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Suppression of secondary electrons off the surface of space-borne particle instrument in energy range of 100 ~ 500 keV

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ABSTRACT

An experimental study of secondary electron suppression is conducted for instruments intended for measuring energy and flux of charged particles. The energy of interest in this study is from about 100 ~ 500 keV for which many important phenomena take place in the Earth's magnetosphere. A special attention has been made to take into account the requirements of space-borne instrument surfaces that are usually derived from other aspects of the development, such as application of black paint on instrument surface for suppression of light scattering. Different methods of surface treatments are compared and employed to the present experiment. The results from the experiment are further analyzed with a comparison of numerical simulation.

1. INTRODUCTION

Modern in-situ observations by utilizing space-borne particle instrument have found that the vicinity of the Earth is dynamically filled with charged particles that are diverse in energy, species, and origin. Charged particles trapped within or beyond the Earth's magnetic fields often interact with instrument surfaces can yield unexpected responses to the detector as a by-product of energy loss of charged particles. In order to reduce the anomaly, a special attention has been made to take into account the requirements of space-borne instrument surfaces that are usually derived from other aspects of the development, such as application of black paint on instrument surface for suppression of light scattering. In case of secondary particle emission, a summary and review of such findings are now available. (Pivi 2008 and M. Ye 2013) These references summarize the test results of secondary electron suppression by manipulating roughened surface with various geometry, material and surface treatments including micro-porous array structure. Further, the result of experiments are compared and analyzed with simulation.

Practically, the energy of interest in this study is from about 100 ~ 500 keV for which many important phenomena take place in the Earth's magnetosphere. The purpose of this research is to analysis through a variety of experiments with numerical

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simulation. The calculation is performed with existing calculation routines such as the GEANT4 (GEometry ANd Tracking) and the SIMION. These tools allow for complicated and elaborate computations of the interaction within the matter while taking into account the real mechanical structure of the space-borne particle instrument structure together with detected charged particles at various locations. In the following section, the results obtained with the method and discussions of the suppression of secondary electrons is described.

2. Applications

The prior task of the experiment is to define and geometrically assess the configuration of the space instrument. When solid state detector having structure, baffles and sensor are contemplated a sample to be analyzed, the parameters that determine the experimental situations are surface status of the structure, baffle thickness and sensor mechanism. Basic configuration of experimental situation can be represented to Figure. 1 including structure, baffles, and sensor. To observe real space environment, charged particles must be directly detected to sensor without any interaction with the structure and the baffles. Such reflection has been found to change the magnitudes of background signals for the detector through straight or secondary particle emission (Kim, Y. 2012).

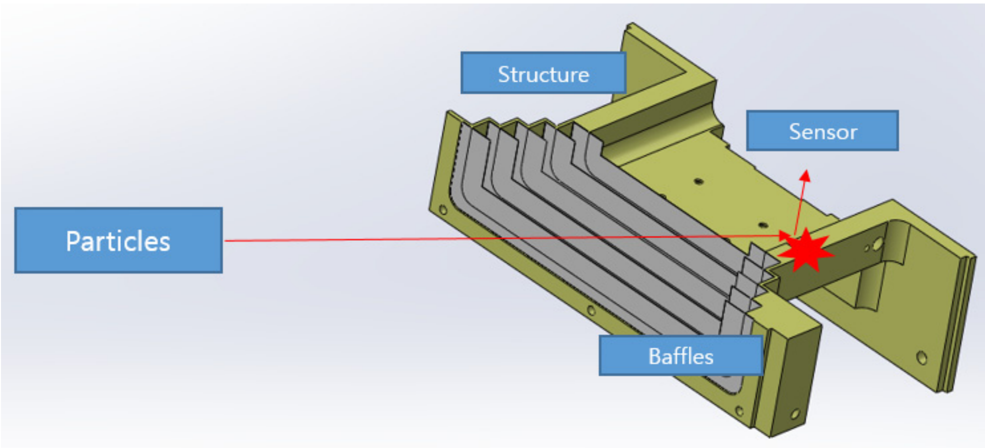

Figure. 1 Configuration of telescope structure and reflected particle incidence

For the purpose of reducing disturbance by background signals, geometry modification of the telescope structure is necessary such as changing the direction of the particle towards the sensor. For example, telescope structure can make to triangular or rectangular with geometrical factor, incident particles reflected to opposite direction of sensor. Look to the classification in the form, to prevent the particles coming towards the sensor relative to the direction of incidence can be considered a sample, such as Figure. 2. Figure. 2 represent four samples of each surface shape. In the sample 1, the ‘x’ is length between start point and end point of triangle, the ‘α’ is angle of triangle. In the sample 2, the ‘c’ is thickness of grooved shape, the ‘e’ is height of the wall, the ‘d’ is width of wall and next. Sample 3 shows similar to sample 1, added to tilt option of the ‘θ’. Sample 4 shows similar to sample 2, added to tilt option of the ‘Φ’ corresponding to sample 3.

