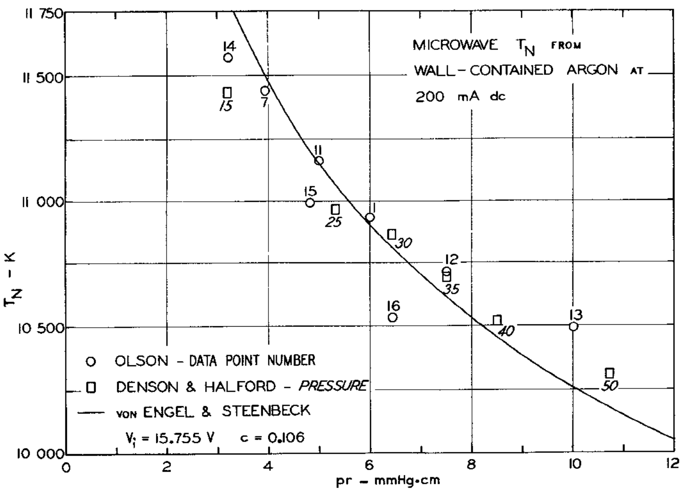

Fig. 1. Measured microwave noise temperature T_N of wall-contained Ar discharges at 200 mA dc versus pr (pressure-radius) product compared with the modified ($c = 0.106$) von Engel and Steenbeck theoretical electron temperature. Circles represent Olson's data points 1, 7, and 11–16. Squares represent Denson and Halford's values from 0.21-cm-inner-radius tubes at the pressures indicated.

tion only, and the theoretical curve will shift to the left.

At present, an accurate calculation of a or c from theoretical considerations does not appear possible because the ionization cross sections for excited states in argon are not known. However, the theoretical determination might be possible in the near future because progress is being made in determining excited-state ionization cross sections [3, p. 29], [4, p. 30], [5, p. 119].

The constant c was multiplied by 2.00 to obtain the curve plotted in Fig. 1; a better fit would have been obtained if a multiplier of 2.07 had been used at 200 mA dc. At 125 mA dc, the average multiplier for c was found to be 1.40; at 150 mA dc, 1.63; and at 250 mA dc, 2.43. These multipliers are less accurate than the values at 200 mA dc because less data were available. However, they were included to show that the multiplier is current dependent and to give an approximate idea of its dependence. The range of validity of the multipliers is presently unknown. The only firm constraint is that the discharge must be wall-contained.

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Microwave Dielectric Properties of an Amorphous Semiconductor System

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Abstract—**Experimental results are presented for the microwave dielectric properties of the glass system $(x)As_2Te_3(1 - x)As_2Se_3$ under temperature and compositional variations. The results indicate that the material exhibits potentially useful microwave properties.**

Manuscript received October 8, 1973.
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I. INTRODUCTION

The electrical switching behavior and low-frequency electrical behavior of the As_2Te_3–As_2Se_3 amorphous semiconductor has been studied extensively [1]–[4]. An interesting feature of this system is its moderately high dielectric constant at microwave and infrared frequencies which has been found to be extremely stable over a wide temperature range. These properties indicate a potentially attractive material for such applications as microwave integrated circuits, strip transmission lines, and dielectric windows. In addition, the switching characteristics of amorphous semiconductors could provide new techniques for microwave filters, switches, and limiters.

II. EXPERIMENTAL

Five compositions of the As_2Te_3–As_2Se_3 glass system were prepared with As_2Te_3/As_2Se_3 ratios of 80/20, 70/30, 60/40, 50/50, and 40/60. The glasses were prepared by fusing the appropriate mixture of reagent grade As_2Te_3 and As_2Te_3 in evacuated vycor ampoules at 800°C in a rocking furnace. After heating for 1 h, the molten material was quenched in water. The samples were shaped and polished using standard glass polishing techniques.

Three methods, depending on the frequency range, were used to determine the dielectric properties of the materials. In the frequency range below 550 MHz, the complex admittance of a disk sample positioned at the end of an air-filled coaxial line, was measured using a Thurston bridge. From this measurement, the dielectric constant and loss tangent were calculated.

The same sample configuration was used in the 500–2000-MHz frequency range, but the dielectric measurements were obtained from the VSWR and nullshift using a precision coaxial slotted line.

A slotted waveguide technique was used above 2000 MHz where the line was terminated with the sample and a variable short circuit. The VSWR and position of a voltage minimum were obtained and used with a graphical technique developed by Von Hippel [5] to determine the dielectric constant and loss tangent of the sample. The results obtained at overlapping frequencies for the three techniques were in excellent agreement.

For variable temperature studies, the sample holding fixture was placed in an environmental chamber and by the methods described above, the dielectric constant and loss tangent were obtained.

III. RESULTS AND DISCUSSIONS

The dielectric constant and loss tangent for the various compositions at 300 K remained constant within 5 percent over the frequency range 0.5–18 GHz. The values obtained are given in Table

TABLE I
DIELECTRIC PROPERTIES OF $(x)As_2Te_3(1-x)As_2Se_3$ FOR VARIOUS COMPOSITIONS AT 300 K

Composition	Dielectric Constant	Loss Tangent
80/20	10.0	0.055
70/30	9.3	0.049
60/40	7.9	0.042
50/50	7.2	0.030
40/60	7.0	0.020

I. No observable variation occurred in either the dielectric constant or loss tangent over the temperature range −193–353 K. The results for the various compositions were exactly the same as those obtained in the earlier study of frequency dependence [6].

