Ge Semiconductor Devices for Cryogenic Power Electronics - IV

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We have been developing semiconductor devices (diodes and transistors), based on germanium, for cryogenic power applications. Target applications include spacecraft for cold environments as well as commercial, industrial, and defense systems that incorporate cryogenics. The applications and motivation for this work are presented elsewhere [1-3].

Our primary reason for basing these devices on Ge is that it enables good performance down to deep cryogenic temperatures (down to 20 K and lower), although there are other advantages to using Ge such as a low p-n junction forward voltage and high mobility.

During this development we have designed, fabricated and characterized the following devices:

(1) Ge power diodes (10-A) that operate from room temperature to approximately 20 K. Their forward voltage is about half that of Si power diodes and we have achieved reverse breakdown voltage as high as 400 V from room temperature down to 20 K.

(2) Ge JFETs with an Idss of more than 0.5 A at liquid-nitrogen and liquid-helium temperatures, and a transconductance of approximately 200–300 mS at cryogenic temperatures.

(3) Ge MISFETs with 10 W capability that operate from room temperature to liquid-helium temperature (Figure 1). Transconductance is approximately 100 mS for all temperatures.

Thus we believe that Ge power devices are practical and offer important advantages for cryogenic space and ground applications.

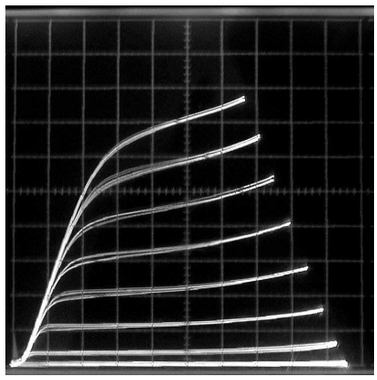

Figure 1 – Output characteristics of a Ge n-channel enhancement MISFET in liquid helium. Vert = 0.1 A/div, horiz = 2 V/div, ΔV_{GS} = 1 V per step.

[1] R. L. Patterson, A. Hammoud, S. Gerber, M. Elbuluk, E. Overton and J. E. Dickman, "Electronics for low temperature applications in space and on Earth," *This Symposium*.

[2] R. L. Patterson, A. Hammoud, J. E. Dickman, S. S. Gerber and E. Overton, "Development of electronics for low temperature space missions," *Proc. 4th European Workshop on Low Temperature Electronics (WOLTE 4)*, Noordwijk, The Netherlands, 21-23 June 2000 (ESA publication WPP-171), pp. 115-119.

[3] R. R. Ward, W. J. Dawson, L. Zhu, R. K. Kirschman, O. Mueller, R. L. Patterson, J. E. Dickman and A. Hammoud, "Ge semiconductor devices for cryogenic power electronics – III," *15th International Symposium on Power Semiconductor Devices & ICs (ISPSD'03)*, Cambridge, UK, 14-17 April 2003.