Optimization of Thin film for the design of H-Alpha Filter

L.Jegan Antony Marcin
Research Scholar,
Sathyabama Institute of Science and Technology,
Chennai – India.
jegan25@hotmail.com

N.M.Nandhitha
Professor & Dean,
Sathyabama Institute of Science and Technology,
Chennai – India.
nandhi_n_m@yahoo.co.in

R.Kural Mathi
Final Year UG student,
Sathyabama Institute of Science and Technology,
Chennai – India.
kuralmathirajendran@gmail.com

Abstract: Electrical power plays an important part and it is a critical contributing element for most of the developments. Numerous power plants are accessible for the production of electrical energy and the most significant power sources are coal, solar power, wind, atomic, gas, Biomass, and so on. Power is also produced from plasma which is an ionized gas. It is said that while producing power from plasma because of some unprecedented reason the plasma begins to deteriorate which leads to the emission of enormous amount of gases including H-alpha which is of wave length 656.3 nm and it is necessary to design a filter to detect the H-alpha discharges. In this paper, a filter design for the H-alpha emission is discussed.

1. Introduction

Aditya Tokomak is device at INSTITUTE FOR PLASMA RESEARCH in GUJARAT in INDIA utilized for the generation of power. It is being worked for over a decade. It was authorized in 1989. It has a major radius of 0.75 meters and a minor radius of 0.25 meters. It has a greatest field quality 1.2 tesla created by 20 toroidal field coils divided symmetrically the toroidal way. It has two power supplies, a capacitor bank Power supplies, a capacitor bank and the APPS (ADITYA pulse power supply).
The plasma parameters amid capacitor bank releases are: $I_p \sim 30\text{kA}$, shot length $\sim 25\text{ms}$, central electron temperature $\sim 100\text{eV}$ and center plasma thickness $\sim 10^{19} \text{m}^{-3}$ and the common parameters of APPS operation is $\sim 100\text{ kA}$ plasma current, $\sim 100\text{ ms}$ span, central electron temperature $\sim 300\text{eV}$ and $\sim 3\times10^{19} \text{m}^{-3}$ center plasma density. Various diagnostics utilized as a part of ADITYA incorporate electric and attractive probes, microwave interferometry, Thomas Scattering and charge trade spectroscopy. By utilizing controlled Nuclear fusion reaction, electric current is generated. The plasma is made at high temperature and heavy magnetic field is delivered to perform nuclear fusion reaction. Also the chamber must be kept up at its working temperature. When the temperature isn't kept up and furthermore because of some unusual reasons at the external boundary of the plasma begins to crumble which prompts colossal measure of arrival of gases like helium, carbon, neon, H-alpha, H-beta, carbon emissions, nitrogen, etc. Therefore it is important to locate a symptomatic method to recognize the disturbances so it can be utilized to mollify the discharges in future.

2. Literature Survey

T.FURUKAWA, K. TAKIZAWA, D. KUWAHARA and S. SHINOHARA (2017) in their paper ‘Electrodeless plasma acceleration system using rotating magnetic field method’ have proposed an alternate procedure for quickening the plasma. They have utilized a radio recurrence receiving wire for producing the plasma and they are quickened by RMF reception apparatus which has two sets of coils looking inverse to each other. The RMF parameters like RMF current and furthermore the present stage contrast can be varied. As a result, the warm pushes increments with the expansion in RMF current. Results demonstrates that the age of plasma and speeding up to a higher rate in this strategy.

M.B.CHOWDHURI, J.GHOSH, R.MANCHANDA (2014) in their paper Measurement of spatial and transient conduct of H-alpha emanation from Aditya tokomak utilizing a symptomatic in view of a photomultiplier tube cluster detailed the spatial and fleeting conduct of h-alpha emissions. By utilizing a photomultiplier tube exhibit based spectroscopic, collimated light is gathered from the plasma and the examinations are conveyed out. It is watched that plasma initiated in high field side in common releases of Aditya. The plasma development is coordinated with invalid field area assessed through reenactment.

