Position Dependent Behavior of a Piezoelectric Lead-Zirconate-Titanate (PZT) Cosmic Dust Detector

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We have developed an in-situ cosmic dust detector covering mass ranging from $10^{-15}$ to $10^{-9}$ kg and velocity from 1 to 100 km/sec in heliocentric velocity. Since resources for a science payload are limited, a compact and light detector is recommended for space exploration. In this sense, we have engaged in developing a cosmic dust detector using piezoelectric lead-zirconate-titanate, PZT. Since the PZT detector is compact and light, it is suitable for an onboard detector onto a spacecraft. When a particle collides with a PZT element, a certain amount of voltage is induced by the piezoelectricity of PZT element. Miyachi et al.¹) studied a relation between incident momentum and output signal by bombarding hypervelocity particles with it.

We use a charge sensitive amplifier as an interface between the detector and the signal processing electronics. A detector capacitance should be matched with an input capacitance of the subsequent signal processing electronics. Because $C_s \ll C_f \times A$ is required, where $C_s$, $C_f$, and $A$ are the capacitance of the PZT, the feedback capacitance and the open loop gain, respectively, we are interested in use of a small collecting electrode that covers a part of the sensor area. Since $C_s$ is expressed as $C_s = \varepsilon S/d$, using the dielectric constant of PZT ($\varepsilon$), area of the electrode ($S$), and thickness of the PZT element ($d$), the capacitance $C_s$ is lowered by reducing $S$. A possible jump of the sensitivity in the vicinity of collector edges is considered accordingly.

In this report, we discuss a sudden change of the detector sensitivity with respect to the position where a particle collides.

Reference