High-Speed Position-Sensitive Devices: Theory and Experiments

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論文内容の要旨

Today's modern industrialized society has brought to the world a number of goods and services, as well as series of problems related to technological development. The ever increasing industrialization makes it a using of different kinds of radiations as a tool and absolutely necessary to its constantly monitor in factories, laboratories, hospitals, and communications.

In recent years, for monitoring spatially dependent information from the incident radiation Position-Sensitive Devices (PSDs) have received a great deal of attention as alternatives to scanning and array techniques. The technology of this device is so matured that it is extensively used for both photons and charged-particle detections in many terrestrial applications. Compared to the conventional integrated scanning devices such as charge-coupled devices (CCDs), the PSD offers the advantage of a large reduction in measuring time by using non-integrated instantaneous measurement techniques. However, this increasing use of the PSD should not be considered as one without disadvantages. In fact, for some special scientific applications, such as astronautical observations and high energy experiment system, where fast light or energy particles are dealt with, using of conventional PSD (CPSD) may be limited since that benefit is offset by the high value of the RC-time constant. For theis reason, in fast excitation measurements, it has become very important to develop the high-speed PSD (HPSD) or to develop an analytical model for the currently available PSD in order to gain a clear knowledge about the expected performance characteristics of the fast-excitation.

The text of this dissertation is divided into four parts. It opens in Part I (Chap.1) with a broad-brush introductions and a brief theoretical background of the different types of the PSDs that have evolved since Wallmark rediscovery of the lateral photo-effect 33 years ago. Chapter 1 also includes an explanation concerned with the usefulness of high-speed studies of the PSD.

After finishing the introductory chapter, Part II of this dissertation is started. This Part II, Chaps.2 through 3, describes the basic analytical models which are based on the RC-transmission line approximation. The analytical model study starts from the one-dimensional (1-D) PSD and it is included in Chap. 2. It covers a derivation of the generalized model equation and its application to the response analyses for the fast-excitation. The extension of the basic analytical model to the two-dimensional (2-D) PSD is the contents of Chap. 3. It also includes the derivation of the space and time dependent generalized model equation and an assessment of the detection errors for the fast-excitation measurement. The studies included in Chaps. 2 and 3 are very necessary, because in many fast-excitation measurements, the PSD currently available is used frequently. These chapters can provide a clear knowledge about the response to the different kinds of the excitations.

Once the study on CPSD finished, one may proceed on the next part of the dissertation. This Part III, Chaps. 4 through 6, deals with the design, fabrication techniques, and performances of the HPSD, proposed in this study. In Part III, two types of novel structures are described, one of which is for the improvement of CPSD response-speed, and the other is a novel concept for new PSD. The improvement of CPSD response-speed by using a mesh-type resistive layer for reducing the device capacitance is the contents for Chaps. 4 and 5. Chapter 4 presents a detail designing consideration for the MEPSD. It also includes an analysis based on the carrier kinetics for selecting the optimum parameters of the MEPSD. In Chap. 5, a detail fabrication techniques of the MEPSD, based on the metal-insulator-semiconductor (MIS) and the p-i-n junctions are included. Completely low-temperature and high-temperature processes are used for fabricating the MIS structured and p-i-n structured MEPSD, respectively. Chapter 5 covers also the characterization of the low-temperature deposited SiNx film used as an insulator in the MIS structured MEPSD. It should be pointed out that both p-i-n and MIS structured MEPSD are compared with the CPSD, fabricated by the same IC technology. In Chap. 6, a novel concept of the HPSD is presented. This new HPSD consists of the p-i-n based matrix structure in where each element can be excited upon single illumination, and it can yield a positional response logically with illumination. The detail fabrication techniques and performances of this HPSD are included in Chap. 6. It also covers a mechanism of yielding high optical-gain using a single layer amorphous silicon carbide (a-SiC)/amorphous silicon (a-Si) heterostructure based p-i-n junction, which makes each element in the HPSD.

In Part Ⅳ (Chap. 7), conclusions of the above works are given with short explanation of the future extensions which are worthy of investigation. Finally, appendixes are given with full derivation of the complicated equations listed in the main text.