K.KITTUI, M. M MWAMBURI and F. GAITHO (2014) have revealed the optical properties of Titanium dioxide in their paper ‘Optical Properties of TiO2 Based Multilayer Thin–films Application to Optical Filters’. They have utilized a high refractive list material tio2 and a low refractive file material sio2 . A five alternating stack of these materials acts as a bandpass with notch filters. It is said that as the thickness of the individual layer increases the number of band passes also increases. Transmittance and Reflectance are measured with spectrophotometer which is equipped with sphere coated with barium sulphate. For 375nm the transmittance was 70% and 80% was the transmittance for 617nm, 2500 nm. Reflectance was 34.9%, 9.8%, 30.3% and 98% at
325 nm, 375 nm, 617 nm and 2500 nm respectively. 80% was the highest transmittance and 9.8% was the lowest reflectance realized at 2500 nm for this filter.

LEYSON G.P and GONG H. (2014) their paper ‘Design of Narrow Band pass filters using thin films’ have planned a narrow band pass channel utilizing thin films and furthermore investigated their optical exhibitions. They have talked about a straightforward and fast strategy to ascertain transmittance and reflectance that is done in Abeles method. For their plan, titanium dioxide and silicon dioxide is utilized. The transmittance bend for it a sharp bend and that won’t bolster for high transmission. In order to overcome that, a coupling Fabry-perot channels is used in the arrangement. Now the bend is to a greater degree a rectangular shape and this channel serves useful for high transmittance signals.

SANTANUBANERJEE, J.GOSH, R. MANCHANDA (2010) in their paper on ‘Observations of H-alpha emission profiles’ in Aditya tokomak have described the H-alpha emissions from the Aditya tokomak. From the hydrogen Balmer alpha (656.28 nm) emissions are recorded for a huge plasma discharges using a Czerny-Turner spectrometer. It has eight simultaneous vertically collimated line of sights. The line of sights can be moved along the major radius to detect the emissions from the major-radial directions. Considerable h-alpha emissions are observed in the bulk plasma. Also, a second peak in h-alpha radial profile was also observed.

ASIM KUMAR CHATTOPADHYAY and ADITYA TEAM (2008) in their paper ‘Instability analysis in Aditya tokomak discharges with the help of soft x-ray’ told about their examination at Instability Analysis in Aditya Tokomak. Discharges with the assistance of delicate x-beam have endeavored to dissect the foundations for the disruptions. It is said that Sawtooth motions and other major disruptions are much of the time saw in Aditya tokomak. To know the reasons for these emanations they utilized Soft x-beam tomography. It is really finished with the assistance of a solitary exhibit of finders and it investigations the mode structure of interior disruptions. As a result, the presence of resonance that makes the signal non-sinusoidal are watched and furthermore said that it could undoubtedly couple in reverberation with the mode motions. Finally, it gives the idea that modes and resonance could be the conceivable reason for these disturbances.

DONGHYUN KIM and KIERON BURKE (2003) in their paper ‘Design of a grating based thin-film filter for broadband spectropolarimetry’ proposed a straightforward system for the plan of integrated single-chip grating based thin-film filter. RCWA simulation shows that if the individually designed thin-film spectral and polarization filter are structurally adjusted, then the desired integration is achieved without significant performance degradation.

3. Proposed Method

In Aditya Tokomak, in order to identify the H-alpha emissions a filter is designed. It is said that the wavelength of the H-alpha emission is 656.3 nm which falls in the visible light region. So, it is necessary to design an optical filter. Optical filters transmit light of selective wavelength rejecting all other wavelength. When one or more thin layers of optical materials are coated on the substrate, it acts as an optical filter. Zinc sulphide, Magnesium fluoride, Titanium dioxide, Silicon dioxide, Indium tin oxide, Aluminium doped zinc oxide, Zinc selenide are the materials that are mostly used for optical coating. The working process for the design of an optical filter is described below.

