Carnegie Mellon

Materials Science and Engineering Seminar Series

Materials Research at Carnegie Mellon

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“Thermal Stability and Degradation Mechanisms in Nickel-Based Ohmic Contacts to n-type Silicon Carbide for High-Temperature Gas Sensors”

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10:00 A.M. Seminar in Hamerschlag Hall B103
Refreshments precede seminar at 9:00 A.M. in 2325 Wean Hall

With increasing attention on curbing the emission of pollutants into the atmosphere, chemical sensors that can be used to monitor and control these unwanted emissions are in great demand. Examples include cylinder-specific monitoring of hydrocarbons from automobile engines and monitoring of flue gases such as CO emitted from power plants. Because many of the polluting processes and gases require sensors that can be operated at high temperatures (~300–800 °C) and in chemically aggressive environments, the intrinsic properties of SiC, such as its wide band gap and chemical inertness, give it substantial advantages for use in these sensors. One of the critical limitations in high-temperature SiC gas sensors, however, is the degradation of the metal-SiC contacts over time. In this study, we investigated the high-temperature stability of Pt/$TaSi_x$/Ni/SiC ohmic contacts, which have been implemented in actual SiC-based gas sensors developed for applications in diesel engines and power plants. The specific contact resistance, interfacial chemistry, and surface morphology were characterized as a function of annealing time in air at 300, 500, and 600°C. It was found that the contacts exhibited sufficient electrical stability for operation at 300°C; the contacts remained ohmic for over 1000 hrs in air. In contrast, the contacts annealed at 500 and 600°C showed large increases in specific contact resistance followed by non-ohmic behavior after 240 and 36 hours, respectively. Depth profiles from Auger Electron Spectroscopy (AES) showed complete oxidation of the tantalum-silicide layer in contacts that failed at 500 °C and 600 °C, even though the annealing times were significantly different. Depth profiles obtained from contacts annealed at 300°C show some modest oxidation confined to the metallic interfaces, as well as some carbon diffusion. In addition, comparison of AES analyses with scanning electron microscope images indicate that carbon freed up from the reaction of Ni with SiC can promote delamination and may serve as a pathway for enhanced oxidation. In this presentation, our evidence for common degradation mechanisms of Ni-based contacts will be discussed along with insight into ways to enhance the stability.

Ariel received her M.S. in Materials Science and Engineering from Carnegie Mellon University in 2006 and Bachelor’s degree in Materials Science and Engineering from the University of Pittsburgh in 2004. She is currently a Ph.D. candidate under the guidance of Prof. Lisa Porter.