DESIGN AND IMPLEMENTATION OF C III FILTER FOR MEASURING DISRUPTION IN ADITYA TOKAMAK

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Abstract- The main objective of this project is to filter carbon gas among many other gases emitted from the plasma in Aditya Tokamak. The aim is to measure the disruptions released by plasma due to some unpredictable conditions. C3 filter detects carbon gases from the various gases emitted from the plasma in Aditya Tokomak. The filter is to be designed with 5-6 layers of the material chosen. Then the signal segmentation for transmittance vs. wavelength is to be achieved using MATLAB software.

Keywords: Aditya Tokamak, C III Filter, Matlab.

1. INTRODUCTION

In thermonuclear fusion research using magnetic confinement, tokamak is the most promising candidate to demonstrate fusion as achievable energy source. A tokamak (“TORoidal Kamera MAGnitnaya Katushka” or "Toroidal Vessel with Magnetic Coils”) is a toroidal device which uses a strong toroidal magnetic field, to confine high temperature plasma within the torus for a sufficiently long time. Final goal of the tokamak research is to reach fusion of deuterium and tritium nuclei for production of electricity. In diagnostic signals of Aditya tokomak certain wavelength 464.7 nm is highly significant. Hence it is necessary to analyse the signals throughout the operation of the Tokamak. Range of wavelengths for which a filter is highly reflecting or transmitting can be altered by changing the characteristics of the thin film components. The transmittance is affected by the choice of the dielectric material, thickness of the dielectric layers, number of these layers, angle of incidence light on the filters. The main objective of
this project is to filter carbon gas among many other gases emitted from the plasma in Aditya Tokomak. The aim of this project is to measure the disruptions released by plasma due to some unpredictable conditions. C3 filter detects carbon gases from the gases emitted from the plasma in Aditya Tokomak. The filter is to be designed with 5-6 layers of the material chosen. Various types of filters are available but we are going to use optical filter since it has lots of advantages over other filters. In optical filters absorptive filters and interference filters are most commonly used for the selective transmission light of certain wavelength and helpful in removing harmful UV rays. Its properties describing the changes of refractive index with respect to the changes in the wave length. To prevents mounting difficulties to ensure the optical system performance. Mechanical properties like elasticity for withstanding the highest pressure, density for heaviness, hardness for scratching resistance. Applications like helpful in fluorescence microscopy, spectroscopy, clinical chemistry and imaging. ADITYA TOKAMAK means a Russian word which means confining the plasma in the torus shape. 'Tokamak' means the Magnetic confinement device needed for producing controlled thermo nuclear fusion power. 'Aditya' means Medium sized tokomak installed at the research centre for plasma research. The tokamak is in the torus shape which is a revolving circle in 3D axis containing polloid and toroid.

To contain the hot plasma needed for producing controlled thermonuclear fusion power (i.e.) electricity for generating heat. Deuterium and tritium has been used which has to be heated up to 1000 degree. There is a vacuum placed inside the torus which contains the hot plasma. The hot plasma is maintained in a certain temperature range to avoid disruptions. The horizontal magnetic windings is known as “poloidal field magnet” and the vertical windings is known as “toroidal field magnet”. This magnetic confinement device contains hot plasma to provide thermo nuclear fusion power. Its radius ranges from 0.25m-0.75m.

2. EXISTING SYSTEM

The two dielectric material with high refractive index (ZnS) and low refractive index (MgF₂) selection is made depending on their property and uses. MgF₂ for highly pure, well suited for optical coating, used for many years in anti-reflection and multi layer coatings. It is insoluble and hard if deposited on hot substrate. MgF₂ evaporates cleanly and completely, without out gassing or spitting and leaves a uniform coating on the substrate. Resist to thermal and mechanical shocks. ZnS for its insoluble in water and well suited for optical coating, substrate BK7 glass. They optimized magnesium fluoride by thermal evaporation method. The number of layers of optical coating of dielectric material onto the substrate is optimized to its efficient values, 6 layers are used as dielectric stack. The thickness of each layers in terms of nm optical coating of dielectric material are predicted from the MATLAB tool using mathematical equations. In heuristic method: H alpha (HLHHLH) (th=279, tl=250), H beta (LHLHLL) (th=347,tl=300), carbon III (LHLHLLH) (th=164,tl=107). In deterministic method: (HLHHLH) H alpha (th=561), H beta (th=100), carbon III (th=95).
Thus the results are analyzed with the comparison of wavelength in nm Vs transmittance coefficient.

