

# Design of high reflectivity multilayers laser mirrors



Science

KEYWORDS :

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## ABSTRACT

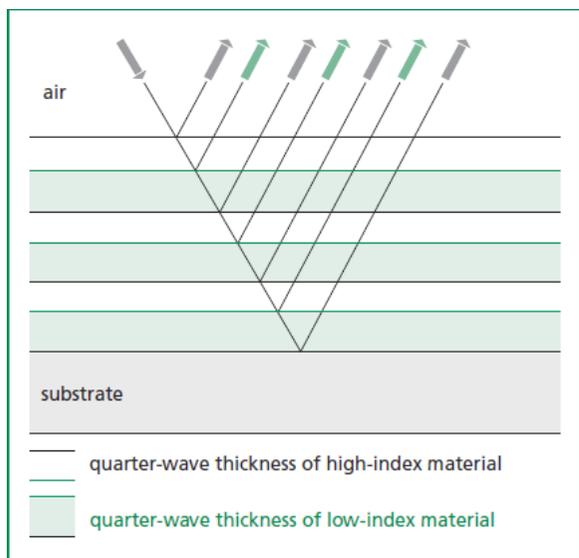
*In this research, a theoretical study to design high reflection mirrors which used as an output coupler for cw laser resonator have been established the (open filter) to study the multi-layers coating on (BK7) substrate From the results, the (maximum reflectivity was 98%) for mirror with (five layers) form (InSb+InAs). While the reflectivity become (90%) for mirror number of (GaAs+InSb) with the same number of layers. By use the MATLAB program, the reflectivity against the number of coating layers have been and studied. Finally we can get the maximum reflectivity when the optical thickness of coating layers quarter wave length and at this value the change in reflectivity become less.*

### 1-Theoretical concepts

When two or more light waves interact, they superimpose and form a resultant wave amplitude depends on the phase difference of the incoming waves. If the waves interfere constructively with a phase difference of the resultant wave has a maximum intensity. If the waves interfere destructively with a phase difference of  $\pi$ , the resultant wave has a minimum intensity. Optical coatings manipulate this interference characteristic to control the reflected wave intensity an incident light reaches an air-film interface[1]. Some of it reflecting waves back to the air and some of it transmits into the film. The transmitted part refracts in the film and reaches a film-substrate interface. Some of it reflects back to the air and some of it transmits into the substrate. The two reflected waves which are generated at the film-air interface and the substrate-film interface interact and produce a resultant reflected light waves. The intensity of the net reflected light depends on the optical thickness of the film[2] these process are shown in fig (1) Optical thickness  $t$  of a film is given by :-

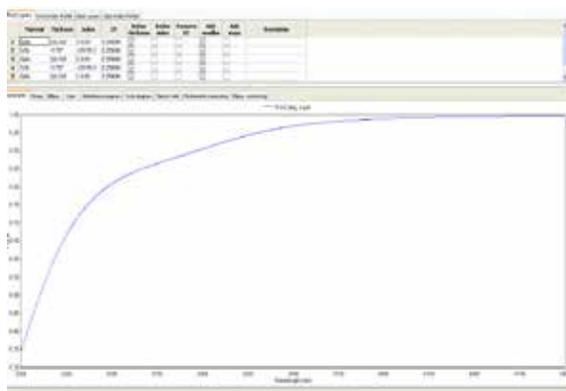
$$nd = \lambda/4 \dots\dots(1)$$

where (  $n$  ) is the refractive index and (  $d$  ) is the physical thickness of the film. If the optical thickness of the film is a quarter wave, the phase difference of the two reflected wave They become out of phase and interfere destructively, then the net intensity of the reflected wave is at minimum[3].



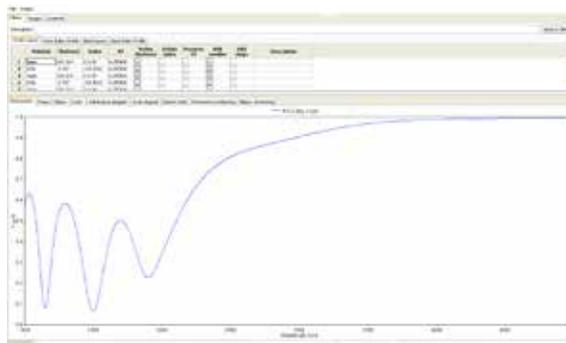
### 2-The results and discussion:

The basic structure is a multi-layer stack of alternately high index and low index thin films, with thickness one-quarter at the design wave length. we used the two material (GaAs) and (InSb) as high and low index materials respectively deposited on BK7 substrate. reflectivity when we calculated the reflectively as a function of wave length we obtain the figure(1-a)



