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Analysis of the Inhomogeneous Barrier in In/*p*-Si Schottky Contact and Modified Richardson Plot

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The current-voltage (I-V) characteristics of In/*p*-Si Schottky barrier contact were measured over the temperature range 230-360 K with interval of 10 K. The calculated zero bias barrier height (ϕ_{bo}) and the ideality factor (n) using thermionic theory show strong temperature dependence. The experimental values of ϕ_{bo} and n for In/*p*-Si Schottky contact range from 0.70 eV and 1.91 (at 360 K) to 0.49 eV and 2.99 (at 230 K) respectively. The conventional Richardson plot exhibits nonlinearity at lower temperature. The Richardson constant determined from intercept at the ordinate of this experimental linear portion is the value of 2.07×10^{-8} A/cm^{2}K^2 which is much lower than the theoretical value 32 A/cm^{2}K^2 for holes in *p*-type silicon. The temperature dependence of Schottky barrier characteristics of the contact was interpreted on the basis of the existence of Gaussian distribution of the barrier height around a mean value due to barrier height inhomogeneties prevailing at the metal semiconductor interface. The modified $\ln\left(\frac{I_s}{T^2}\right) - \left(q^2\sigma_0^{\,2}/2k^2T^2\right) versus \frac{1}{T}$ plot gives ϕ_{bo} = 1.17 eV and A^* = 31.16 A/cm^{2}K^2 with standard deviation σ_0 = 0.16 V.

Keywords: Zero bias barrier height, Schottky contact, Ideality factor, Modified Richardson plot, Standard deviation.

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1. INTRODUCTION

Metal-Semiconductor (M-S) contacts are found to be important research activity because the knowledge of barrier formation is still far from the complete despite the fact that they are work horse at many electronic applications like surge protection, high speed operation, microwave field effect transistors, radio frequency detectors, temperature sensors and solar cells etc. [1-4]. Although, M-S contacts have been used as research tool in the characterization of new semiconductor materials. In the information era, it is continuing need faster and complex systems to improve in device technology. Usually, the analysis of the characteristics I-V are linear in the semi-logarithmic scale at low voltages, but deviate noticeably from linearity due to the effect of parameters such as the series resistance, the interfacial layer and interface states [6-9]. The series resistance is only effective in the downward-curvature region (non linear region) of the forward I-V characteristics at large applied voltages but ideality factor and barrier height are effective through out the region of characteristics [10, 11]. This is because that the lining up process of energy bands in M-S junctions after contact are expected to depend on various charge transfer mechanisms, e.g. intrinsic surface states, metal induced gap states, impurities, microstructure defects,, crystallography and relative orientations of atoms at contact and across the interface [12, 13]. The performance and stability of Schottky contact especially depend on the formation of insulator between M-S interface, inhomogeneties and series resistance. The analysis of the I-V characteristics of the Schottky contact based on thermionic emission theory typically, reveals an abnormal decrease of zero bias barrier height and increase in the ideality factor with decrease in temperature. [14-21]. The decrease in the barrier height at low temperatures leads to non-linearity in the Richardson's plot, and is found to be non ideal. The theoretical studies based on the effect of a Gaussian distribution of Schottky barrier on the I-V characteristics have been also reported in literature [22-28].

In the present study the forward bias I-V characteristics of In/*p*-Si Schottky contact were measured over the temperature range of 220-360 K. The temperature dependent Schottky barrier height and ideality factor of the non ideal In/*p*-Si Schottky contact modified Richardson plot offers a good straight line over the entire temperature range [29]. The resultant temperature dependent non ideal Schottky contacts have been explained on the basis of the existence of a Gaussian distribution of the barrier heights around a mean value due to inhomogeneties at the M-S interface.

2. EXPERIMENTAL PROCEDURE

In/*p*-Si Schottky diode was prepared on a well polished single crystal of silicon having resistivity ($\rho \approx 1$ Ω·cm) with (100) orientations. The sample, p-type silicon wafer was ultrasonically degreased by dipping into isopropyl alcohol

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