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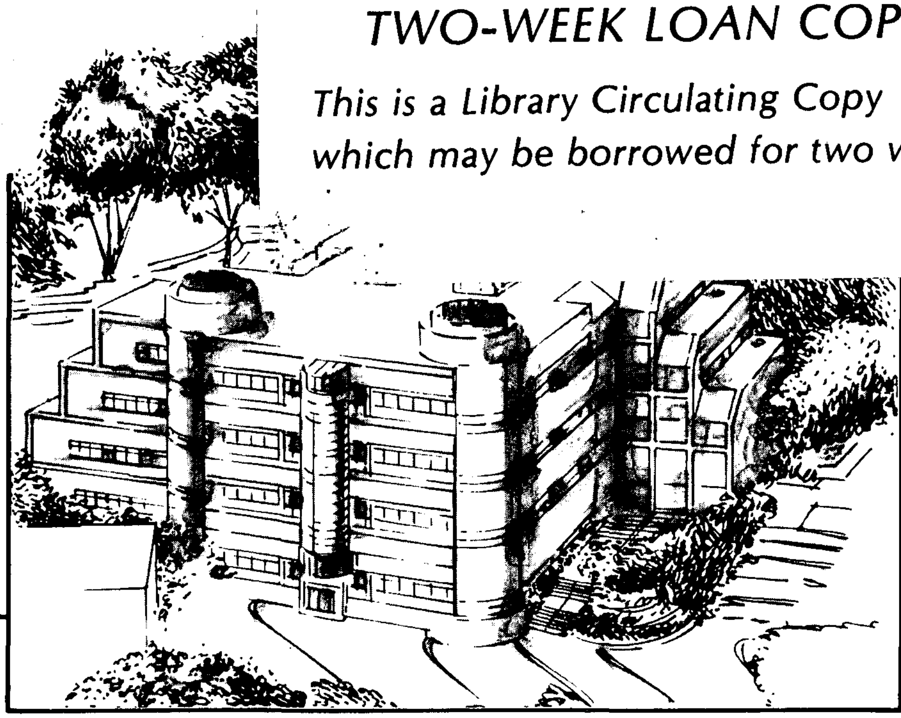

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DISCLAIMER

PRESSURE DEPENDENCE OF SCHOTTKY BARRIER HEIGHT AT Pt/GaAs INTERFACE

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ABSTRACT

The pressure dependence of Schottky barrier height at the Pt/GaAs interface has been studied using a diamond anvil cell. The pressure coefficient of the Schottky barrier height suggests that whatever states responsible for the Fermi level pinning follow the valence band edge under pressure. Within models that simple intrinsic defects are responsible for the formation of Schottky barriers in GaAs, our results suggest that these intrinsic defects may involve vacancies.

INTRODUCTION

The basic mechanisms of the formation of Schottky barrier(SB) on the surface of semiconductors such as GaAs by deposition of metal overlayers are still not well understood. Detailed studies of the chemical, electronic, and spatial structure of metal-semiconductor interfaces have indicated very weak dependence of the Schottky barrier height on metal work function and electronegativity. Also a large density of states at metal-semiconductor interfaces[1-3] have been proposed to be responsible for pinning the Fermi level. So far the microscopic nature of those states is not clear, although some theories attributed these states to defects while others attributed them to metal-induced gap states. In this paper we present a measurement of the pressure coefficient of Schottky barrier heights at Pt/GaAs(n-type) interface and compare it with pressure coefficients of different types of deep levels introduced by native defects. We found that the SB height under pressure shifts to higher energy with a linear pressure coefficient of 11 meV/kbar and with a nonlinear coefficient of -0.26 meV/kbar^2. Our results are found to be consistent with level in heavily irradiated group III-V and IV semiconductors. In particular it was suggested that simple defects, such as V_{Ga} (acceptor) and $As_{Ga}+V_{As}$ (donor), together could stablized the Fermi level position in the forbidden gap.

So far there is no way to prove or disprove these models since there has been no direct evidence of the existence of such defects at the interface. Pressure dependence offers one way to test these models since the pressure dependence of SB height should be determined by the pressure dependence of the defect levels responsible for the pinning of the Fermi level. For example, the pressure dependence of the EL2 has been determined by Dobaczewski *et al.*[14]. The linear and nonlinear pressure coefficient are 4.4 meV/kbar and -0.11 meV/kbar^2 respectively. These pressure coefficients are significantly different from that of the SB determined by this work that one has to exclude the EL2 as responsible for pinning the Fermi level at the Pt/GaAs interface. It is more difficult to test the model of Walukiewicz since the pressure coefficients of the intrinsic defects V_{Ga} and $As_{Ga}+V_{As}$ have not been reported. To explore further the idea of stabilization of the Fermi level by defects, we compare the pressure coefficients of the SB with the pressure coefficients of deep centers in GaAs compiled by Kumagai *et al.*[15] and Wallis *et al.*[16]. From Table 1 in Ref.15, we conclude that only two deep levels , E_3 and E_4 have pressure coefficients consistent with our result. Their pressure dependences are shown in Fig.2 for comparison with those of the SB. Unfortunately the identification of these deep levels are still uncertain. The level E_3 has been associated with V_{Ga} mainly because it has been found to track with the valence band edge as a function of pressure and of the Al concentration in $Ga_{1-x}Al_xAs$ alloys[17]. It was argued that, since the wavefunctions of Ga vacancies were derived predominantly from valence band states, they should follow the valence band edge. This identification has been questioned for example by Ren *et al.*[18]. Based on their theoritical calculations of the pressure coefficients of deep defect levels, these authors have concluded that both E_3 and E_4 were probably complexes, possibly an interstitial As-V_{As} pair. Thus our results are consistent with the model of Walukiewicz provided the intrinsic defects, responsible for pinning the Fermi level at metal/GaAs interfaces, are complexes containing vacancies of As or Ga.

CONCLUSIONS AND ACKNOWLEDGEMENTS

We have shown that the native defect EL2 is not responsible for the Fermi level pinning at metal-GaAs interfaces. The pressure dependence of the SB height is consistent with the amphoteric native defect model of the Schottky barrier formation provided these intrinsic defects involve complexes of Ga and As vacancies.

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