the acid to act for about 1 min, and then thoroughly rinse to remove the excess acid. Araldite was applied to both surfaces, the parts placed together and allowed to set over night. The nylon parts had an O-ring groove machined in the sealing surfaces, this insured that a thick layer of epoxy existed along the length of the sealing surface. It was found that thin walled copper tubes are easily sealed into nylon with Araldite. For reliable use of Araldite it is recommended that after the resin and hardener are thoroughly mixed, the mixture should be out gassed for 1 h to break up large air bubbles which inevitably form when they are mixed. The etched nylon–Araldite seal proved reliable except during severe cold shocks. In this case the Araldite cracks due to its inability to relieve thermal stress fast enough. Test seals were cycled from room temperature to liquid nitrogen temperature no less than ten times without failure if allowed to cool at a rate equal to or less than approximately 0.6 K/s.

An alternate sealing method which does not involve the epoxy was tested. This method involved fusing the nylon parts using concentrated sulfuric acid. The procedure was to wipe the surfaces with acid, allow it to act for a few minutes, join the parts and hold in contact for about 1 h, then rinse off excess acid. In this case no O-ring groove was used. This method results in a seal which will withstand repeated cold shocks and is as durable as the nylon itself. However, this method has the disadvantage that the acid must be removed from the interior of the chamber.

Test chambers using the above two methods were cycled between room temperature and 1.7 K twice and have proven to be superfluid tight using a helium leak detector which can detect leak rates greater than 10^{-9} cm^3/s.

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Note added in review. The low temperature use of an epoxy commercially known as Stycast 1266 has been brought to our attention. This product is castable, machinable, and room temperature curing which makes it an attractive choice for constructing chambers. However, its magnetic susceptibility in comparison to CMN has as yet not been determined.

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GaAs junction field effect transitors for low-temperature environments

S. R. Forrest and T. M. Sanders, Jr.

Randall Laboratory of Physics, The University of Michigan, Ann Arbor, Michigan 48109

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Thermal, electrical, and noise characteristics of a GaAs junction FET are described. Low voltage noise [1.5 ± 0.2 nV/(Hz)$^{1/2}$ at $T=4.2$ K] and insensitivity to temperature change in the range $1.3 \leq T \leq 300$ K make it suitable for low-temperature applications.

The suitability of III–V semiconductor junction FETs for low-temperature applications has been pointed out in a review by Lengeler.[1] We have characterized several aspects of performance of GaAs JFETs and have found that they are indeed excellent low-noise transistors well suited for use at low temperatures, and for many applications they present advantages over Si MOS and junction FETs.

We have tested 5 GaAs FETs[2] all of which operated down to 4.2 K. Figure 1 shows transfer characteristics of a typical GAT 1/010 at $T = 300$ and $T = 4.2$ K. For a typical operating point $V_{DS} = 2$ V, $V_{GS} = -2$ V, $I_D = 3$ mA, the transconductance is $g_m = 6.3$ mmho at 300 K and $g_m = 7.4$ mmho at 4.2 K. We did not observe irregularities in the transfer characteristics reported by Lengeler[1] for devices operating at low temperatures.[3] As the device transfer characteristics do not vary greatly with temperature, designing a circuit that operates both at room and helium temperatures is very easy. This is also different from previous observations,[3] where the devices are reported[1] to be "very sensitive to thermal cycling." The transconductance of the devices typically changes by a few per cent during the first few thermal cycles, but does not show significant changes upon subsequent cycling. Also, they are not sensitive to thermal shock by rapid immersion in liquid helium. Several of the devices have been tested at $T = 1.3$ K. None was damaged by direct immersion in superfluid helium,

