C00-2314-13

Experimental Determination of the
Temperature Dependence of Metallic
Work Functions at Low Temperatures

Progress Report

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Abstract

Progress made under ERDA Contract No. EY-76-S-02-2314.002 is described. Efforts to gain theoretical insight into the temperature dependence of the contact potential of Nb near the superconducting transition have only been qualitatively successful. Preliminary measurements of adsorbed ^4He gas on the temperature dependence of the contact potentials of metals were performed and compared with a previously developed theory.

Much of the work in the past year has been involved with attempts to develop a theoretical understanding of the temperature dependence of the contact potential in niobium near the superconducting transition. This is described in Technical Report No. C00-2314-12. Although the experimental results show qualitative agreement with simple theoretical ideas no quantitative agreement can be obtained. This effort is hampered by the lack of first principles calculations of the temperature dependence of contact potentials even in simple normal metals.

Also in the past year we have begun in earnest studies of the effects of adsorbed ^4He gas on the temperature dependence of metallic contact potentials. These effects were observed in earlier experiments but have received little detailed attention.^{1,2} Recent theoretical calculations on helium adsorption to metal surfaces has provided some impetus to take a closer look³ and so we have done some preliminary work which will be extended in the coming year. These preliminary experiments were performed to get a feeling for the importance of various parameters such as ^4He gas volume, pressure and base temperature. These were done without modifying the cryostat mainly to provide guidance in determining the modification necessary for detailed studies. Typical data for ^4He on Nb are shown in figure 1.

The main features of the data are that the peak height seems to be independent of the total amount of ^4He gas admitted to the sample region and that the peak position moves to higher temperature as more gas is admitted. Another, and perhaps more significant, feature is the rapid drop of the temperature derivative of the contact potential, $\frac{dW}{dT}$, at the lower temperatures. We have previously developed a phenomenological theory to explain adsorption effects based on the Langmuir isotherm ². This theory cannot account for the data below the temperature at which the peak in $\frac{dW}{dT}$ occurs.

This last fact plus the rather low ^4He adsorption energy required to obtain even approximate agreement between the theory and the experiments leads one to suspect that the origin of the effect is more complicated than simple thermal desorption of the ^4He . High precision experiments to be performed in the coming year should shed some light on this.

References

1. A. Th. A. Am. de Waele, R. deBruyn Ouboter and P. B. Pipes, Physica 65, 587 (1973)
2. Progress Report No. C00-2314-9
3. E. Zaremba and W. Kohn, Phys. Rev. B 15, 1769 (1977)

FIGURE 1. The effect of 10^{-4} mole/liter adsorbed ^4He gas on the temperature derivative of the contact potential of Nb.

The principal investigator devoted about 25% of his time to this project during the months of March-May, 1977 and September-November 1977. He will devote about 75% of his time to the project between now and the end of the contract year.

Papers Published

D. H. Darling and P. B. Pipes, Physica 85B, 277 (1977).