The Low Frequency Dielectric Constant of
Vitreous Arsenic Trisulfide*

John Fontanella

United States Naval Academy, Annapolis, Maryland 21402

and

Carl Andeen and Donald Schuele

Case Western Reserve University, Cleveland, Ohio 44106

The 1000 Hz, 300°K dielectric constant of two samples of Servofrax arsenic trisulfide glass was measured to an accuracy of about 0.01% by the method of substitution (two-fluid technique). The values were determined to be 7.9093 and 7.9097. These results are discussed in the light of recent refractive index and reflectivity measurements.

-1-

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

There have been several recent studies¹ of the optical properties of the infrared transmitting glass arsenic trisulfide. One of the parameters which is basic to much of this work is the static dielectric constant, ϵ_s , as it reflects the total oscillator strength of the various infrared modes when considered in conjunction with the optical frequency dielectric constant, ϵ_∞ . Specifically, values of ϵ_s , ϵ_∞ , and $\Delta\epsilon = \epsilon_s - \epsilon_\infty$ are often determined from reflectivity measurements. It is thus of interest to compare these values with those determined by other methods.

Accurate measurements for the refractive index exist,²⁻⁴ but, as is often the situation, an accurate value for ϵ_s is not in common use. In the case of As_2S_3 this is largely due to the fact that As_2S_3 reacts with most electrode materials and the common techniques for determining ϵ_s require electrodes. There exists, however, an electrodeless technique for measuring ϵ_s in which the samples come in contact with fluids only and thus is well suited to As_2S_3 . This method is described elsewhere^{5,6} and has been used previously by the authors⁷ to determine ϵ_s for several materials to an accuracy of 0.01%.

In the present work measurements were performed on two Servofrax arsenic trisulfide glass samples using the procedure and equipment described in Ref. 7. The results

for ϵ_s for the two samples are 7.9093 and 7.9097. These numbers are to be compared with the values 8.1, 7.53, and 8.9 quoted by Wolfe,⁸ Onomichi et. al.,⁹ and Zlatkin and Markov¹⁰ respectively. The latter two values were calculated directly from their reflectivity data and their similarly determined values for ϵ_∞ are 5.90 and 6.0. Another estimate for ϵ_∞ can be obtained from refractive index data. Young² fits his refractive index data from 0.2 to 25 μm (part of which was determined from thin film interference fringe measurements and the rest from measured bulk and thin film reflectivity and absorption) to the Drude equation. In the long wavelength limit his fit yields a value of $\epsilon_\infty = 5.73$. Other refractive index data,^{3,4} indicate that the refractive indices for Servofrax arsenic trisulfide are slightly larger than Young's data and thus it is felt that a slightly better value for ϵ_∞ for Servofrax is about 5.75.

Finally, it is of interest to compare values of $\Delta\epsilon$ which from this work is determined to be 2.16. Onomichi et. al. and Zlatkin and Markov obtain 1.63 and 2.9 which disagree strongly with the present results. Lucovsky has also recently reported¹ a result for $\Delta\epsilon$ which was arrived at by analyzing new reflectance spectra in terms of damped Lorentzian oscillators. He has subsequently reexamined¹¹ the low frequency modes using a different fitting procedure which yields a higher contribution from the optic

modes. Lucovsky's new value for $\Delta\epsilon$ is approximately 2.26 which is in good agreement with the results of the present work. In addition, his new fits have yielded values for ϵ_∞ of 5.73 and 5.78. Lucovsky feels that the former represents the better value. These results are once again in good agreement with the present analysis.

D. Treacy and P. C. Taylor have also recently completed reflectivity measurements on As_2S_3 . From the data they have arrived at¹² values of $\epsilon_s = 7.9$, $\epsilon_\infty = 5.8$, and consequently $\Delta\epsilon = 2.1$ which also agree well with the present analysis.

The authors would like to thank P. C. Taylor and the Solid State Applications Group of the Naval Research Laboratory under the Cooperative Research Program with the U. S. Naval Academy for the loan of the samples. Two of the authors (C. A. and D. S.) acknowledge^e support from the U. S. Atomic Energy Commission.

REFERENCES

1. An extensive bibliography is given by G. Lucovsky in Phys. Rev. B6, 1480 (1972).
2. P. A. Young, J. Phys. C.: Solid St. Phys. 4, 93 (1971); Applied Optics 10, 222 (1971).
3. W. S. Rodney, I. H. Malitson, and T. A. King, J. Opt. Soc. Am. 48, 633 (1958).
4. In their technical data brochure, Servo Corporation quotes a set of values determined by NBS for their material.
5. C. Andeen, J. Fontanella, and D. Schuele, Rev. Sci. Instr. 41, 1573 (1970).
6. W. P. Harris and A. H. Scott, 1962 Annual Report of the Conference on Electrical Insulation, NAS Publ. 1080, p. 51.
7. Some alkali halides, Phys. Rev. B2, 5068 (1970); the alkaline earth fluorides, J. Appl. Phys. 42, 2216 (1971); vitreous silica, α -quartz, sapphire, and MgF_2 , submitted to Phys. Rev.
8. W. L. Wolfe, Military Handbook of Infra-red Technology (Washington: US Govt Printing Office, 1965).
9. M. Onomichi, T. Arai, and K. Kudo, J. Non-Cryst. Solids (Neth) 6, 362 (1971).
10. L. B. Zlatkin and Yu. F. Markov, Phys. Stat. Sol. 4, 391 (1971).

11. G. Lucovsky, private communication.

12. D. Treacy and P. C. Taylor, private communication.

* Work supported in part by the Naval Academy Research Council.