[II~8]

The critical condition for preserving of the S-passivation effects in the Schottky barrier formation on GaAs(100)

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I. Introduction

Since Sandroff et. al. has reported the dramatic improvement of HPT gains as a result of treating the GaAs surface with an aqueous S-solution in 1987[1], the S-treatment effect was widely investigated in order to understand the origin of such improvement. Up to now it has been accepted that the S atoms efficiently remove some defects on the GaAs. Although such passivation works on most of III-V compound semiconductors, the systematic metal contact results on the S-passivated surface has not been reported. In the present work, we tested the possibility of the ideal Schottky contact on the S-passivated GaAs through evaporating five kinds of metals with different work-functions ranged from 2.3eV to 5.65eV.

II. Experimental

The degreased GaAs(100) was etched with a dilute HCl solution to remove the native oxide layer and dipped into the (NH4)2SX solutions at 50℃ for 30min. Details of the processes were similar to those of Iyer and Lile.[2] This S-passivated GaAs(100) was analyzed by XPS. In-situ metal evaporation and resistive annealing were also conducted in the analysis chamber. The samples were n-type (Si-doped) GaAs(100) and the thermally evaporated metals were K(Φwork = 2.3eV), Mg(3.66eV), Al(4.28eV), Au(5.1eV), and Pt(5.65eV). The evaporation was controlled by the thickness monitor using the quartz oscillator.

III. Results and Discussions

The Fermi level(Ef) of S-passivated GaAs(100) was at 0.6eV below the conduction band minimum(CBM) in the gap. The additional annealing shift Ef to 0.5eV below CBM, which was checked by Ga 2p core level. The Ef movements of metal-evaporated GaAs can be summarized as follows :

For K(~3ML), the Ef moves to 0.3eV above CBM, which implies the type inversion from n-type to p-type. For Mg(~3ML), the Ef moves to 0.8eV below CBM. For Al(~3ML), the Ef moves to 0.3eV below CBM, and for additional deposition(~20ML) 0.7eV below CBM. For Au(~3ML), the Ef moves to 0.9eV below CBM. For Pt (~1ML), the Ef moves to 0.9eV below CBM, but it shifts to 0.1eV below CBM for

additional deposition(~4ML).

For Mg, Al, and Au, the final positions of Ef were almost matching with those previously reported in the metal deposition on GaAs surfaces without S-passivation.[3] This implies that Ga-S bondings acting the major roll of sulfur-passivation were dissociated by the evaporated metals. The possible products at the interface might be Al_2S_3, MgS, and AuGa alloy. Hence, as a results of metal deposition, the regeneration of antisite defects drive the Ef to be pinned at the midgap.

But, for alkali metal deposition on unpassivated GaAs, the final Ef was 0.65eV(for Cs) below CBM, which is quite different from our K-deposition result. This must be the result that K atoms can not dissociate Ga-S bondings, and the S-passivated GaAs(100) can keep Ga-S bondings despite of deposition of thick metal with small work-function (2.3eV). For aligning the vacuum levels of both materials at the contact, the Ef shift to above CBM. These results imply that, in only K-deposition, the Ef tends to follow the direction of the ideal Schottky contact.

Ⅳ. Conclusion

In the metal contact with S-passivated GaAs(100), the deposited metals, except K, destroyed S-Ga bondings through either formation of metal sulfides or metal-Ga alloys. The subsequently induced antisite defects induced midgap pinnings, which are almost same results as those of unpassivated GaAs. Hence, in order to exploit the S-passivation on GaAs, the deposited metal should reserve Ga-S bondings, then the Fermi level tends to follow the direction of ideal Schottky contact.

Acknowledgements

The present studies were supported by the Basic Science Research Institute program, Ministry of Education, 1996, project No. BSRI-96-2433.

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