half as good as that calculated by (7) and that there was no significant change in sensitivity with a variety of diodes and bias conditions.

Since the above treatment establishes that the radiometer's sensitivity is independent of the detector characteristic, (7) should be identical to the results of the prior authors. The recent comment by Goldstein[1] revising his earlier result, which was the same as (7) above, is in error. Since Goldstein's treatment can be obtained as a special case of the present work, it was easy for the author to establish that his expression for the autocorrelation function of $v(t)$ reduced to Goldstein's $R_2(\tau)$,

$$R_2(\tau) = \frac{k^2}{8}\sigma_s^4 \cos\omega_q\tau + k^2\left[\frac{17}{32}\sigma_s^4 + \frac{3}{2}\sigma_s^2\sigma_n^2 + 2\sigma_n^4\right] \cdot \frac{\cos\omega_q\tau \sin\frac{\omega\beta\tau}{2}}{\frac{\omega_a\tau}{2}}. \tag{8}$$

The autocorrelation of $w(t)$, $R_3(\tau)$, can be obtained easily from $R_2(\tau)$. Since

$$w(t) = v(t)\cos\omega_q t, \tag{9}$$

$$\begin{aligned} R_3(\tau) &= \lim_{T\to\infty}\frac{1}{T}\int_0^T w(t)w(t+\tau)dt \\ &= \lim_{T\to\infty}\frac{1}{T}\int_0^T v(t)v(t+\tau)\cos\omega_q t\cos\omega_q(t+\tau)dt \\ &= \lim_{T\to\infty}\frac{1}{T}\int_0^T v(t)v(t+\tau)\frac{\cos\omega_q\tau}{2}dt \\ &+ \lim_{T\to\infty}\frac{1}{T}\int_0^T v(t)v(t+\tau)\frac{\cos\omega_q(2t+\tau)}{2}dt. \end{aligned} \tag{10}$$

The second integral on the right vanishes in the limit. Hence

$$R_3(\tau) = R_2(\tau)\frac{\cos\omega_q\tau}{2} \tag{11}$$

and thus

$$\begin{aligned} R_3(\tau) &= \frac{k^2\sigma_s^4}{32}\left[1+\cos 2\omega_q\tau\right] \\ &+ \frac{k^2}{2\omega_a\tau}\left[\frac{17}{32}\sigma_s^4 + \frac{3}{2}\sigma_s^2\sigma_n^2 + 2\sigma_n^4\right] \\ &\cdot \sin\frac{\omega\beta\tau}{2}\left[1+\cos 2\omega_q\tau\right]. \end{aligned} \tag{12}$$

The contributions to the power spectrum by the $\cos 2\omega_q\tau$ terms lie outside the region of interest and are omitted. The correct statement for $R_3(\tau)$, deleted of terms that are subsequently filtered out, is just one half of Goldstein's original expression. Thus Goldstein's recent revision is correct but not complete. In computing the signal-to-noise ratio, the common factor of one half canceled out and the original result of Goldstein was correct although based upon a slightly incorrect autocorrelation function.

The use of a rectangular pass band for the output filter has been criticized by Tucker.[3] Since only the noise bandwidth of the output filter enters into the computation of sensitivity, this criticism appears trivial. On the other hand, the shape of the amplifier and band-pass response functions do enter into the problem since the autocorrelation functions are computed by evaluating the Fourier transforms of the signal leaving these stages. Fortunately, the error introduced is small and these convenient approximations can be used.

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Prediction of Semiconductor Surface Response to Ambients by Use of Lewis Acid-Base Theory*

During the last few years, changes produced by ambient atmospheres, or ambients, in conductivity,[1,2] surface conductance,[3,4] contact potential,[5] photoconductivity,[6] and surface-recombination velocity[7,8] of single-type semiconductors have been reported, as have the role of ambients in forming inversion layers, or channels, on diodes.[9,10] Ambient-induced effects on reverse currents in a germanium diode[11] and on collector-base reverse saturation current, surface-breakdown voltage, and dc alpha of germanium alloy-junction transistors[12] have also been observed.

With two partial exceptions[8,11] which may be associated with experimental error, Lewis acid-base theory permits predicting all these ambient-induced changes.[1-12] A p-type surface is considered a Lewis acid (electron-pair acceptor) and an n-type surface, a Lewis base (electron-pair donor). By their acceptor action, Lewis-acid ambients will decrease surface concentration of electrons and increase surface concentration of holes. Through their donor action, Lewis-base ambients will produce the opposite surface concentration changes. Hence, Lewis-acid ambients, such as oxygen, will decrease conductivity in an n-type surface and recombination velocity in a p-type surface while increasing conductivity in a p-type surface and recombination velocity in an n-type surface. While they are not Lewis acids, electronegative halogen atoms will act in the same way. On the other hand, Lewis-base ambients, such as ammonia, will produce exactly the opposite surface results. The extent to which these mechanisms are observed by the onset of ionic-like surface currents has yet to be determined.

From these considerations and Webster's data for germanium alloy-junction transistors,[13] the following generalization can be made: An ambient-induced change in collector-base reverse saturation current in alloy-junction transistors, will move in the same direction as the change made by the ambient in base surface-recombination velocity and minority-carrier concentration in the base. In grown-junction transistors, ambient-induced changes in collector-base reverse saturation current should be able to be predicted from expected changes in minority-carrier concentration and in surface-recombination velocity in the collector. In the case of dc alpha in germanium alloy-junction transistors, experimentally observed changes with ambient[12] can be accounted for by considering the competing changes produced by ambients in the first two terms in Webster's[13] equations for $1/h_{fb}$.[14] The first of these terms involves surface recombination in the base. The second contains the ratio of minority-carrier concentrations in the emitter and in the base. On applying these $1/h_{fb}$ equations to grown-junction transistors, it is found that the second term will probably be dominant for two reasons: 1) The trend toward reduction of surface-recombination in the base and 2) the fact that minority-carrier concentrations in *both* the emitter and base are large enough to show significant ambient-induced changes in opposite directions. The principles used in achieving these correlations should allow prediction of the change in electrical properties produced by exposure to an ambient. Detailed treatment of the correlations mentioned here will be published elsewhere.

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