reflectivity, FWHM, centroid wavelength and period (d-spacing) of the mask blank multilayer coating as a function of the position in Excel or .CSV
- Fixed angle of incidence range (from normal)- 6 degrees
- Angle of incidence precision- less than 0.05 degrees.

Specifications of the EUV Reflectometer

Model No. LPR1016-FS1515

- MTBF > 500 hours.
- Extremely reliable cassette-based, MESC compatible vacuum mask blank handling transfer system to load the mask blanks from a standard container (RSP 200).
- Particle adders - < 0.06 cm⁻².
- Clean-room compatible.
 - (can reside in a class 1 clean room)

Service Support

- We will train the operator to perform basic, routine maintenance
- We stock critical long-lead items such as gratings, slits and mirrors.
- Laser: Services directly from the manufacturer.
- Also, we can have a person on site within couple of days.

Design philosophy:

- The system will be designed using industry standard products by reputable suppliers.
- Technical support is key during the development of a new tool.
- Technical support perspective was strongly weighted in our decisions on subcontractors for subsystems.
- Semi specs and conventions will be applied in all aspects of the tool.

Front End

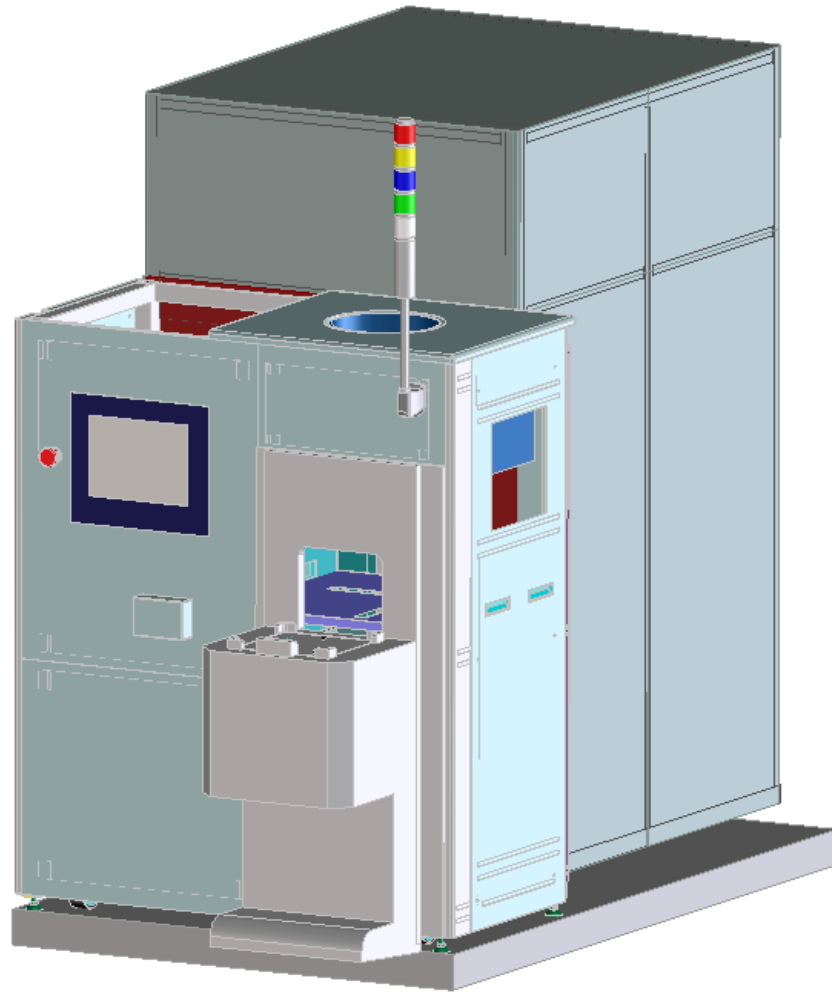
- BOLTS compatible opener, a standard product from Integrated Dynamics Engineering.
 - The opener will expose the reticle to a class 1 HEPA filtered environment
 - A three axis robot will remove the reticle from the opener and place it into a dual axis SEMI MESC compatible load-lock and delivery system.
- Load-lock, a modified version of the Transfer Engineering Teammate, single substrate loading system.
 - The door and gate valve of the load-lock are VAT products. Pumping and gauging are from Pfeiffer.

SLS 200Bolts compatible 200 mm SMIF pod loader

- SEMI and CE certified
- Fast load/unload time
- High reliability
- Compatible with SEMI E19 and E63 for reticle POD management.
- Standard compliance: SEMI E19; SEMI E63; SEMI S2-00; SEMI S8-95
- Cassette presence sensing

