ON MULTIPACTING-FREE WAVEGUIDE FOR HIGH CURRENT LIGHT SOURCE

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Abstract

The effect of surface roughness on the secondary electron emission from a sandblasted surface is investigated using a Monte-Carlo method. Sandblasted surfaces can significantly reduce the secondary emission yield and have a large sensitivity to the percentage of surface roughness.

INTRODUCTION

Multipactor (MP) presents a serious problem for operation of modern high power microwave device [1]. Where MP occurs, a large number of electrons are generated, consuming the RF power in the system and resulting in vacuum degradation or discharge and metal sputtering [2]. MP has caused frequent trips during the operation of the CESR (Cornell Electron-positron Storage Ring) type waveguide input couplers [3]. MP suppression can be achieved by preventing MP trajectories from forming. In that case, for example the trajectory can be altered by applying static electric filed or a weak magnetic field [4]. However this method does not work in some regions such as where there is strong magnetic field. Clearing surfaces, direct reduction of the secondary electron yield by coating, cleaning the surfaces or by increasing the surface roughness, are a number of possible techniques to suppress MP. The suppression of the secondary electron yield (SEY) with triangular and rectangular surfaces in a magnetic field has been simulated [4-6]. In this paper we study another approach to reduce secondary electron which uses sandblasting on the surface of metal. Our analysis in this paper is based on the Monte–Carlo method which tracks trajectories of the primary and secondary electrons using a wide range of parameters.

MONTE-CARLO SIMULATION

When the primary electron hits the surface, using a series of random numbers to determine its velocity and direction, a number of secondary electrons are emitted depending on the secondary electron emission yield. This process is repeated and, eventually, a large amount of energy is gained from the RF electric field. The vacuum waveguide of CESR RF system is the case where parallel plates can be used for simulating MP inside the waveguide. In our simulation Monte-Carlo method within a parallel plate model is employed using Vaughan's empirical model for the secondary emission yield (SEY). Vaughan proposed a parametric formula of the SEY which allows one to fit experimental data:

$$\sigma(\mathrm{w}) = \sigma_{\max}(\theta)\left[\mathrm{w}\exp(1\text{-}\mathrm{w})\right]^{k(\mathrm{w})},$$

where $\sigma_{\max}(\theta) = \sigma_{\max}(1 + k_s\theta^2/2\pi)$, $\mathrm{w} = W_i / W_m$, $\mathrm{k}_s = 1$

and $\mathrm{k(w)} = 0.62$ for w<1

$\mathrm{k(w)} = 0.25$ for w>1

Our simulation was carried out at the secondary emission yield $\sigma_m = 2.2$ at normal incidence at the energy W_m = 400 eV as in Ref. [7]. The velocity distribution of the emitted secondary electron is Maxwellian with a mean value corresponding to energy of 2eV. The angular distribution of the secondary electrons is assumed to be proportional to $\cos\varphi$, where φ is the angle of the electron direction with respect to the normal to the surface. In our simulation the RF frequency and the gap size are taken to be 500 MHz and 4" respectively. In our Monte Carlo simulation the motion of charged particles is followed in only one dimension while the Maxwellian distribution involves three velocity components. The RF electric field and the secondary electron emission model are described above [1,7]. The charge per electron is kept fixed and the number of electrons varies. We do not consider the effect of the space charge, which is mainly responsible for the saturation of the MP discharge [1]. The number of secondary emissions yield averaged over the number of electrons impacts on the plate is called the final number of electrons (N). N is calculated and recorded in each running of the code. A final number of electrons, N, larger than unity seems to be a suitable criterion for MP avalanche growth.

OUR MODEL

A sandblasted surface is shown in Fig.1. An initial electron whose trajectory in Fig.1 is shown in red hits the surface at point A and produces secondary electrons shown in blue lines. Depending on the emission angle, some of the secondary electrons can move away from the surface. Other secondary electrons could hit an inner side of the rough surface and they are absorbed. In each simulation step the secondary electrons are generated by 3×10^6 primary electrons to provide sufficient statistics.

