Hard UV coatings for free electron laser

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Country	Storage Ring	Minimum wavelength
France	SuperACO	300 nm
Germany	DELTA	420 nm
Italy	ELETTRA	**218 nm [3]**
Japan	UVSOR	238 nm
	NIJI-IV	212 nm
USA	Duke University	194 nm

Table 1:
Table of operating Storage Ring FEL's

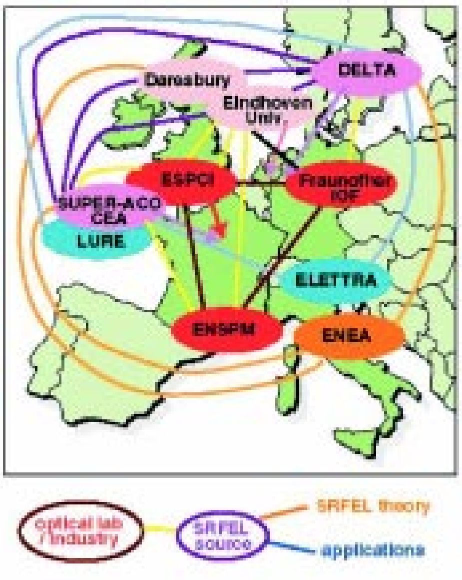

Fig. 1:
EU Network "Storage Ring Free Electron Lasers down to 200 nm" Fraunhofer IOF manages and coordinates the optical task.

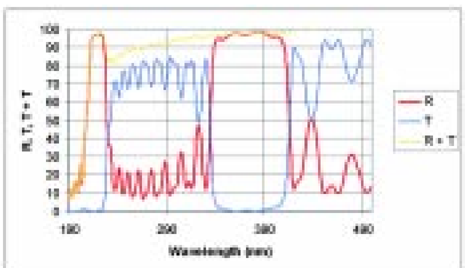

Fig. 2:
Dual Band Mirror HR @ 220 nm and 380 nm designed for the Elettra Storage Ring Free Electron Laser.

Free Electron Lasers (FELs) are tunable sources of monochromatic and coherent radiation delivering high peak and average power. FELs have the great advantage of being easily tunable in wavelength as well as being able to achieve very high average and peak powers without material breakdown. Being intense and tunable light sources in the UV/VUV range, they can fill the gaps in the wavelength regions covered by conventional lasers.
At the moment, there are only six operating storage ring FELs in the world and in all these facilities (listed in Table 1), there is a continuing effort to reduce lazing wavelength and improve the quality of the FEL as an advanced light source for scientific applications. In particular, tunable and reliable operation with high power below 200 nm is a very important target since it cannot be presently obtained with conventional lasers.
In the context of a EU network, Fraunhofer IOF is working for the three European SRFELs, leading and coordinating a large R&D program for the design of prototype FEL mirrors. Indeed, it is crucial to produce high reflectivity and robust mirrors in order to optimize the extracted power required for most of the applications. The front mirror of the laser cavity receives not only the first harmonic where the lasers operates but all the synchrotron radiation emitted by the undulator: a wide spectrum extending towards X-rays. These short wavelengths are responsible for the mirror degradation which results from changes in the coating materials (high induced absorption, color centers, heating ...) as well as from carbon contamination.
For Fraunhofer IOF Jena, Plasma and Ion Assisted Deposition techniques had provided dense films of low absorption also in the UV region close to the electronic band gap of the oxide materials (SiO_2, Al_2O_3, HfO_2) which were employed with very good results. The degradation tests have been successfully validated at both the synchrotron facilities Super ACO (Orsay, France), Elettra (Trieste, Italy) and Delta (Dortmund, Germany). Checked tests have proven the good robustness of IOF mirrors able to maintain their reflectivity even under extreme environmental conditions /1/, /2/ such as synchrotron radiation.
More over, in May 1999, the Elettra FEL, "third-generation" synchrotron radiation facility, lazed at both 356 nm and 220 nm /3/ using IOF dual band mirror (Fig. 2).
The lowest tuning range achieved was 217.9 nm – 224.1 nm. New designs are currently in fabrication. As shows in table 1, "218 nm" is yet actually the third world record, just behind the Japanese and the American machine.

References

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"European Project to Develop an UV/VUV FEL Facility on the ELETTRA Storage Ring"
Nucl. Inst. Meth. A 429 (1999) 179-184 R., R. Walker et al. "The European UV/VUV FEL project at Elettra" EPAC 2000, Vienna.