Sample 1. isosceles triangle, length x, angle α **Sample 3. Tilted triangle, angle α, angle θ, length x**

Sample 2. rectangle, thickness c, height e, width d **Sample 4. Tilted rectangle, thickness c, height e, width d, angle Φ**

Figure. 2 Configuration of samples for surface treatment

In addition, energy of the particle can decrease depending on the species of surface treatment on telescope structure. (1) Black paint be applied to aluminum surface for reducing light scattering (2) titanium nitride coating, (3) bare aluminum for default result and (4) combination of black paint and titanium nitride coating. The surface treatment and geometry can composite to each other, experimental cases are shown in Table. 1. The ‘α’ and ‘d’ on tilted triangle and tilted rectangle cases are dominant parameters corresponding to direction of incident particles. The ‘α’ is lower, reflecting angle of incident particle is lower. The ‘d’ is narrower, incident particles are confined between wall and next wall.

Table. 1 Sample list and descriptions according to geometry and surface treatment

Materials	Surface	Shape	Description	Remarks
Al 6061	Bare	Flat	N/A	
		Tilted triangle	x: 2 mm, α: 90 ˚, θ: 30 ˚	Sample 3
		Tilted triangle	x: 2 mm, α: 45 ˚, θ: 30 ˚	
		Tilted rectangle	c: 1 mm, d: 5 mm, e: 5 mm, Φ: 60 ˚	Sample 4
		Tilted rectangle	c: 1 mm, d: 3 mm, e: 5 mm, Φ: 60 ˚	
	Black paint	Flat	N/A	
		Tilted triangle	x: 2 mm, α: 90 ˚, θ: 30 ˚	Sample 3
		Tilted triangle	x: 2 mm, α: 45 ˚, θ: 30 ˚	
		Tilted rectangle	c: 1 mm, d: 5 mm, e: 5 mm, Φ: 60 ˚	Sample 4
		Tilted rectangle	c: 1 mm, d: 3 mm, e: 5 mm, Φ: 60 ˚	
	Titanium Nitride	Flat	N/A	
		Tilted triangle	x: 2 mm, α: 90 ˚, θ: 30 ˚	Sample 3
		Tilted triangle	x: 2 mm, α: 45 ˚, θ: 30 ˚	
		Tilted rectangle	c: 1 mm, d: 5 mm, e: 5 mm, Φ: 60 ˚	Sample 4
		Tilted rectangle	c: 1 mm, d: 3 mm, e: 5 mm, Φ: 60 ˚	
	Black paint +TiN	Flat	N/A	
		Tilted triangle	x: 2 mm, α: 90 ˚, θ: 30 ˚	Sample 3
		Tilted triangle	x: 2 mm, α: 45 ˚, θ: 30 ˚	
		Tilted rectangle	c: 1 mm, d: 5 mm, e: 5 mm, Φ: 60 ˚	Sample 4
		Tilted rectangle	c: 1 mm, d: 3 mm, e: 5 mm, Φ: 60 ˚	

3. CONCLUSIONS

Several solutions are analyzed in order to reduce secondary electron emission and particle scattering for application of triangular and rectangular geometry with surface treatment. With respect to secondary particle emission and particle scattering, the samples are sufficiently explained purpose. For each case, grooved geometry and surface treatment should test with computer simulation. We hope that the proposed experimental cases will be of interest for designing a space instrument.

REFERENCES

Pivi, M., King, F. K., Kirby, R. E., Raubenheimer, T. O., Stupakov, G., & Le Pimpec, F. (2008), “Sharp reduction of the secondary electron emission yield from grooved surfaces”, Journal of Applied Physics., 104.10

Ye, M., He, Y. N., Hu, S. G., Wang, R., Hu, T. C., Yang, J., & Cui, W. Z. (2013), “Suppression of secondary electron yield by micro-porous array structure”, Journal of Applied Physics.

McCall, S. H., Pompea, S. M., Breault, R. P., & Regens, N. L. (1993), “Reviews of black surfaces for space and ground-based optical systems”, In San Diego'92”, International Society for Optics and Photonics., 158-170.

Kim, Y., Kim, D., Park, S., Seo, Y., Lee, Y., & Seon, J. (2012), “Computational method for analyzing the cumulative ionizing effect from solar-terrestrial charged particles and cosmic rays with geant4”, Journal of the Korean Physical Society, 61(4), 653-657.