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Effects of a light reflecting layer to the response of piezoelectric PZT elements

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We have studied responses of piezoelectric PZT elements for measuring cosmic dust. This report is aimed at a theme on effects of a light reflection layer to the response of the PZT element.

The BepiColombo mission that explores Mercury and its environment is progressed as a joint project between JAXA and ESA. Since the measurement of dust ambient Mercury is one of the approved programs, the Mercury Dust Monitor (MDM) has been developed onboard the BepiColombo mission (MPO). Because of restricted resources to the MDM, it comprises piezoelectric PZT elements and electronic circuits.

Since the MDM is to be operated around the Mercury orbit, the thermal flow around the PZT element is estimated using a thermal model. The temperature condition under which the element is operated is crucial, because the piezoelectric character should be maintained. In order to overcome this difficulty, we discussed a layer that reflects thermal flow from the sun. The layer is useful to lower temperature down at which piezoelectricity is retained. On the other hand, this layer would considerably affect the characteristic of the PZT.

The effects of the layer on the characteristic responses were experimentally studied by bombarding hypervelocity microparticles with the PZT element. The microparticles were supplied by the Van de Graff accelerator at MPI-K, HIT of University of Tokyo, and the GUN at ISAS.

The PZT element was a square of a 40 x 40 mm2 and its thickness of 2mm. One side of the element was covered with a ˜5 um thick silver layer over the entire surface. At the rear side a 5 x 5 mm2 and ˜5 um thick silver layer was embedded as a collector of induced signal. Thus then, the surface of the silver layer was painted with a paint up to ˜100 um thick. The paint was produced by Ube Kosan C.o. (PETI-330m, high heat resistance material composition polyimide resin). Hereafter we call this paint layer as a white paint.

Output signal from the collector was processed with a charge sensitive amplifier and measured with an oscilloscope. A photomultiplier was set near the element to observe light flashes immediately after collision.
The PZT element was bombarded with microparticles at room temperature. The observed signal forms measured and recorded by the scope were processed in offline analysis. A first one cycle of the signal form was interested in analysis.

The amplitude was plotted against the momentum of the incident particle. Here, let define the sensitivity of the PZT element as the ratio of the increment of amplitude dA to that of momentum dp; dA/dp. Thereby, the sensitivity clustered into three groups. The first group corresponded to the case in which the sensitivity of the PZT element overlapped with that of PZT elements without covering the white paint. There existed the second group that its sensitivity is approximately expressed as a sum of dA/dp and a certain offset. The third group clustered in a region different from those of the first and second groups, and the dA/dp values are considerably small.

At present, it is unclear why the three groups coexist. Except for the first group, the effect of the white paint to the response of PZT element is significant. As an intermediate result, we are interested in the second group that is considered to be significantly influenced by the white paint. Therefore, the present results could be worth reporting, since there are very few reports that the effects of the white paint to the system comprised white paint and the PZT element has been quantitatively discussed.

Keywords: cosmic dust, dust, BepiColombo, PZT