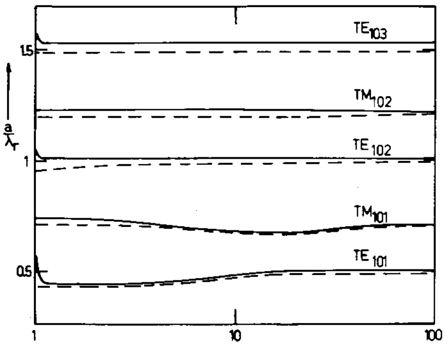

Fig. 3. Ratio a/λ_r for resonances versus ε_r; ——— eigenmodes after Gastine *et al.*, – – – maxima of the radiation resistance.

TABLE I

Values of Q for $\varepsilon_r = 100$ and Different Modes

	Eigenmodes	Forced Modes
TM_{101}	590	640
TM_{102}	100	390
TE_{101}	150	140
TE_{102}	100	310

rials such as titanates, very high ε_r (15 to 12 000) can be obtained; for example, $SrTiO_3$ has a permittivity of $\varepsilon_r = 300$ at room temperature. With $\varepsilon_r = 165$, an applied frequency of 300 MHz, and a dipole length of 1 cm, the "resonance" sphere radius would be 5.5 cm and a radiation resistance of 210 Ω could be reached in a lossless material. Such values may easily be matched to a generator and a considerable reduction of antenna dimensions compared with the usual half- and quarter-wave antennas can be obtained.

It is interesting to see that, although there is a singularity at the center, these resonances are very close to the resonances of the TE_{10r} and TM_{10r} eigenmodes of the sphere (Fig. 3). Only small differences exist due to the assumed lossless material in both cases as is usual for high-Q resonators.

For the free dielectric resonator Q is defined as ω times the ratio of stored energy to radiated energy per cycle, while in our case Q is defined by the 3-dB bandwidth at the peaks of the radiation resistance; this can be regarded as a reasonable assumption for a matching problem. Some numerical values of Q for $\varepsilon_r = 100$ are compared in Table I.

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Comment on "A Current Transformer for Microsecond Pulses"

In a recent letter,[1] Sarjeant and Brannen describe a toroidal current transformer for measuring 0.5- to 20-μs pulses of up to 250-A peak. Design equations are given and a system to reduce spurious-signal pickup using a single turn in the plane of the toroid is described.

Smith[2] has given more direct and comprehensive design equations, and more complete methods of shielding against spurious signal pickup have been described in the literature.[3,4] Current transformers for equivalent pulses in excess of 200-A peak were developed by Elliott for the Stanford Linear Electron Accelerator.[5]

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Author's Reply[6]

In applications where electrostatic pickup is a problem, as is the case when the transformer must be placed at a high potential above ground, shielding of the type described by Brady and others becomes essential. Where magnetic pickup is serious, a single turn has been customarily used, for example with Rogowski coils,[7] to eliminate the effect of extraneous magnetic flux passing through the major opening of the torus. We adopted this approach in the current transformer described and gave waveform comparisons. It is worthwhile noting that the current range was extended to 70 kA experimentally. Current transformers with at least 50-kA capacity and double electrostatic shielding have been available commercially for some time.[8]

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GaSe Schottky Barrier Gate FET

***Abstract*—Advantages of the Schottky barrier gate technique are reviewed, and an experimental field-effect transistor constructed from *p*-type GaSe is discussed. Device characteristics are consistent with calculations based on material parameters and the geometry employed.**

The Schottky barrier gate[1] is ideal for the construction of field-effect devices since it avoids the difficulties of *p-n* junction formation, particularly in wide band gap materials, and the Schottky barrier depletion layer is

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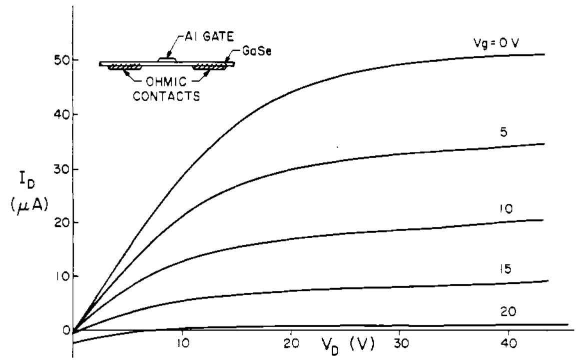

Fig. 1. $I_{\rm drain}$-$V_{\rm drain}$ characteristic of an experimental GaSe FET. Pinch-off occurs at $V_{\rm gate}=20$ volts. Inset shows a schematic cross section of device configuration.

not affected by the presence of surface states. A properly formed Schottky barrier has nearly theoretical reverse current and does not exhibit the drift and instability problems associated with MOS structures. Hence the Schottky barrier gate technique can be employed to construct active devices from materials which cannot be otherwise utilized.

GaSe[2,3] is a layer semiconductor having 2 eV band gap. A recent study of surface barriers on GaSe[4] indicates that the advantages of the Schottky barrier gate technique will allow the construction of a field-effect device from this material.