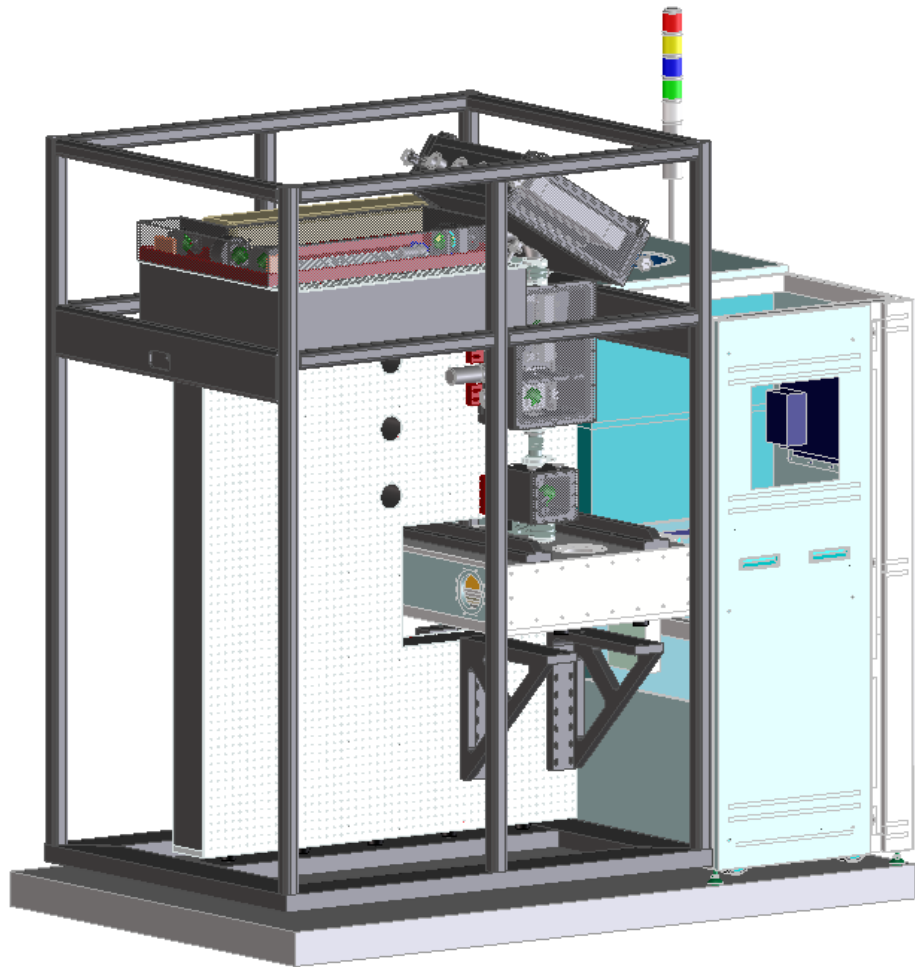
SLS 200 Technical Specifications

- Dimensions H x W x D 1395 x 470 x 430 mm
- Loading height 900 ±10 mm
- PWP < 10⁻⁵ particles/cm²/pass.
- MCBF 500000 cycles
- MTTR < 30 minutes
- Weight 66 kg
- Open/close time 12 seconds
- Power supply 24 VDC
- Compressed air N/A



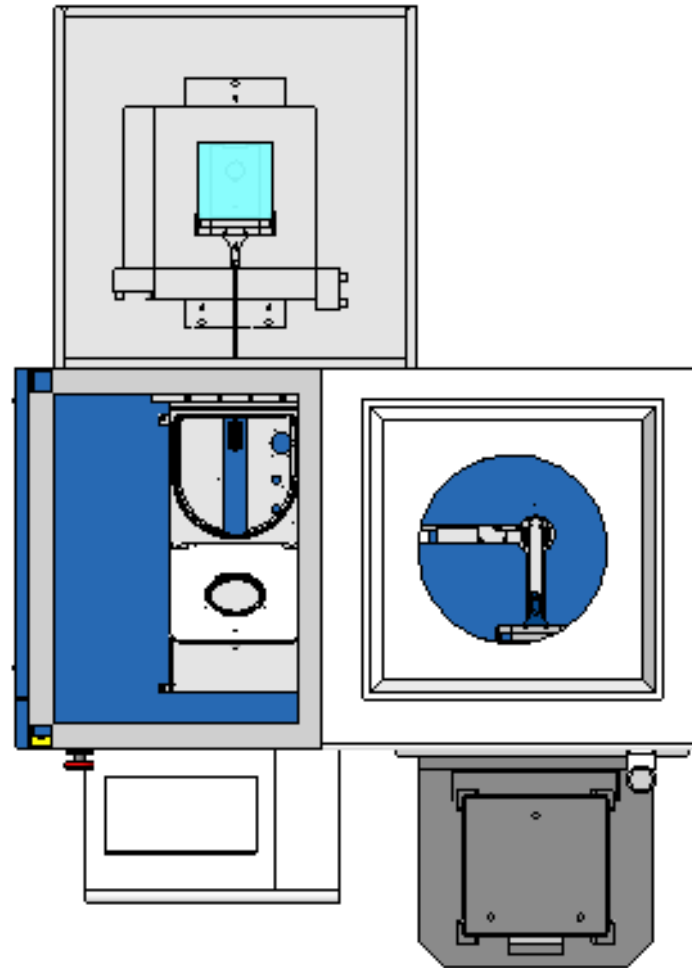
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Conclusions

- **Demonstrated performance of the commercially available in-line EUV Reflectometer Model No.LPR1016**
 - Wavelength to $\pm 0.1 \text{ \AA}$
 - Reflectance to $\pm 1\%$
 - Add no printable defects
 - Fab compatible
 - Set up time is considerably faster (less than 1 min)
 - Turn around time is even faster (about 5 min)
 - Time per measurement comparable to SR facilities
 - Can be installed and used on the shop floor
- **Laser Plasma Reflectometry is clearly a viable option for mask measurement**
 - Need SR facilities like ALS, HIT, PTB etc. to make accurate EUV measurements and for standardization.