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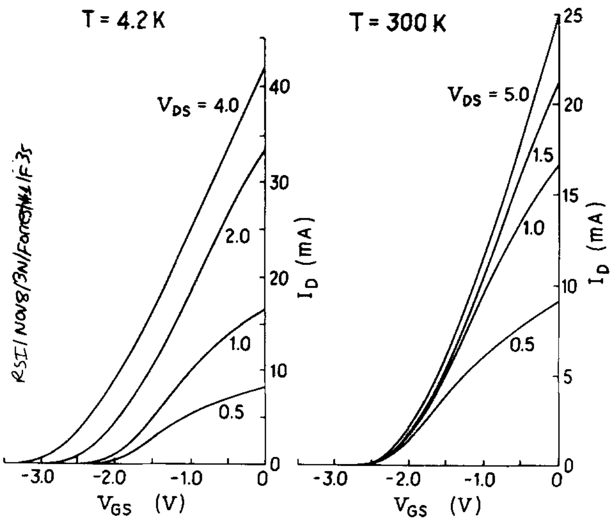

FIG. 1. Transfer characteristics at 4.2 and 300 K. Drain current I_D is plotted against gate-source voltage V_{GS} for several values of drain-source voltage V_{DS}.

where the presence of superleaks could be a problem. In any case, self-biased transistor circuits, using a resistor in the source lead, are quite insensitive to device variation; our circuits behave well over the entire range $1.3 \leq T \leq 300$ K. The JFETs are available in a TO-5 style package which is magnetic, and in microstrip packages made entirely of nonmagnetic materials. We have not found any differences in performance between the two package types.

The voltage noise of two of the transistors has been measured near 6 MHz. One transistor was found to have rms voltage noise referred to the input of (2.4 ± 0.2) nV/(Hz)$^{1/2}$ at T = 300 K. The voltage noise at T = 4.2 K was (1.5 ± 0.2)nV/(Hz)$^{1/2}$. The second GAT 1/010 was then tested, and the measured noise voltages were (2.5 ± 0.2)nV/(Hz)$^{1/2}$ at 300 K and (1.5 ± 0.2)nV/(Hz)$^{1/2}$ at 4.2 K. This suggests a degree of reproducibility in noise performance from device to device. The change in voltage noise between room temperature and T = 4.2 K is not as great as predicted by the Nyquist formula, where voltage noise due to channel conductance is proportional[4] to $(T/g_m)^{1/2}$. In marked contrast to MOSFET[5] and Si JFET[6] behavior, no unusual temperature dependence in the noise was observed as the devices were cooled. The noise voltages of the GaAs JFETs are more than an order of magnitude smaller than reported for[1,5,6,7] Si MOS and junction FET noise at 4.2 K.

At the present time we are using two GAT 1/010 JFETs in a low-noise, radio-frequency preamplifier which operates well over the temperature range from 300 to 1.3 K. These JFETs are designed for use at microwave frequencies, and have low internal capacitances—another factor which simplifies circuit design. The preamplifier dissipates roughly 30 mW which is acceptable in our application.

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PUBLICATIONS

All books received in the office of the editor will be acknowledged by listing in the Books Received column of this section. Books pertaining directly to instrumentation or closely allied subjects will be selected for review as space permits. Reviews of books on physics or engineering, other than instrumentation, will be carried in Physics Today *or other journals published by the American Institute of Physics.*

Books Received

Handbook of Optics. Walter G. Driscoll, Editor, and William Vaughan, Associate Editor. Pp. 1166 + vii. Illus. McGraw-Hill Book Company, 1221 Avenue of the Americas, New York, NY 10020, 1978. Price: $55.00.

6800 Assembly Language Programming. Lance A. Leventhal. Osborne & Associates, Inc., P.O. Box 2036, Berkeley, CA 94702, 1978. Price: $8.50 (paperbound).

Seventh Internatinal Conference on High-Energy Physics and Nuclear Structure. Zürich, Switzerland, 28 August–2 September 1977. Edited by M. P. Locher. Pp. 435. Illus. Birkhäuser Verlag, P.O. Box 34, CH-4010 Basel, Switzerland, 1978. Price: Sfr. 92.—.