高エネルギー電子照射によるアバランシェフォトダイオードの劣化

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Degradation of avalanche photodiodes by high-energy electron bombardment

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The application of avalanche photodiodes (APDs) as electron detectors has recently been considered intensively, especially for use in space missions. Specifically, APDs have advantage for detection of medium-energy electrons (1-100 keV), compared to MCPs and conventional silicon detectors, in terms of the sensitivity. We, therefore, plan to utilise them for the medium-energy electron instrument, which will be onboard our radiation belt mission ERG (Exploration of energization and Radiation in Geospace). On the other hand, a well-known drawback of APDs in space use is a significant degradation of their performances due to the irradiation by high-energy particles. Typically, the noise level increases due to the radiation damage, and it results in the shift of the lowermost detectable energy toward the higher-energy. For the mission life of ERG spacecraft, the estimated total dose is ˜100 krad for electrons and ˜10 krad for protons (4-mm Al shielding is assumed). Although we have already demonstrated the degradation by high-energy protons in our previous study, the effect of the electron radiation has not been quantified yet. In this study we irradiated four APDs with high-energy (1.5 MeV) electrons and observed the increase of the dark current, which corresponds to the increase of the noise level. We found the average increase rate is ˜0.18nA/krad (under the APD gain of 15) up to around 100 krad, despite non-negligible part-to-part differences (especially for higher dose). This rate is lower than the proton case by about two orders of magnitudes. For the ERG mission, therefore, we conclude the APD degradation by electron radiation is not prominent compared to that by protons.