High Temperature Characteristics of Pt/$TaSi_2$/Pt/W and Pt/Ti/W Diffusion Barrier Systems for Ohmic Contacts to 4H-SiC

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Abstract

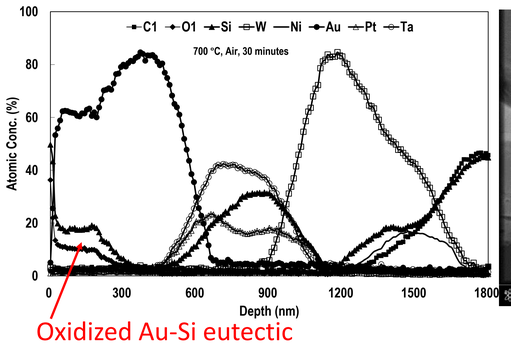
The degradation of ohmic contacts to 4H-SiC sensors over time at high temperature is primarily caused by two dominant failure mechanisms: migration of bond pad Au and atmospheric oxygen toward the ohmic contact/SiC interface; and the inter-metallic mixing between diffusion barrier systems (DBS) and the underlying ohmic contact metallization. We have investigated the effectiveness of Pt/$TaSi_2$/Pt/W and Pt/Ti/W DBS in preventing Au and O diffusion through the underlying selected W:Ni [1] and Ti/W [2] ohmic contacts to 4H-SiC up to 700 °C.

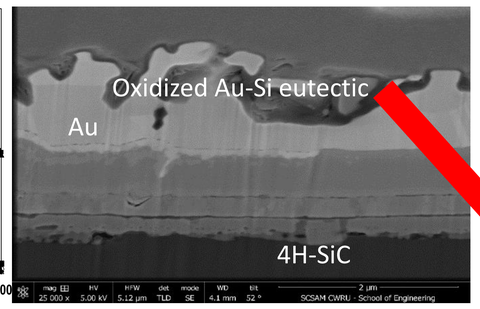
Objectives and Goal

Evaluate the diffusion characteristics of selected metallization stacks on known ohmic contacts to 4H-SiC with the goal of identifying the stack that would support long term reliable operation of sensors and electronics at temperatures as high as 700 °C.

Pt/$TaSi_2$/Pt/W Diffusion Barrier System

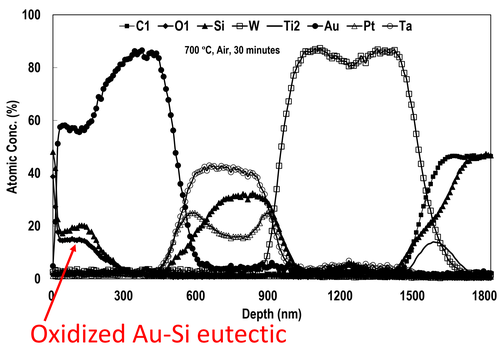
Pt (200 nm)/$TaSi_2$ (400 nm)/Pt (100 nm)/W (300 nm) DBS with W:Ni Ohmic Contact

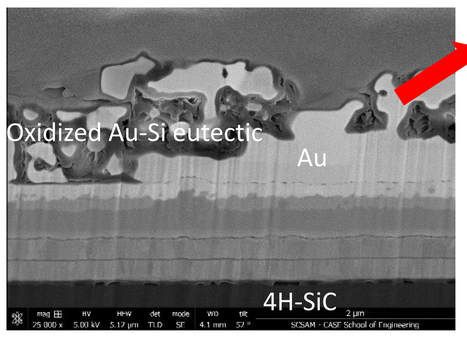




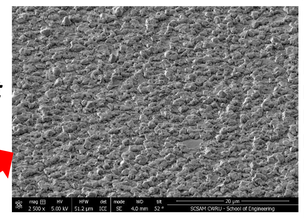
Oxidized Au-Si eutectic

Pt (200 nm)/$TaSi_2$ (400 nm)/Pt (100 nm)/W (300 nm) DBS with Ti/W Ohmic Contact





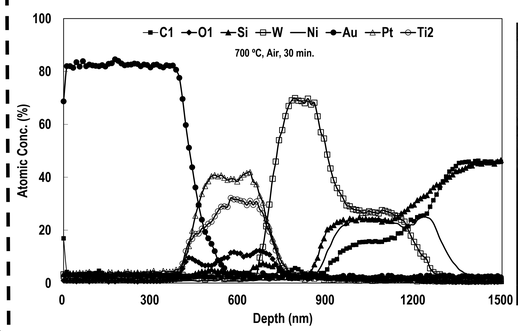
Oxidized Au-Si eutectic

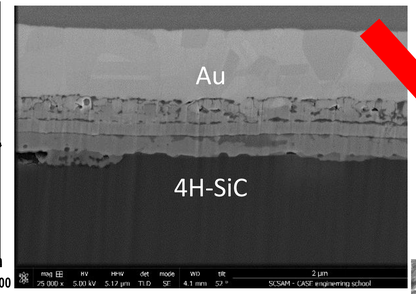


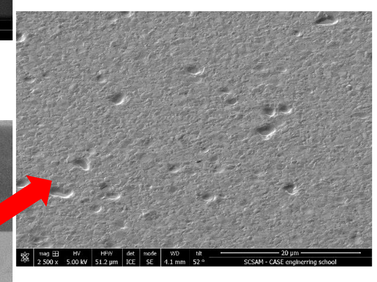
Rough surface morphology induced by Au-Si eutectic phase

