Materials Contributors to Transistor Should be Recognized

To the Editor:

I have long been of the opinion that the materials scientists involved in the initial inventions of the transistors have not been given their full recognition in all circles. The recent article by Ian Ross in the December 1997 issue of *Physics Today*, "The Foundation of the Silicon Age," fortified this opinion. There is scant mention of the materials researchers who contributed to the Brattain-Bardeen and Shockley patents. Even the recent book *Stuff* by Ivan Amato (published by the Basic Books Division of Harper-Collins) [reviewed in *MRS Bulletin*, July 1997, p. 80] does not mention any materials scientists/engineers who contributed.

When I arrived at the Bell Telephone Laboratories in January 1946, there was a group in the Chemistry and Metallurgy Division headed by John H. Scaff working on semiconductor materials. Henry C. Theuerer and William G. Pfann were in this group. The group reported to Earle E. Schumacher. The information that follows is taken from *A History of Engineering & Science in the Bell System, Physical Sciences 1925–1980*, edited by S. Millman and published by AT&T Bell Laboratories in 1983. The recent article, "Semiconductor Silicon: The Extraordinary Made Ordinary," by H.J. Leamy and J.H. Wernick published in the May 1997 issue of *MRS Bulletin* [Links of Science & Technology, p. 47] gives a very good description of the materials science research that preceded the inventions of the transistor. A good deal of this information was known to me. It is not my intention to detract from the contributions of the physicists to the discovery of the transistor; these were of primary importance.

Research on preparation, purification, and properties of Si and Ge began in the metallurgy group in the late 1930s. Both Si and Ge were used as rectifiers for microwave detection. Henry Theuerer was largely responsible for the preparation and purification and Bill Pfann was largely responsible for developing the advanced point contacts. The procedures developed by Henry for purifying germanium tetrachloride and making coarse-grained polycrystalline ingots of germanium were used to make germanium for the first transistor. Henry gave the germanium to Walter Brattain for the first transistor. About the time the discovery of the point contact transistor was announced I was told that another laboratory had conducted related experiments but they had failed because of insufficiently pure materials.

R.S. Ohl and J.H. Scaff prepared and discovered the first *p-n* junction. It was in a directionally solidified silicon ingot. They also named the two types of silicon *p*- and *n*-type. Pfann, Scaff, and Theuerer conducted early experiments that related the origin of the junction to segregation of impurities. Theuerer later discovered that *p*-type Si could be obtained by doping with B, *n*-type could be obtained by doping with P and that B and P opposed each other. He was thus able to make *p*-type ingots of highly uniform electrical resistivity. Pfann later developed zone refining and Theuerer later developed float zone refining of Si. The latter is mentioned in the Ross article. Later materials developments by many others, of course, enabled commercialization of the transistor and all of the later developments and these are more fully mentioned in the Ross article than the earlier contributions of Scaff, Pfann, and Theuerer.

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