High-Temperature Reliability of Ni/Nb Ohmic Contacts on 4H-SiC For Harsh Environment Applications

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Introduction: SiC with large bandgap, high breakdown electric field strength, high thermal conductivity, high electron saturation velocity, etc., has been one of the most promising candidate for high temperature and high power applications [1]. Nonetheless, the operation lifetime of the devices are strongly affected by the reliability and stability of metal/SiC contacts. Up to now, Ni is known as one of the best candidates for ohmic contact to 4H-SiC because of low specific contact resistivity. However, the disadvantage of the Ni/SiC ohmic contact is that free carbon atoms released from SiC substrate can cause graphite or carbon agglomeration, which cause larger contact resistance and reduce the operation lifetime of the SiC devices [2]. Niobium (Nb) was reported as one of candidates that can completely eliminate excess carbon and thus improve the quality of the ohmic contacts to SiC [3].

Results and Discussions: In this research, we investigated the high temperature stability of the Nb/Ni and Ni/Nb ohmic contact to 4H-SiC. For fabrication, 50 nm thickness of Nb and 50 nm thickness of Ni with different order were deposited on n-type 4H-SiC substrates with nitrogen doping $N_D \approx 1x10^{18}$ cm^{-3}. After the metal depositing process, the samples were annealed at 1000 ^{0}C for 3 min by rapid thermal annealing (RTA) method to form ohmic contact. In order to release the thermal stability, the samples were aged in N_2 atmosphere at 400 ^{0}C for up to 100 hours. The results (shown in Fig. 1) illustrate that while the Nb/Ni/4H-SiC sample lost the ohmic characteristic after being aged for 10 hours, the Ni/Nb/4H-SiC sample still showed good ohmic behavior with a relatively small increasing of the specific contact resistance after being aged up to 100 hours. To explain for the high-temperature stability of the Ni/Nb/4H-SiC ohmic contact, 2-dementional X-ray Diffraction (2D-XRD) analysis was performed. As shown in Fig. 2, the Ni_2Si and Nb_6C_5 compounds remain stable at the contact layer. The absence of carbon peaks after annealing and aging suggests that the formation of Nb_6C_5 compound prevent the formation of the graphite at the interface, therefore, improve the ohmic contact stability when operating in high temperature environment. It is suggesting that Ni/Nb/4H-SiC ohmic contact could be a potential candidate for high temperature and harsh environment applications.

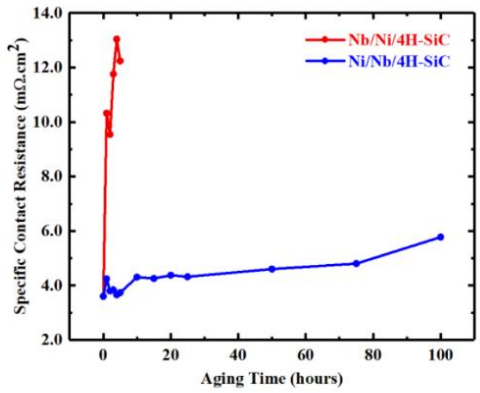

Figure 1. Average specific contact resistance of the Nb/Ni/4H-SiC and the Ni/Nb/4H-SiC ohmic contacts as a function of aging time at 400 ^{0}C in N_2 ambient

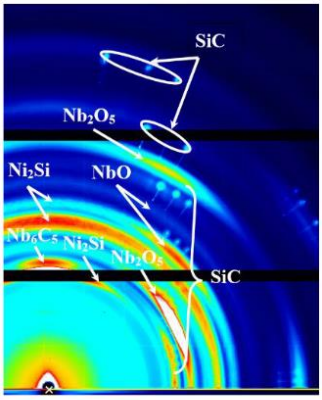

Figure 2. 2D-XRD images of the Ni/Nb/4H-SiC contact after aging at 400 ^{0}C for 100 hours

References

[1]. Tsunenobu Kimoto et al., John Wiley & Sons, Singapore (2014).

[2]. Milantha De Silva et al., ECS Journal of Solid State Science and Technology **5** (2016) 457-460.

[3]. Milantha De Silva et al., Appl. Phys. Lett. **109**, (2016) 012101.

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