V. N. Alfeev. *Properties and Uses of Structures Based on Paraelectrics, Superconductors and Semiconductors.* 1. Structures based on the materials that the author calls "cryogenic paraelectrics" (PE) and on junctions of superconductors (SpC) and semiconductors (SmC) are interesting objects of study and open up new possibilities for cryoelectronics, which usually uses either SpC or SmC elements.

2. The properties of "cryogenic paraelectrics" are discussed: the departure from the Curie-Weiss law at low temperatures and the absence of a phase transition to the ferroelectric state due to the appearance of the lattice zero-point vibrational energy. The paper indicates types of structures based on PE- film junctions in the normal or superconductive state, which can be used to create various types of elements. The results of experiments performed jointly with N. A. Irisova, T. N. Narytnik, G. V. Kozlov, V. P. Fedorov, and I. M. Chernyshev in the course of low-temperature studies of the dispersion, dielectric and nonlinear properties, and controllability of PE structures with metallic electrodes are reported; they confirmed the possibility of obtaining low lag, a broad range of electronic tuning, and high Q. The basic results according to literature data are reviewed, and certain new trends affecting $SrTiO_3$ and other PE in the normal and superinductive states are discussed.

3. The combination of SpC and SmC in the same structure produces qualitatively new results and broadens the possibilities of these materials. Features of

SpC-SmC-SpC energy diagrams are examined and their advantages over tunnel SpC structures with dielectric gaps no greater than 10–20 Å in thickness with Josephson tunneling are pointed out. Results on Josephson and single-particle tunneling in such structures using various SpC and SmC are reported. Certain properties of single SpC-SmC junctions are discussed. The behavior of SpC-SmC junctions at the natural resonance frequency under exposure to an external microwave signal and the influence of infrared radiation on the characteristics of tunnel SpC structures with SmC are considered. Published experimental results are generalized, including those of experiments to study anomalies in degenerate SmC p-n junctions near $V = 0$, in which B. M. Bul, N. V. Zavaritskiĭ, É. I. Zavaritskaya, B. A. Logan, E. I. Wolf, and others observed the influence of the SpC ohmic junction. Problems of using hard SpC in the structures are discussed.

4. Structures based on PE, SpC and SmC broaden the possibilities of known materials greatly and may be used to create cryoelectronic devices for various purposes: amplifiers, generators, resonators, detectors, convertors, selectors, infrared detectors, and other devices, perhaps even ranging up to new laser types and modulators.

Structures containing SpC and SmC may also be used in cryotronic integrated circuits for computers, in the form of microstrip SpC filters on SmC bases. In addition, PE structures can be used in a broad temperature range as resonators and filters with electronic tuning, phase shifters, parametric devices, temperature sensors, and bolometers for a broad range of electromagnetic wavelengths.

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LITERATURE WITH A DIRECT BEARING ON THE PAPER

[1]V. L. Ginzburg, Zh. Eksp. Teor. Fiz. 19, 36 (1949); Usp. Fiz. Nauk 77, 621 (1962) [Sov. Phys. Usp. 5, 649 (1963)].
[2]J. H. Barret, Phys. Rev. 86, 118 (1952).
[3]B. M. Vul, Izv. AN SSSR, Ser. Fiz. 21, 3 (1957).
[4]B. M. Vul, É. I. Zavaritskaya, and N. V. Zavaritskiĭ, Fiz. Tverd. Tela (Leningrad) 8, 888 (1966) [Sov. Phys. Solid State 8, 710 (1966)].
[5]J. Giaever and H. R. Zeller, J. Vac. Sci. and Technol. 6, 502 (1969).
[6]É. I. Pashitskiĭ, Ukr. Fiz. Zh. 14, 1882 (1969).
[7]I. O. Kulik and I. K. Yanson, Éffekt Dzhosefsona v Sverkhprovodyashchikh Tunnel'nykh Strukturakh [The Josephson Effect in Superconductive Tunnel Structures], Nauka, Moscow, 1970.
[8]B. M. Vul and A. S. Selivanenko, Dokl. Akad. Nauk SSSR 5, No. 115 (1968).
[9]V. N. Alfeev and T. N. Narytnik, Élektr. Promyshlennost' 5, 53 (1976).
[10]G. A. Smolenskiĭ, V. A. Bokov, V. A. Isupov, N. I. Kraĭnik, R. E. Pasynkov, and M. S. Shur, Segnetoélektriki i Antisegnetoélektriki (Ferroelectrics and Antiferroelectrics), Nauka, Leningrad, 1971.
[11]O. G. Vendik, Fiz. Tverd, Tela (Leningrad) 14, 989 (1972) [Sov. Phys. Solid State 14, 849 (1972)].
[12]V. G. Vaks, Vvedenie v Mikroskopicheskuyu Teoriyu Segnetoélektrichestva (Introduction to the Microscopic Theory of Ferroelectricity), Nauka, Moscow, 1973.
[13]V. N. Alfeev, Izv. Vyssh. Ucheb. Zaved. Radioélektronika 13, 1163 (1973).
[14]K. H. Keller, J. E. Nordmann, J. Appl. Phys. 44, 4732 (1973).
[15]M. McColl, M. F. Millea, and A. H. Silver, Appl. Phys. Lett., 23, 263 (1973).
[16]L. Solymar, Superconductive Tunneling and Applications, Halsted, 1972.
[17]N. B. Brandt, D. V. Gitsu *et al.*, Pis'ma Zh. Eksp. Teor. Fiz. 22, 225 (1975) [JETP Lett. 22, 104 (1975)].