Among so many materials available for optical coating, the suitable material is determined. Refractive index of the material plays major role in it. Both material of high and low refractive index should be used in order to prevent complete reflection or refraction of the light incident on it. For the H-alpha filter design, Titanium dioxide (TiO2) and silicon dioxide (SiO2) are used. Titanium dioxide is basically a tasteless and Odourless white powder of high refractive index and it has a wide band-gap. This material exhibits high transmittance in the visible region (380 nm-760 nm). Its optical properties and colour makes it suitable for optical coating and as opacifiers. TiO2 can be manufactured by different techniques like sputtering, sol-gel, pulse laser deposition, electrode position, etc. This material is cost effective for large area deposition and also pairs up well with other materials compared with other materials available. Silicon dioxide (SiO2) is the most abundant oxide on earth’s crust. It is an amorphous and smooth material of lower refractive index. It is also durable and also it is insoluble in water but plays a major role as it will not get dissolved in nuclear reactor and also these properties makes it suitable for optical coatings.
3.1 Substrate
The materials will be coated on the BK7 glass. It is a high quality optical glass with high homogeneity, low bubble and inclusion rate. It also shows an excellent transmittance in visible and near IR region. Due to their optical properties they are used in lenses, prisms and also most suitable for mirror and filter coatings.

3.2 Number of Layers and their Thickness
The process started with a two layer combination of the materials and many layers of combinations are worked out. For each combination, the thickness of the materials are varied. MATLAB tool plays a very important role for this process. The mathematical formulas for transmittance and reflectance are also framed and worked on Matlab and the transmittance for it is traced. More than number of outputs are obtained for this process.

4. Results and Discussions
The outputs obtained for different layers of combinations for different thickness are given below

Figure 2. WORK DESCRIPTION

- Choosing the suitable Dielectric material for the Design of filter
- Optimizing the number of layers of thin film
- Determining the thickness of each layer
- Obtaining the desired wavelength
- Dielectric Material of appropriate number of layers band thickness for desired wavelength will be deposited on the substrate
- Testing of the filter with appropriate light source and Validation
5. Conclusion

In this paper, the working of the tokomak and the problems during the operation and also the emissions from the tokomak are also discussed. It also clearly says the need for an optical filter. For the filter design, TiO2 of high refractive index and SiO2 of low refractive index are optimized because of their optical properties. From the MATLAB tool, number of layers and thickness of each layer is determined using Transmittance and reflectance coefficient. Many number of outputs of desired wavelength are obtained for various layer combinations and thickness. The suitable output will be used for the design of this optical filter for H-alpha.

References

[1] Asim kumar Chattopadhyay and Aditya Team (2008), ‘Instability analysis in Aditya tokomak Discharges with the help of soft x-ray’.
[2] Beggs, D. M., M. A. Kaliteevski, S. Brand, R. A. Abram, ‘Optimization of an optical filter with a Square-shaped pass band based on coupled micro activities’.
[3] Chowdhuri M. B., J. Ghosh, R. Manchanda (2014)’Measurement of spatial and temporal behavior of H-alpha emission from Aditya tokomak using a diagnostic based on a photomultiplier tube arrays’.
[4] Daniela M. Topasna, Gregory A. Topasna, ‘Numerical modelling of thin film optical filters.
[5] Donghyun Kim and Kieron Burke (2003), ‘Design of a grating based thin-film filter for broadband spectropolarimetry’.
[6] Furukawa, K., K. Takizawa, D. Kuwahara, and Shinohara, (2017)’ Electrodeless plasma acceleration system using rotating magnetic field method’.
[7] Kitui, M. M. Mwamburi, F. Gaitho, (2014)’Optical properties of TiO2 based multilayer thin-films: Application to optical filters, International Journal of thin films science and technology.
[8] Leyson G. P., Gong, H., (2014)’Design of narrow bandpass filters using thin films’.
[9] Santanubanerjee, J. Ghosh, R. Manchanda (2010) ‘Observations of H-alpha emission profiles in Aditya tokomak’.
[10] Tibulaec, S., R. Magnusson,’ Narrow-line width band pass filters with diffractive thin-film layers’.