Hydrogen Detection Analysis for Pd/InP Schottky Diode Sensors

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INTRODUCTION

It was reported that the hydrogen sensitivity of a Pd Schottky structure is arisen from a change in the *I-V* properties. And, it is presently believed that the change is attributed to hydrogen permeating through Pd film and adsorbing at the Schottky interfaces (Fig. 1). As it was well-known, the corresponding current under various hydrogen concentrations is strongly dependent on the hydrogen adsorption at the Schottky interface. However, different deposition techniques lead to different surface morphologies of Pd film, which is also related to the energy states of adsorbed hydrogen. In this work, the electroless plating was employed for Pd/InP Schottky diode fabrication. An attempt was focused on analyzing the hydrogen detection by a proposed model and interpreting the well behavior of the Pd/InP Schottky diode.

EXPERIMENTAL

In fabrication of the Pd/InP Schottky diode device, an n-InP epilayer grown on a semi-insulting InP was employed as the substrate. The ohmic contact was made by thermal evaporation of AuGe, and the Schottky contact was depositing Pd on the surface of InP substrate by electroless plating technique at 30 ℃. A hydrazine-based solution with appropriate composition was used in the Pd deposition procedure. Hydrogen concentrations ranging from 200 ppm to 1.0 % in air were employed for detection. The *I-V* characteristics were measured with a potentiostat (627A, CH I. Co.) at 293 K, 313 K and 333 K, respectively.

RESULTS AND DISCUSSION

At steady state, the hydrogen adsorption in the Pd-InP interface can be considered as a chemical reaction as Eq (1).

$$H_2 + 2\theta_i \Leftrightarrow 2H - \theta_i \qquad (1)$$

Based on the thermionic emission model combining with Langmuir adsorption theory, the dependence of current on the hydrogen concentration can be derived with the assumption of $\Delta\Phi = \theta_i \Delta\Phi_{\max}$ expressed as Eq (2).

$$\frac{1}{\ln\left(\frac{I_{og}}{I_o}\right)} = \frac{1}{\ln\left(\frac{I_{og,\max}}{I_o}\right)} + \frac{1}{\ln\left(\frac{I_{og,\max}}{I_o}\right)}\left(\frac{1}{KP_{H_2}}\right)^{0.5} \qquad (2)$$

where K the equilibrium constant, I_o the saturation current in air, and I_{og} the saturation current in hydrogen. As seen in Fig. 2, plots of current versus hydrogen concentration were all linear. From the van't Hoff equation, $\ln K = -\Delta H / RT + \Delta S / R$, the values of ΔH and ΔS for hydrogen adsobed at Pd/InP interface was determined to be -61.2 $kJmol^{-1}$ and -167.2 $Jmol^{-1}$ K^{-1}, respectively. Comparing the heat of adsorption ΔH with others, it can be found the heat evolved is larger than those of Schottky diodes fabricated by thermal evaporation. That is, the hydrogen adsorbed at electroless plated Schottky interface is more stable than that at thermal evaporated Schottky interface. And, this is a reasonable explanation for well-behaved Schottky diode via electroless plating.

CONCLUSION

In summary, the hydrogen adsorption on the electroless plated Pd/InP interface can be described by a proposed model. From the thermodynamic properties of ΔH and ΔS, it provided a good explanation for promising fabrication of Pd/InP Schottky diodes by electroless plating.

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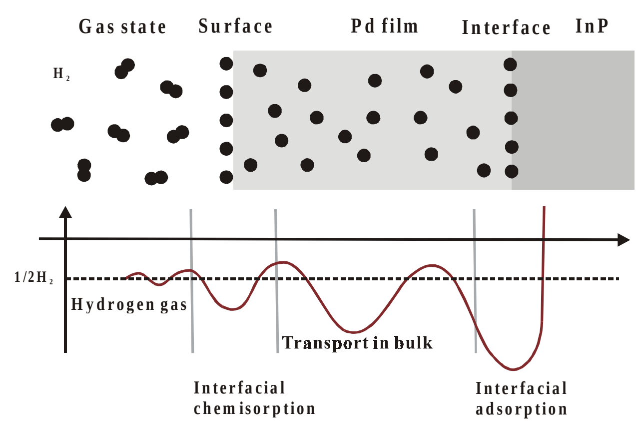

Fig. 1 Potential diagram for hydrogen adorption in Pd/InP Schottky diode.

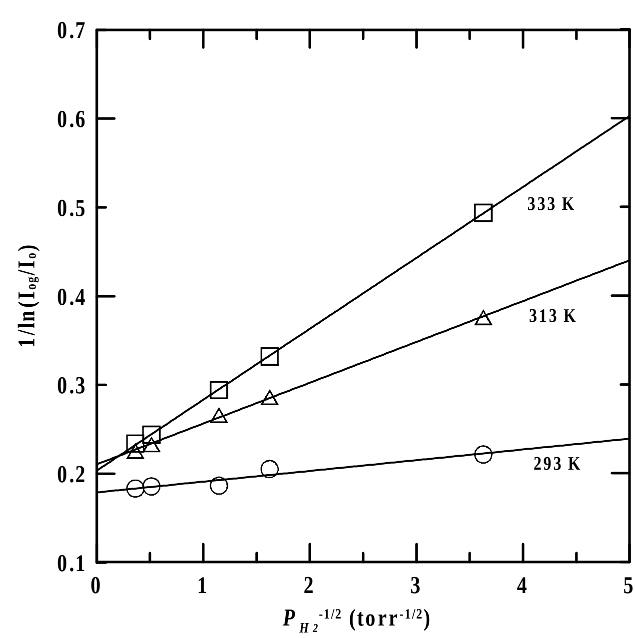

Fig. 2 Plot of $1/\ln(I_{og}/I_o)$ versus $P_{H2}^{-1/2}$.