3. PROPOSED SYSTEM

Thermo nuclear fusion power provides heat to generate electricity. Fusion is the process of fusing two small nuclei together to form a heaviest nuclei. This heaviest nuclei releases some energy. In nuclear fusion, there are two types of reactors stable enough to conduct fusion: magnetic confinement reactors and inertial confinement reactors. The former method of fusion seeks to lengthen the time that ions spend close together in order to fuse them together. Inertial confinement reactors, unlike magnetic confinement reactors, use laser fusion and ion beam fusion in order to conduct fusion. However, with magnetic confinement reactors you avoid the problem of having to find a material that can withstand the high temperatures of nuclear fusion reactions. The heating current is induced by the changing magnetic fields in central induction coils and exceeds a million amperes. Magnetic fusion devices keep the hot plasma out of contact with the walls of its container by keeping it moving in circular or helical paths by means of the magnetic force on charged particles and by a centripetal force acting on the moving particles. The most serious problem caused by magnetic islands is the major disruption, it is the disturbance caused in any event or process. The vacuum consists of hot plasma inside it. Plasma is sometimes the fourth state of matter, sometimes referred to as ionised gas. Disruption is sudden and complete loss of plasma confinement and a collapse of the plasma current, which result in large electromagnetic and pressure forces in the surrounding structure. These generally occur at the sufficiently high plasma density or high plasma current. Due to some unpredictable conditions, disruptions will occur. This disruption leads to the emission of various gases like H alpha, H beta, Carbon, etc., One mechanism for the disruption is nonlinear coupling of two islands which generate a large stochastic magnetic region within the plasma volume destroying the plasma confinement. Magnetic islands, when uncoupled or only loosely coupled to each other, grow on a time scale of milliseconds. This growth rate is too slow to explain the sudden nature of the hard disruption which happens on a microsecond time scale. If, however, two magnetic islands of different felicity were to grow and overlap, The resulting region engulfed by the islands may explosively grow into a stochastic magnetic region of poor confinement. If the initial islands were large enough, a large percentage of the plasma confinement would be destroyed there by terminating the discharge. Thus we are going to detect CHII gases which get transmitted in the wavelength of 464.7nm.
4. HARDWARE ARCHITECTURE

4.1 Titanium dioxide (TiO2):
Its refractive index n=2.4335, extinction coefficient K=0.0001, Appearance-White solid, Odour-Odourless, Melting point-1843°C (116 K), Boiling point-2972°C (245K), Solubility – insoluble, Refractive index-2.488, Density-3.78 g/cm³

Natural occurring mineral (i.e) earth mineral. Helps in thickening, whitening, and lubricating process. It helps from harmful UVA and UVB radiations. It is considered to have no risk to skin sensitivity.

4.2 Silicon dioxide (SiO2):
Its refractive index n=1.4432, extinction coefficient K=0.00002, Appearance-White solid, Odour-Odourless, Melting point-1713°C (1986 K), Boiling point-2950°C (3220K), Solubility – insoluble, Refractive index-1.4585, Density-2.2 g/cm³

Earth mineral containing quartz used to make glasses which helps in providing layers of substrate. No risk to skin sensitivity.

4.3 Zinc Sulphide (ZnS):
Its refractive index n=2.2719, Wavelength : 1.53846 um, Appearance-White solid, Melting point-1850°C (120 K), Boiling point-2230°C (245K), Solubility – negligible, Refractive index-2.3677, Density-4.090 g/cm³

It is an organic compound formed by chemical vapour deposition. It is usually product from waste material. By product from ammonia synthesis using CH4 usage of ZnS thus causes irritation, itching skin. Thus it is poisonous and hazardous.

5. LITERATURE CITED

Bin Alexander et al (2017) analyzed the acceleration of rotating plasma flows in crossed magnetic fields. A solenoid and permanent magnets were used. The change of axial magnetic flux induces an azimuthal electric field that rotates electron and ion flows in different direction, which produces induction acceleration. Using the linearity of the Maxwell equations, the total electric and magnetic fields of the system were presented. The interaction of azimuthal electron and ion flows with the radial component via the Lorentz force leads to the axial acceleration of electrons and ions in the same axial direction. In an axial direction, the twirling plasma flow in a cylindrical vortex are accelerated which resulting In an energy/momentum transfer in the axial direction. This will help in the creation of plasma thrusters [1].

