DEPARTMENT OF INFORMATION ENGINEERING
UNIVERSITY OF PADOVA

Extreme ultraviolet multilayer coatings with improved spectral filtering for solar observation applications

Reflective X-rayOptics

Suman M.[1,2], Pelizzo M. G.[1,2], Windt L. and Nicolosi P.[1,2]
[1] Department of Information Engineering, University of Padova, via Gradenigo 6/B 35131 Padova, Italy
[2] CNR-INFM Laboratory for Ultraviolet and X-Ray Optical Research , via Gradenigo 6/B 35131 Padova, Italy
[3]Reflective X-ray Optics LLC, 1361 Amsterdam Ave., Suite 3B, New York, NY 10027, USA

ABSTRACT: In In recent years telescopes based to multilayer mirror technology have been employed in missions dedicated to the Sun observation in EUV wavelengths. Performances of multilayer are mainly evaluated in term of peak reflectivity at working wavelength and rejection capability of unwanted lines.

Mo/Si multilayer are conventionally used for their high stability, but, when the structures are optimized for the 28.4 nm, the reflectivity is broadband and include the unwanted strong HeII line. A more narrowband solution has been obtained through an a-periodic design or using other material combinations.

We propose an innovative method for designing suitable capping layer covering the multilayer which do not affect the reflectivity peak while rejecting unwanted lines. The capping layer solution can be adopted both in case of periodic and a-periodic multilayer, made by different materials. Thank to its flexibility, the design tool can provide innovative solutions with important improvement that can strongly affect the capability of the future solar instruments.

We show and discuss theoretical and experimental results of some coatings designed by the use of the new mathematical tool.

For more information: sumanmic@dei.unipd.it

ANALYTICAL DESIGN METHOD

Basic principle

If a layer is grown at the node-position of the standing wave field intensity distribution the performance of the structure results essentially insensitive to the cap-layer absorption coefficient.

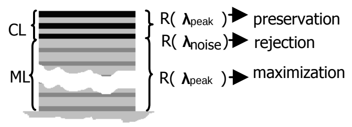
M. Suman et al., Applied Optics, Vol. 47, Issue 16, pp. 2906-2914 (2008).

Design method

ML → structure made of last layers covering the ML, which is λpeak designed in order to preserve the λnoise wavelength signal and suppress the wavelength signal

CL → coating sub-structure constituted by the repetition of two or more materials designed in order to obtain the best reflectivity peak at the λpeak wavelength

Objectives



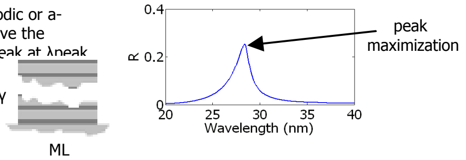
λpeak → useful wavelength

λnoise → rejected wavelength

Step 1

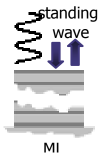
Design of the ML (periodic or a-periodic) in order to have the maximum reflectivity peak at λpeak

parameters optimized → period , γ



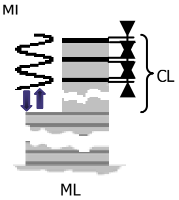
Step 2

Computation of the standing wave in the ML structure for λpeak wavelength, and also computation of the standing wave in the ML structure at λnoise wavelength



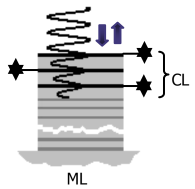
Step 3

Optimization of the thicknesses and the number of the CL layers by growing the absorber layers into the λpeak standing wave nodes in order to preserve the reflectivity at the λpeak wavelength and as close as possible to the anti-nodes of the λnoise standing wave in order to efficiently reject the contribution at this wavelength



Step 4

Finally we optimize the CL layers and the ML period and γ parameters in order to improve the ratio R(λpeak)/R(λnoise) while keeping high peak reflectivity.



SIMULATION OF SOME RESULTS

(blue) → standard periodic reflectivity
(black) → optimized multilayer reflectivity

Simulations performed by IMD program

Case 1

Objectives parameters

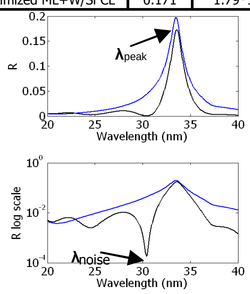
ML	CL	λ_{peak}	λ_{noise}
Mo/Si	W/Si	33.5	30.4

Multilayer structures

CL Structure	Value
W	2.0 nm
a-Si	16.5 nm
W	2.2 nm
a-Si	16.5 nm
W	2.0 nm
ML structure	**Value**
Period (a-Si/Mo)	18.2 nm
Ratio	0.89
Period number	35