Pt/Ti/W Diffusion Barrier System

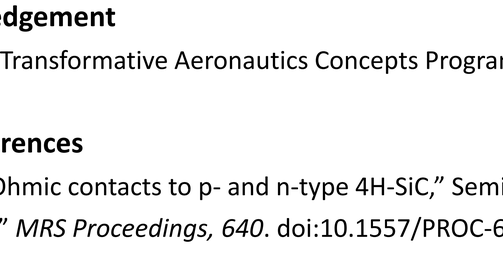
Pt (300 nm)/Ti (100 nm)/W (300 nm) DBS with W:Ni Ohmic Contact

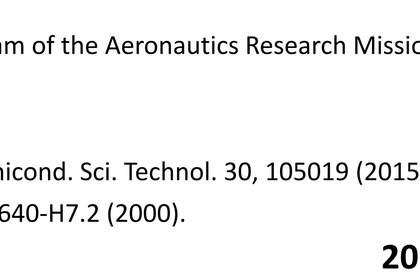






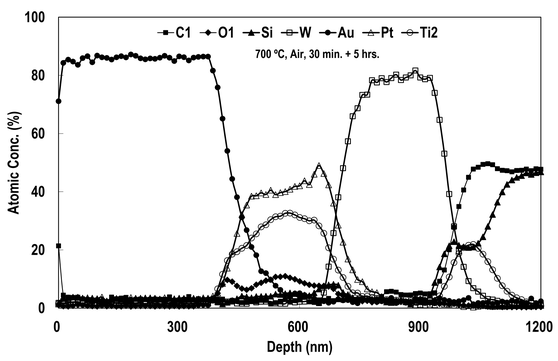
Pt (300 nm)/Ti (100 nm)/W (300 nm) DBS with Ti/W Ohmic Contact

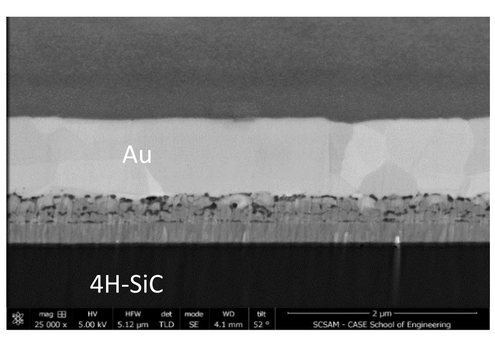




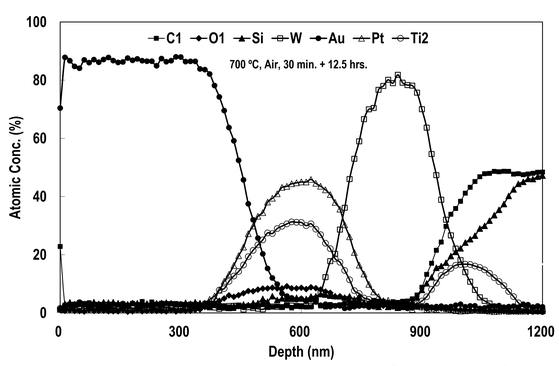
Smooth surface morphology

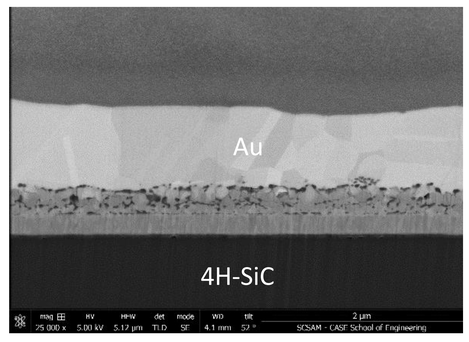
Long Term Evaluation of Pt/Ti/W DBS on Ti/W Ohmic Contact at 700 °C in Atmosphere





After 5 hrs. at 700 C in Air





After 12.5 hrs. at 700 C in Air

Summary and Conclusion

- For the Pt/$TaSi_2$/Pt/W DBS on both the W:Ni and Ti/W ohmic contacts, FIB-FESEM revealed the transformation of the surface morphology to one that was densely populated with sub-micron solid globular features, identified to be a Au-Si eutectic phase. The Au-Si eutectic at the surface acts as a nucleation site for the oxidation of Si, which then extends 300 nm into Au layer. This oxidation of the Au-Si eutectic at the top surface will degrade the mechanical and electrical integrity of the contact after wire- or flip-chip bonding.
- For the Pt/Ti/W DBS on both W:Ni and Ti/W ohmic contacts, the Au layer remained free of O diffusion. The surface morphology remained smooth and minimal zonal intermetallic mixing was observed.
- Further evaluation of the Pt/Ti/W DBS on Ti/W ohmic contact at 700 C after 5 hours and 12.5 hours showed little change in the intermetallic mixing zones. The microstructural characteristics also remained unchanged and no evidence of atmospheric oxygen migration through the contact metallization.

Acknowledgement

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References

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2) S. Lee, C. Zetterling, and M. Östling, "Titanium Tungsten (TiW) for Ohmic contacts to n-and p-type 4H-SiC," *MRS Proceedings, 640*. doi:10.1557/PROC-640-H7.2 (2000).

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