Does the Crystal Structure of Solid Single Crystal Bismuth Exist After the Bismuth Crystal is Melted?

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Several investigators have asked this question because they have found that single crystal bismuth exhibits striking or peculiar physical properties near the melting point. Some of these physical properties, peculiar to solid single crystal bismuth, seemed to exist after the bismuth crystal had become molten. For example, Soroos,[1] working in the University of Iowa Laboratories, found that the thermo electric properties characteristic of solid single crystal bismuth existed to some extent in the molten bismuth until it reached a temperature about 8° C. above the melting point.

This would seem to indicate that the crystal structure of solid bismuth existed to some degree after the bismuth crystal had become molten.

Inasmuch as crystal structure also affects resistance it seems reasonable to expect that the resistance, characteristic of solid single crystal bismuth, should exist to some degree after the bismuth becomes molten.

The writer[2] of this paper conducted a series of experiments in which he measured the resistance of seven single crystals of bismuth of various orientations, at successive short intervals of time, as the temperature of the crystal slowly rose to about 10° C. above the melting point.

One of the chief difficulties encountered in this investigation was the determination of the exact time at which melting began and ended. Four different methods were used to determine these points. (1) The temperature was measured near the center of the crystal by a copper constantan thermo-couple. (2) A curve showing the temperature and time was plotted and the flat portion indicated the period in which melting took place. (3) Both junctions of a thermo-couple were placed within the furnace, one near the crystal and the other on the lid of the box holding the crystal. During melting the difference in temperature of these junctions became much greater. (4) The junctions of a thermo-couple were placed near each end of the crystal. The

[1] Adolph Soroos, Phys. Rev. 41, 516 (1932).
[2] J. Henry Schroeder, Master's Thesis, University of Iowa.

temperature of each junction was nearly the same until melting began, then the difference in temperature steadily increased until melting was complete.

The fourth method seemed to be the most accurate method because the junctions were near the ends of the crystal where the lead wires conducted heat away from the crystal, thus causing the ends to melt last.

In each of the methods described above, the low thermal conductivity of the bismuth crystal coupled with the relatively high thermal conductivity of the lead wires attached to each end of the crystal was the chief disturbing factor. The inaccuracy due to this cause was estimated to be at most about 2° C. It was also found that the resistance change expected of bismuth when it became completely melted, occurred within this 2° temperature range. This leads the writer to believe that liquid bismuth does not exhibit resistance characteristic of solid bismuth and that the crystal structure of bismuth does not exist in the molten bismuth.