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Determination of Intrinsic Response Times of Electrons and Holes from Avalanche Noise Measurements*

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SYNOPSIS

Characterizing the avalanche properties of diodes with greater precision demands techniques capable of resolving residual inhomogeneities in the junction. Towards this end high resolution apparatus has been developed that can measure fine-grained multiplication at high levels ($M > 10^6$) and also local current fluctuations at high current density (6×10^3 A/cm^2). In this paper it is shown that these multiplication and current fluctuation measurements at high resolution and stability offer a unique method for determination of intrinsic response time, a parameter of importance at high frequency.[1]

It has been shown previously[2] that due to the effects of time dependence of multiplication process, the avalanche noise is attenuated by a factor $(1 + \omega^2 M^2 \tau^2)^{-1}$ where ω is the frequency, M is the multiplication factor and τ is the intrinsic response time. This factor is significant only when $\omega^2 M^2 \tau^2 \gtrsim 1$. If avalanche noise is plotted as a function

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of multiplication factor M, then the intrinsic response time τ, can be determined accurately from the slope of the curve when $\omega^2 M^2 \tau^2 > 1$. As an example, the noise measurements from one of the diodes are shown in Figure 1. In this diode τ is measured to be 9.0×10^{-12} sec. The values of τ_n and τ_p for electrons and holes, respectively, can also be determined by this method and will be described at the meeting. Such measurements have not been possible before because of the high stability required in noise measurements at high levels of multiplication.

Stability of noise measurements at high orders of multiplication and current density has been achieved by using a He-Ne laser for exciting the avalanche process and measuring the noise at 30 MHz. High resolution is achieved by focussing the light to a spot 2 microns in diameter. These noise measurements correspond to values of multiplication much higher than have been previously reported.[3]

The intrinsic response times obtained from noise measurements are compared with theoretically calculated values and are found to be in good agreement.

References

1. C. A. Lee, R. L. Batdorf, W. Wiegmann and G. Kaminsky: "Time Dependence of Avalanche Processes in Silicon," J. Appl. Phys. 38, pp. 2787-2796, June 1967.

2. I. M. Naqvi: "Effects of Time Dependence of Multiplication Process on Avalanche Noise," IEEE Trans. on Electron Devices (to be published).

3. I. M. Naqvi, C. A. Lee and G. C. Dalman: "Measurements of Multiplication Effects on Noise in Silicon Avalanche Diodes," Proc. IEEE 56, pp. 2051-2052, November 1968.

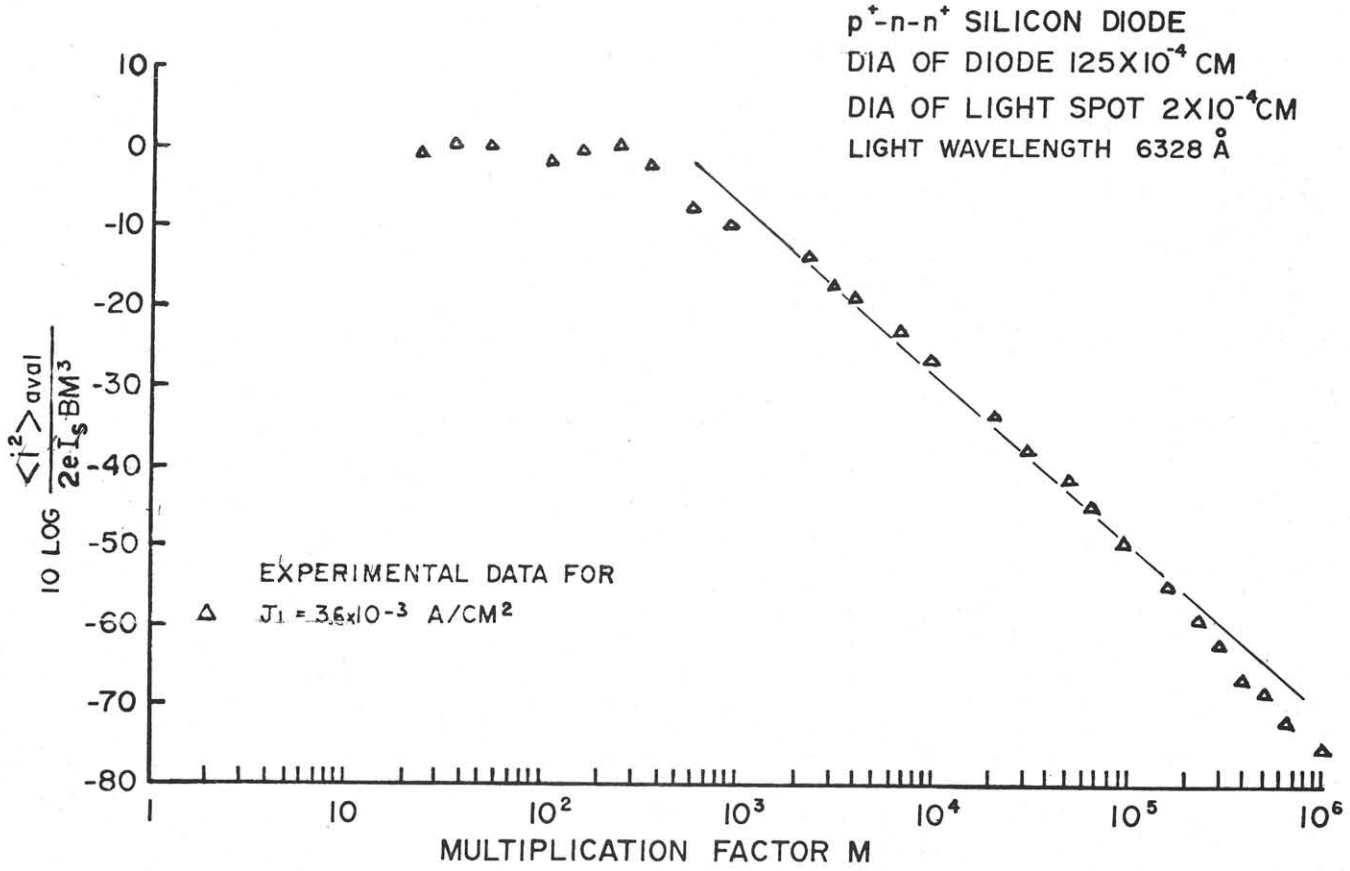

Figure 1 Normalized Avalanche Noise Current vs. Multiplication Factor. J_L is the photo-injected current density at unity multiplication.