Results

	$R_{33.5\ nm}$	$R_{30.4\ nm}$
Standard periodic	0.197	0.044
Optimized ML+W/Si CL	0.171	$1.79*10^{-4}$



Case 2

Objectives parameters

ML	CL	λ_{peak}	λ_{noise}
Mo/Si	Al/MgF2	28.4	30.4

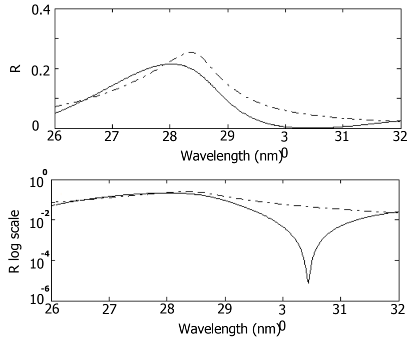
Results

	$R_{28.4\ nm}$	$R_{30.4\ nm}$
Standard periodic	0.25	0.045
Optimized ML + Mo/Si CL	$0.1953.7 \cdot 10^{-5}$	$0.1953.7 \cdot 10^{-5}$

Multilayer structures

CL Structure	Value
MgF_2 (thickness)	5 nm
Al (thickness)	10.25 nm
MgF_2 (thickness)	3.5 nm
Al (thickness)	25.4 nm
MgF_2 (thickness)	3.5 nm
ML structure	**Value**
Period d(a-Si/Mo)	15.33 nm
Ratio a-Si/d	0.77
number of periods	35

▪ ▪ ▪ Standard periodic
▬ Aperiodic



Case 3

Objectives parameters

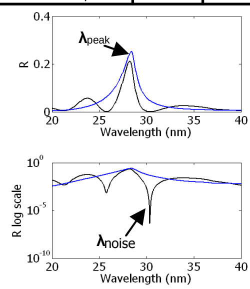
ML	CL	λ_{peak}	λ_{noise}
Mo/Si	Mo/Si	28.4	30.4

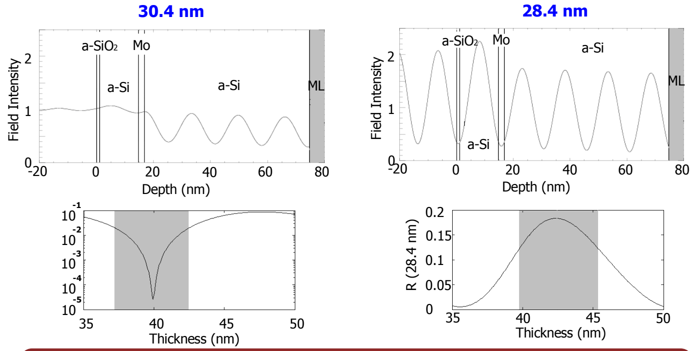
Results

	$R_{28.4\ nm}$	$R_{30.4\ nm}$
Standard periodic	0.25	0.045
Optimized ML + Mo/Si CL	0.196	$2.62*10^{-5}$

Multilayer structures

CL Structure	Value
a-Si	14.7 nm
Mo	2.2 nm
a-Si	57.75 nm
Mo	2 nm
ML structure	**Value**
Period (a-Si/Mo)	151.5 nm
Ratio	0.868
Period number	35





EXPERIMENTAL RESULTS

Multilayer structures

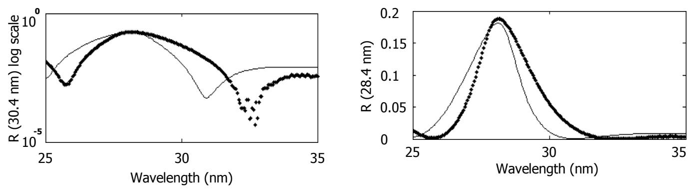
CL Structure	Value
a-Si	15.4 nm
Mo	3.55 nm
a-Si	41.2 nm
Mo	3.55 nm
ML structure	**Value**
Period (a-Si/Mo)	153 nm
Ratio	0.768
Period number	40

ML+CL structure performance is critically dependent on the optical constants of materials, accordingly an optimized structure design has been derived using the optical constants experimentally measured and reported by Tarrio et al. [Applied Optics, Vol. 37, (1998)]. A prototype of this sample has been deposited (RXO) and tested. The reflectivity has been measured with a laser plasma facility D. L. Windt et al. [Journal of Vacuum Science Technology B 12, (1994)].

Objectives parameters

ML	CL	λ_{peak}	λ_{noise}
Mo/Si	Mo/Si	28.4	30.4

▪ ▪ ▪ Experimental data
▬ Theoretical calculation



DGaO Proceedings 2009 – http://www.dgao-proceedings.de – ISSN: 1614-8436