Figure 3 Flow diagram
Scott Robertson et al (2017) modelled the acceleration of plasma from a source region of high magnetic field to a region of lower field. The model combined the electron and ion equations of motion and includes a source term to replenish plasma in the source region, the acceleration from the ambipolar electric field, the acceleration from the magnetic mirror force. The gyro fluid equation for axial motion to finding the acceleration of plasma from a source region in strong magnetic field into region of lower field was obtained. The model is applicable to plasma experiments with helicon sources and plasma processing configurations [2].

Geraldo Roberson et al (2017) constructed an area preserving and integrable map to represent magnetic surfaces with triangularity in single null divertor tokamak. The magnetic surfaces obtained by the map can assume different asymmetric geometries. The shape of cross section of these magnetic surfaces played an important role on plasma stability and confinement in fusion reactors includes trajectory integration method and Equilibrium model. This map can be used to investigate the dependence of stability and deposition patterns in terms of different equilibrium parameters. The application of this methodology permits to obtain the escape patterns of magnetic field lines on the divertor plates [3].

Qin Hang et al (2017) analyzed the experimental advanced Superconducting Tokamaks. A good knowledge of the total plasma inductance was benefitted to map the discharging of vertical magnetic field by Maxwell’s equation. The relationship of vertical magnetic field and line averaged density was derived during flat-top phase for given plasma current. An increase in magnetic strength of vertical field will allow high temperature, high density, high beta and high bootstrap current fraction to be achieved. High confinement mode and long-pulse steady-state operation was an important goal of current magnetic fusion energy research [4].

M.Afsharmanesh et al (2017) simulated the study of the factors affecting the collisional power dissipation in helicon plasma. Plasma density and magnetic field strength were modified to maximize the collisional power absorption in the helicon plasma. Helicon plasma sources were designed to allow helicon wave propagation. Simulations were done for two common types of RF antennas namely; half helix and Nagoya type-3. The simulations were performed with the CST Microwave studio code. The method was reliable. CST code had the capabilities that calculate the power absorption for different antenna types. The power deposition was significantly asymmetric when the ratio was more than a determined value. Asymmetric power absorption was favorable for the efficient ion beam extraction from the helicon plasma [5].

Dingee Yang et al (2017) conducted an experiment to improve the controlling effect of arc plasma and to understand the arc characteristics and the effect of magnetic field on the plasma jets. The Axial Magnetic Field (AMF) is the field of contacts were conducted in a Helmholtz coil. It is used to generate the different external imposed AMF’s. It may lead to transfer of arc column when the composite AMF in inter electrodes to different directions at a certain moment. Appearance of cathode plasma jets was analyzed by three methods. They are appearance of cathode plasma jets, inclination of cathode plasma jets and its mechanism. It can be concluded that the appearance of individual cathode plasma jets can be manipulated by the variation of AMF. It was used to study the interaction between the arc plasma and electrodes. By introducing the external imposed AMF, the composite magnetic field vector direction changed [6].

Denis Eremin et al (2017) developed a model for resonant surface wave excitation in a large CCP reactor. Low pressure plasmas produced in Capacitive Coupled Plasma (CCP) reactors operated were used in large amount in the plasma processing industry. By using the resonant excitation of surface modes that a CCP reactor can support, they explained it. It showed how such modes are triggered and how they were affected the radial plasma density. This paper discussed some aspects of the physics of large scale CCP reactors driven at very high RF frequencies, which might affect uniformity of the plasma density. It was showed that in highly collisional plasmas, the non uniformities caused by the modes disappear due to the large mode damping [7].

6. RESULT AND DISCUSSION

Thus we executed for various layers starting from 2 layer combinations to 6 layers result is much closer to carbon wavelength. We got exact peak for 6 layer combination. All the existing systems proposed using maximum of 2 layers but we are using maximum of 6 layers in order to increase the efficiency. Using of TiO2, SiO2 is cost efficient and hazardless. These are the output closer to our work.
Thus we got the exact output i.e. CARBON III(464.7nm) for 6 layer combination using material like SiO2,TiO2 with thickness of dielectric material of about t1 is 164 and tH is 107 with refractive index of substrate is 1.5240, the refractive index of thin film material SiO2 is 2.4533 and refractive index of thin film TiO2 is 1.3809 with dielectric stack (HLHHLL) FWHM of 2nm.

7. CONCLUSION

In Aditya Tokomak for generation of electric power and various kind of disruption occurring in the reactor due to unpredictable reasons is the Major challenges, in this design identifying a suitable thin film, determining the thickness of thin film, number of layers. The thickness of each layers in terms of nm optical coating of dielectric materials are predicted from the mat lab tool using mathematical equations. The results are analysed with the comparison of wavelength in nm Vs. transmittance coefficient.

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