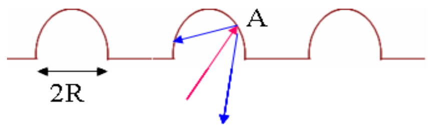

Fig.1 Sandblasted surface is characterized by the radius R.

NUMERICAL RESULTS

The results of the simulation for sandblasted surface with R= 10μ for power= 330KW is shown in Fig.2. As it is shown in the picture, final number of electrons decreases by increasing the percentage of sandblasted surface. It decreases from 235, to a value of about 25 in this case. In Fig.3 we compare results for sandblasted surface with different radii. As it is shown, N is independent from the size of sandblasted surface. In Fig. 4 we have presented simulation calculations for different powers.

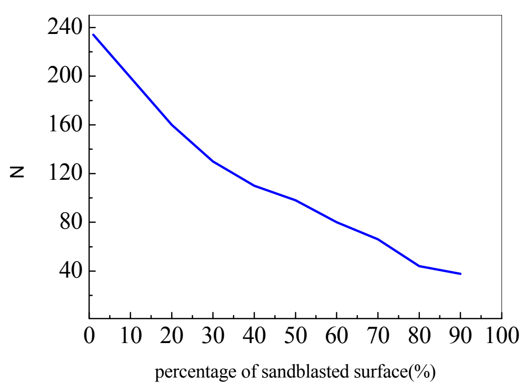

Fig.2: The final number of electrons, N, versus percentage of sandblasted surface for the power 330KW.

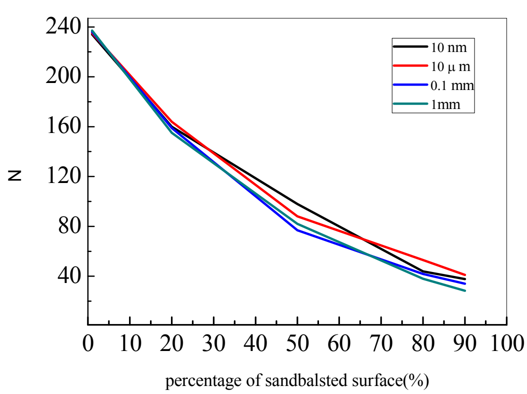

Fig.3: The final number of electrons, N, versus percentage of sandblasted surface for the power 330KW for different radii of spherical model.

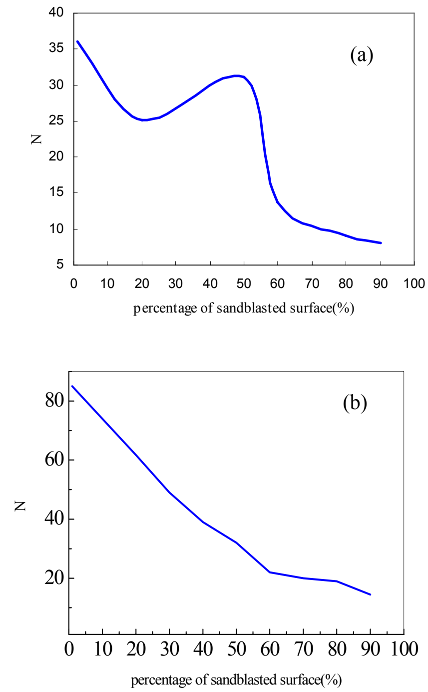

Fig.4: The final number of electrons, N, versus percentage of sandblasted surface (a) power 178KW (b) power 220KW

CONCLUSIONS

The effect of sandblasted surface was simulated using the Monte-Carlo method. It was shown that one could reduce secondary electron yield with a sandblasted surface design of waveguide of CESR RF system. The suppression depends on the dimensionless parameter that states the percentage of roughness of the surface. Because of this independence, we hope the waveguide to be easy to fabricate.

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