Experimental devices were constructed from $\sim 8\ \mu$ thick cleaved layers of p-type ($p \sim 10^{14}/\mathrm{cm}^3$) GaSe. A schematic cross section appears in the inset of Fig. 1. The source and drain ohmic contacts were alloyed Zn-Au spaced 0.5 mm apart; device width was 3 mm. An aluminum gate 0.1 mm across was evaporated directly onto the freshly cleaved surface. Open-gate-channel resistance was 300 kΩ. The $I_{\rm drain}$-$V_{\rm drain}$ curves are shown in Fig. 1. Observed transconductance and pinch-off voltage agree well with those calculated for the materials and geometry employed. Channel depth was measured optically and carrier concentration determined from the capacitance-voltage characteristic of the gate-channel barrier. Note that the zero bias transconductance is equal to the channel conductance at small drain voltage.

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Enhanced Radiation from a Plasma-Imbedded Antenna

Abstract—**The radiation of a monopole antenna imbedded in a finite volume of plasma can be enhanced if the antenna is operated at a frequency much lower than the plasma frequency and the antenna dimensions are properly chosen. Experimental observations are reported.**

INTRODUCTION

A conventional approach to overcoming the blackout problem suffered by a satellite antenna during reentry is to raise the antenna frequency above the frequency of the plasma sheath covering the satellite. It has been experimentally proved that the radiation of a linear antenna imbedded in a finite volume of plasma can be enhanced if the antenna frequency is drastically reduced to a value much lower than the plasma frequency. This phenomenon may provide an effective way to overcome the blackout problem. The first study on this phenomenon was made by Messiaen and Vandenplas.[1] In their experiment a small spherical antenna covered by a spherical layer of plasma was driven at a frequency of 300 MHz. A strong enhancement in radiation was observed for certain plasma densities. A number of resonance peaks and an important influence of the plasma sheath on the antenna radiation were also predicted theoretically.

In our investigation, linear monopole antennas are immersed in a relatively large volume of plasma. Antennas of various sizes are driven over a wide range of frequency. The plasma frequency is also varied over a wide range. The purpose of this experimental study is to observe the phenomenon of the enhanced antenna radiation and to study the effect of the antenna dimensions, the plasma parameters, and the antenna frequency on the phenomenon.

EXPERIMENT AND RESULTS

The experimental setup is schematically shown in Fig. 1. A cylindrical volume (15.24-cm diameter and 30.48-cm length) of a mercury arc plasma is created in a pyrex glass container which is directly attached to the ground plane. The plasma tube is continuously pumped and the discharge is maintained by a dc voltage. The plasma density can be varied from zero to about $1.5\times10^{11}/\mathrm{cm}^{-3}$. The electron temperature and the pressure of the plasma are about 20 000°K and 3×10^{-3} mmHg, respectively. A monopole antenna is fed into the center of the plasma tube through the ground plane and is driven by a RF signal. The antenna is dc blocked from the rest of the system to insure a floating potential for the antenna. The antenna is also connected to a bias voltage to test the effect of the plasma sheath on the antenna radiation. The radiation of the antenna through the plasma volume is then measured by a movable receiving antenna which is connected to a heterodyne receiving system. The distance between the radiating and receiving antennas is 1 meter. The radiating antenna with the plasma tube and the receiving antenna are enclosed in a microwave anechoic chamber.

In the course of experiment, monopoles of various lengths are driven by various frequencies. For each antenna driven at a particular frequency, the radiated field is measured as a function of the plasma density. The plasma density is varied from zero to a value which corresponds to a plasma frequency much higher than the antenna frequency.

Fig. 2 shows the experimental results for a monopole of 3-cm length driven at a number of frequencies. At each driven frequency the antenna radiation is measured as a function of the plasma density and the radiated power is plotted relative to the value when no plasma is present (free-space radiation). The antenna radiation shown in Fig. 2 is measured at the broadside direction of the radiating antenna. For an antenna frequency higher than 1.6 GHz, the antenna radiation undergoes a sharp cutoff at the plasma frequency and remains very low for high plasma densities. For a frequency between 0.8 and 1.4 GHz, the antenna radiation goes through the cutoff and then builds up again as the plasma density is increased. As the antenna frequency is decreased to a value lower than 0.8 GHz, the antenna radiation is enhanced over the free-space radiation level after going through the cutoff phenomenon. When the antenna frequency is 0.4 GHz, a 20-dB enhancement of the antenna radiation over the free-space radiation is obtained when the plasma frequency (ω_p) is about six times the antenna frequency (ω). For the case of 0.3-GHz antenna frequency, a 20-dB enhancement in the antenna radiation is also observed at $\omega_p=6\omega$.

The enhanced radiation phenomenon can be explained intuitively. The antenna radiation is strongly enhanced when the antenna is electrically short and the dielectric constant of the plasma, $\varepsilon_r=1-\omega_p^2/\omega^2$, becomes negative. At this condition, the plasma behaves like an inductive element to tune out the capacitive reactance of the antenna so that more power can be transferred into the antenna.

The same experiment has been conducted for monopoles of 7-cm, 15-cm, and 25-cm length. For the 7-cm monopole, a similar phenomenon has been observed. However, for the longer monopoles, no enhancement in the antenna radiation has been observed. For this reason, the simple model

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