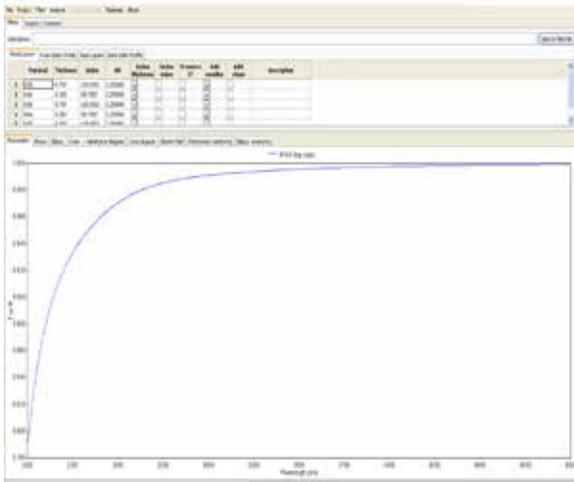
**Fig (1-a).shows the reflectivity characteristics of the multi-layer stack with wave length**

The arrangement of materials was BK7 HL HL With H (GaAs) and L(InSb) layers being one quarter wave thick at 3000 nm .In fig (1- a) notice that reflectance is directly proportional with the wave length .And (1-b) we can see that the peaks represent the maximum value of reflectively correspond the wavelength value.



**Fig (1b)shows the reflectivity characteristics of the same multilayer stack with different wavelengths**

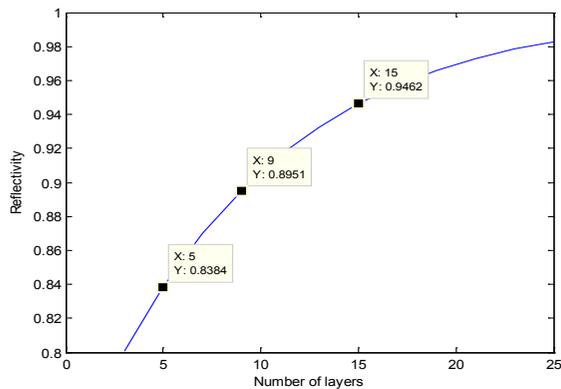
**Fig(2) Shows the reflectance characteristics of the multi-layer stack deposited BK7 HL HL H With the H(InSb) and L (InAs) layers being one quarter thick at 3000 nm**



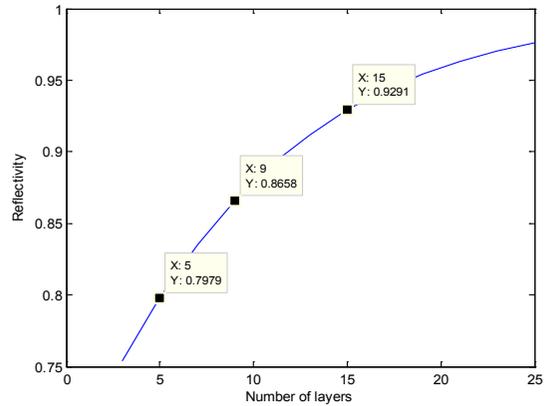
**Fig 2.shows the reflectivity characteristics of the multilayer stack with wave length**

From fig (3) and (4)we notice that the number of layers for materials (InSb+InAs) and (GaAs+InSb) proportional with reflectivity .in other Word the values of reflectivity increase with the number of layers as shown in this eq.

$$R = \frac{(n_2^{2(B+1)} - n_1^{2(B-1)})}{(n_2^{2(B+1)} + n_1^{2(B-1)})} \dots \dots (2)$$



**Fig (3) shows the number of layers for material (InSb+InAs) proportional with reflectivity**



**Fig (4) shows the number of layers for material (GaAs+InSb) proportional with reflectivity**  
from the table, notice that the relation between the number of layers and the reflectivity for the materials that used for mirror (GaAs+InSb) and reflectivity for (InSb+InAs)

InSb+InAs	GaAs+InSb	Number of layer
83.84	79.79	5
89.51	86.58	9
94.62	92.91	15

show that the sample (InSb+InAs) is prefer on the sample (GaAs+InSb) because can get the required reflectivity with less number of coating layers .that is very important at the design and fabricate the laser mirrors The increasing of coating thickness(number of coating layers) exposed the films for the more stress and become more brittle from the films that have little thickness.

**3-Conclusions**

When we studied the effect of number of layer and the type of coating material on reflectivity we can conclude the following :

- 1- The reflectivity increases when incident the wave length increasing, reaches Until reach to the maximum value (3000) nm and still stable at (90.4)nm
- 2- increasing the number of layers to (9) notice that the reflectivity is sharply increases with the wave length increase and reaches to the maximum (100%) for wide range of wave length from (2000-5000)nm for the sample (InSb+InAs),the reflectivity of five layers is (98.5%) at the (3000)nm.

**REFERENCE**

[1] Nave, C.R., Hyper Physics, <http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/antiref.html>,GeorgiaState University, 2005. (Visited 1st November, 2005) . [2] Baumeister, Philip and Pincus, Gerald, "Optical Interference Coating", Scientific American, Vol. 223, pp59, December 1970. [3] Flory, François R., Thin Films For Optical Systems, New York: Marcel Dekker, Inc., 1995 .