Thermal Stability of Ni-based Ohmic Contacts to *n*-SiC For High Temperature and Pulsed Power Device Applications

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Due to its wide bandgap, high bond strength, high electric field strength, and high electron saturation velocity, SiC has great promise for high temperature and high power device applications [1, 2]. Electron devices based on SiC are expected to operate at temperatures on the order of 300 - 800 ^{o}C. As a consequence of this extreme operational environment the detection sensibility and the stability of SiC based high temperature, high power electronic devices has been found to be extremely temperature dependent [3]. High temperatures and high power device operation is constrained primarily by issues related to metallization, that is, Ohmic and Schottky contacts. In terms of metal contacts to SiC, runaway diffusion barriers, instability of contact resistance, stress induced surface roughness, thermomechanical and thermochemical stability, are among several challenges that must be overcome in order to extend the operating temperature range of SiC devices beyond 350 ^{o}C.

It has been documented that most SiC based electronic devices which were unable to sustain long term operation at an elevated temperature suffered deterioration of their metal-SiC contacts [3,4]. Two major contributions deemed responsible for the contact deterioration were interfacial diffusion and reaction between the contact and SiC at elevated temperatures. The thermal integrity of the contact metal-SiC system is violated when post contact fabrication temperatures in excess of reaction temperatures of conventional metals with SiC are employed, thereby causing nonuniformity in contact properties, device operational reliability and yield issues. Therefore, an important technology for realization of high temperature and high power devices is the development of low resistance Ohmic contacts which are stable at high temperature.

Several metallization schemes described in the literature have been studied for electrical, chemical and/or microstructural characteristics after annealing, however, few studies have examined the thermal stability of the contacts at elevated operating temperatures [4]. The development of low resistance contacts with the capability of handling extended high temperature stress/fatigue, which simulates the device operational environment, is crucial. Similarly, for pulsed power switching applications the contact must maintain electrical and structural integrity in response to palpitated operational thermal stress. Thus, contact stability in response to the influence of extended high temperature aging and acute pulsed thermal fatigue needs to be investigated in order to determine and exploit the full potential of SiC for high temperature and high (pulsed) power device applications.

The goal of the present investigation was to examine the thermal stability and performance reliability of Pt/Ti/WSi/Ni Ohmic contacts to *n*-SiC. Pt/Ti/WSi/Ni Ohmic contacts to *n*-SiC, initially annealed at 950 and 1000 ^{o}C for 30 s, were evaluated for thermal stability via pulsed/cyclic thermal fatigue and aging experiments at 650 ^{o}C. Modifications of material properties in response to cyclic thermal fatigue and aging tests were quantitatively assessed via current voltage measurements, field emission scanning microscopy, atomic force microscopy and Rutherford backscattering spectrometry. Negligible changes in the electrical properties, microstructure, and surface morphology/roughness were observed for both annealed Ohmic contacts in response to 100 cycles of acute cyclic thermal fatigue. Aging of the 950 ^{o}C annealed contact for 75 hours at 650 ^{o}C resulted in electrical failure and chemical interdiffusion /reaction between the contact and SiC substrate. The 1000 ^{o}C annealed contact retained Omicity after 100 h of aging and was found to be chemically and microstructurally stable. These findings indicate that the 1000 ^{o}C annealed Pt/Ti/WSi/Ni Ohmic contact to *n*-SiC is thermally stable and merits strong potential for utilization in high temperature and pulsed power devices.

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