the acoustic losses, etc. A final assessment of the nature of the microwave radiation in tellurium calls, however, for more detailed experimental investigations.

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[1] G. Nimtz and K. H. Seeger, Appl. Phys. Lett. 14, 19 (1969).
[2] T. Ishiguro and T. Tanaka, J. Phys. Soc. of Jap. 21, Supplement, p. 489 (1966)

GENERATION OF HIGH-FREQUENCY OSCILLATIONS BY THIN SUPERCONDUCTING TIN FILMS

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At the present time there is no doubt in anyone's mind that superconductors, particularly with small dimensions, have strong nonlinear properties. Their mechanisms may be different, but their outward manifestations are similar in many respects. This can be traced by analyzing weak-coupling superconductors [1] in thin superconducting films [2 - 5]. Whereas weak-coupling superconductors of the type of Josephson junctions or point contacts certainly gnerate electromagnetic waves, all that could be obtained so far with bridge structures was a low-frequency noise spectrum [6]. On the other hand, thin superconducting films having no special geometry or structure produced only parametric generation, which required the pres presence of at least one high-frequency pump signal [2 - 4].

We describe in this paper the results of experiments on observation of the generation of high-frequency oscillations by long thin superconducting films. We investigated films of tin deposited on a glass substrate by the vacuum-sputtering method and having the following dimensions: thickness 250 Å, width 0.15 mm, length 13 mm. The films had current and potential contacts and were connected either as part of a resonant circuit kept in liquid helium and serving as the input circuit of a tuned amplifier, or else directly to the amplifier input. The amplifier had several frequency bands in the range from 30 to 230 MHz and its gain was 4.5×10^5.

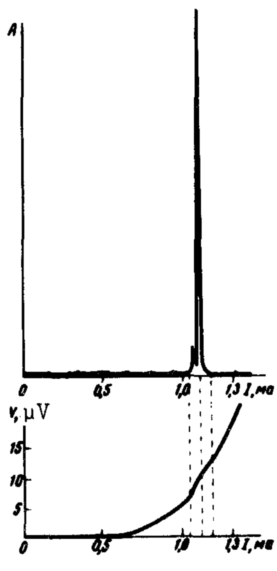


Fig. 1

The investigated films had at 4.2°K a resistance of 60 ohms. Direct current flowed through the film during the time of the experiment, and the current-voltage characteristics were recorded in synchronism with the generated high-frequency signal.

As seen from Fig. 1, the generation of high-frequency oscillations occurs when the film is in the resistive state. A singularity then appears on the current-voltage characteristic if the film is connected in the resonant circuit. There is no hysteresis in the region of the singularity when the current is alternately increased and decreased. But the film was connected directly to the amplifier input, the generation of the high-frequency oscillations continued at the same values of the current, and the singularity vanished from the current-voltage characteristic.

At a given temperature and a given value of the current, within the limits of the resistive section on the current voltage characteristic, one frequency is generated. When the current is increased, the frequency of the generated signal increases, i.e., each value of the current corresponds to a different value of the frequency. To verify this, we plotted the amplitude-frequency characteristic of the amplifier with the aid of a standard signal generator. We then connected the superconducting film to the input of the amplifier, and plotted the output signal as a function of the current through the film. The plot obtained in this manner duplicated exactly the amplitude-frequency characteristic of the amplifier. This indicates a sufficiently high monochromaticity of the generated signal. With decreasing temperature, the excitation of the given frequency occurs at large currents and voltages, until the resistive section disappears completely and the film goes over into the normal state. No generation is observed subsequently. The dependence of the amplitude of the excited signal (in relative units) on the relative temperature is shown in Fig. 2 for a frequency of 30 MHz. Similar plots were obtained for other frequencies in the 30 - 230 MHz range. The absolute power of the generated oscillations is on the order of 10^{-12}W.

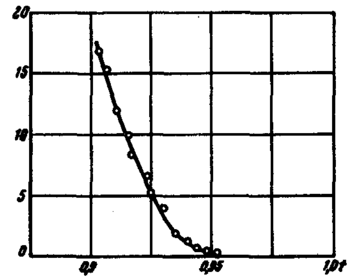


Fig. 2

Thus, we observed generation of monochromatic high-frequency oscillations by superconducting thin films of tin in the resistive state. Further research is needed to explain the mechanism of the excitation of the oscillations and to derive quantitative equations.

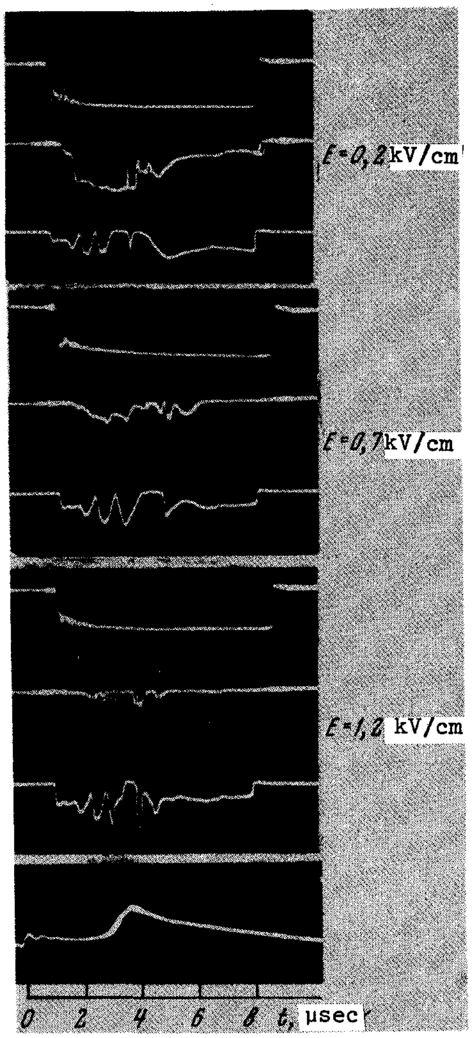
[1] I. M. Dmitrenko, Ukr. Fiz. Zh. 14, 439 (1969).
[2] A. S. Clorfeine, Proc. IEEE, 52, 844 (1964).
[3] P. Bura, Appl. Phys. Lett. 8, 155 (1966).
[4] R. V. D'Aiello and S. J. Freedman, Appl. Phys. Lett. 9, 323 (1966).
[5] G. E. Churilov, V. M. Dmitriev, F. F. Mende, E. V. Khristenko, and I. M. Dmitrenko, ZhETF Pis. Red. 6, 752 (1967) [JETP Lett. 6, 222 (1967)].
[6] G. I. Rochlin, Proc. of the 11 intern. confer. on low temp. phys. St. Andrews Univ., 1968, v. II, p. 741.

ERRATA

In the article by Dzh. L. Chkareuli, published in Vol. 9, No. 9, the mass terms in formulas (1) and (2) should enter with positive signs, and formula (3) should read:

$$A_\mu = a_\mu - \frac{f}{m^2} d_\mu P , \qquad a = 1 + \frac{f^2}{m^2}$$

In the article by I. R. Gekker et al., published in Vol. 9, No. 7, the correct Figure 2 is as shown on the reverse page.



Corrected Fig. 2 of article by I. R. Gekker et al., Volume 9, Number 7.