Current Capabilities at the Metrology Light Source

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PTB’s Metrology Light Source (MLS)

630 MeV electron storage ring
Synchrotron radiation from THz to EUV

PTB owned,
HZB* operated

*Helmholtz-Zentrum Berlin,
formerly BESSY

2004
2006
2008
2011

user operation
completion of exp. stations
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<tr>
<th>Year</th>
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Outline

• **Operation**
  - *special operation modes*
  - *standard operation*

• **Instrumentation**
  - *experimental stations ("beamlines")*
  - *single instruments*

• **Applications**
MLS design parameters

- electron energy
  105 MeV to 630 MeV
- electron beam current
  1 pA (1 electron)
  to 200 mA (2\cdot10^{11} electrons)

synchrotron radiation
calculable by
Schwinger theory
\[ \Phi = \Phi (W, l, B, \sum y, \psi, d, r) \]

(J. Schwinger, 1949)

e.g. calibration of Single Photon Avalanche Diode, see talk of I. Müller
MLS as primary source standard

Calculable radiation source = primary source standard

special operation modes:
variable energy
variable ring current
variable electron bunch length

Bunch length variation

Special operation mode: Coherent synchrotron radiation (CSR) emission in the THz spectral range

incoherent emission
(bunch length $s > 5$ mm)

coherent emission
(bunch length $s < 1$ mm)

Power $P$

number of electrons $N$

$P \sim N$

$N \approx 10^8$ electrons per bunch!

The MLS has a dedicated electron optics design for the CSR mode
Intensity gain in CSR mode

... by more than 3 orders of magnitude at $\lambda = 1$ mm ($\nu = 0.3$ THz)
HZB team optimizes operation for:

**Special operation**
- flexibility
  - primary source standard
  - spectral tuning
  - radiant power tuning
  - CSR mode for THz

**Normal operation**
- stability
  - detector calibration
  - reflectometry

At the MLS, easy switching of operation modes is possible!
Synchrotron radiation beamlines operating in the spectral range from the THz to the extreme ultraviolet (EUV) regime

Experimental stations at the MLS

operational before 2011:
# 1a IDIR, 1c IDWL, 1e
# 2b DWL direct beam
# 4 UV/VUV
# 5 IR
# 6 THz
# 7 Diagnostics
Synchrotron radiation beamlines operating in the spectral range from the THz to the extreme ultraviolet (EUV) regime

Operational end of 2011:
- # 1d IDB
- # 2a UV/VUV source cal.
- # 3 EUV
Undulator radiation beamline

U180:
- tunable radiation from EUV to IR
- high intensity
- high linear polarization

Monochromator beamline:
- combined NI / GI geometry,
  wavelength range 4 nm to 400 nm
- under commissioning
- prospected applications:
  cryogenic radiometry
  EUV/VUV spectroscopy, ellipsometry
Source calibration beamline

- Calibration of transfer source standards to MLS (spectral intensity, spectral radiance)
- Combined GI / NI geometry in rotatable set-up for extended wavelength range 7 nm to 400 nm (BESSY II: 40 nm to 400 nm)
- 6 gratings in revolver mounting
- In operation from end 2011 onwards
Source calibration beamline

- Calibration of transfer source standards to MLS (spectral intensity, spectral radiance)
- Combined GI / NI geometry in rotatable set-up for extended wavelength range 7 nm to 400 nm (BESSY II: 40 nm to 400 nm)
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EUV beamline for reflectometry

- (extended) EUV reflectometry
- wavelength range 5 nm to 50 nm (BESSY II: 0.7 nm to 35 nm)
- higher flux for $\lambda > 20$ nm than at BESSY II
- adjustable spot size at sample position
- reflectometer: currently at BESSY II,
  user operation at MLS from (end of) 2012 onwards

focal image at the beamline for different slit sizes

0.1 mm  0.5 mm  1 mm
Instrumentation at MLS

Basic tasks:

• Spectral responsivity: 5 nm to 400 nm
• Spectral intensity, spectral radiance: 7 nm to 400 nm
• Reflectance/transmittance: 5 nm to 400 nm

+ applications (spectrometry etc.)
Detector based radiometry

Electrical substitution cryogenic radiometer as detector standard

Comparison of MLS calculated radiant power with power measured by radiometer

Optimized for VUV radiation
100 mK/µW sensitivity
120 s time constant

Conclusion

• MLS user operation since 2008:
  continuous improvement in normal operation & special operation

• MLS experimental stations:
  first set-up phase finished by end of 2011, 12 endstations in operation

• Applications & new capabilities: still to come!
Acknowledgement:
HZB MLS Team
PTB co-workers

Thank you