One of the samples $(80)As_2Te_3(20)As_2Se_3$ was tested in the far-infrared region from 5 K to room temperature [7]. The sample exhibited essentially constant transmission properties over the entire temperature range.

IV. CONCLUSIONS

The amorphous system $(x)As_2Te_3(1-x)As_2Se_3$ exhibits characteristics that appear to make them useful as microwave dielectric materials. The high dielectric constant and low loss tangent which is easily controlled by compositional variation, remains constant from 0.5 to 18 GHz over the temperature range from −80 to +80°C. The material is easily worked to a smooth finish suitable for high-quality thick films and substrates.

Preliminary tests indicate that the dielectric properties are constant at even higher frequencies and lower temperatures but some variation was noted above 80°C. Since the materials have relatively low softening temperatures, their use for applications above 100°C would be somewhat restricted [1].

ACKNOWLEDGMENT

The authors wish to thank K. Button of the Massachusetts Institute of Technology for the measurements in the far-infrared region.

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Anomalies in Duplexing Very Short Pulses

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The advent of nanosecond pulse sources with multikilowatt power at X band [1] has created a need for a suitable duplexing scheme for incorporation into a monostatic radar configuration. The advantages and disadvantages of various ferrite and diode duplexer structures have been evaluated. It is the purpose of this letter to report these results and to indicate several phenomena that were observed to be unique to short-pulse operation.

An IKOR Cavatron short-pulse source that generates a damped sinusoidal output waveform, as shown in Fig. 1, was used in the duplexer evaluations. It has an X-band output power spectrum with a half-power bandwidth of 0.2 GHz, while the peak power is variable up to 20 kW.

Manuscript received November 5, 1973. This work was supported in part by the Air Force Avionics Laboratory, Wright-Patterson AFB under Contract F33615-72-C-1930.
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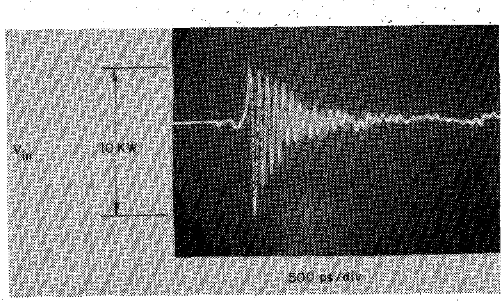

Fig. 1. Short-pulse transmitter—typical RF output.

A schematic of the three basic duplexer configurations evaluated is shown in Fig. 2. All are active devices utilizing p-i-n diode switching properties or a combination of ferrite circulator and p-i-n diode switching action.

Referring to Fig. 2(a), the two shunt-mounted diodes constitute a simple TEM switching structure with low-level short-pulse transmission properties similar to those observed with a CW signal. However, with the diodes reverse biased under intense short-pulse field conditions, the capacitive reactance of the diodes becomes shunted by a large RF voltage-dependent conductance. As a consequence, the insertion loss of the switch increases with applied power, as shown in Fig. 3. It appears that electrons and holes present in equilibrium in the diode's I region are accelerated, giving rise to bulk ionization of the lattice structure, which develops into a controllable avalanche. The effect is reversible and does not permanently impair the diode's characteristics.

Again referring to Fig. 2(a), the circulator is a waveguide partial-height ferrite Y junction being connected to the diode switch structure via a coaxial-to-waveguide transducer. A very short pulse propagating in a waveguide is subject to dispersion [2], which causes distortion of both the envelope and the carrier wave of the pulse. Thus the short-pulse transmission losses are measured with respect to the transmission through an approximate equivalent length of waveguide. Fig. 4 illustrates the circulator's forward (low-loss) transmission path properties. The insertion loss is 0.4 dB greater than the measured CW value, while the pulse shape is relatively distortionless. Note, if the short-pulse spectrum does not fall within the passband of the circulator, severe pulse elongation will occur. The short-pulse isolation is only 17 dB compared to the greater than 27 dB measured with a CW signal. The exact nature of the isolation degradation is not understood. Others [3] have reported excessive spike leakage with ferrites; however, an explanation of this occurrence will require further investigation.

The balanced duplexer configuration of Fig. 2(b) utilizes two diode switches identical to that previously described in the ferrite/diode duplexer. The hybrids are constructed in stripline using a standard quarter-wavelength overlay technique. The transmission losses of short pulses through this duplexer are comparable to the measured CW data, other than the nonlinearities introduced by the reverse-biased diodes. Further, short-pulse transmission is relatively distortionless, though the hybrids do appear to alter the relative height of the first half-cycle of the pulse. Due to breakdown in the overlay coupling structure, power handling is limited to 18 kW. In general, the short-pulse breakdown voltage is much greater than the CW breakdown since the buildup of ionization, or the formative time, is comparable to pulsewidth [4].

The modified branched duplexer, Fig. 2(c), is not particularly