

Metallization Scheme for 800 °C Silicon Carbide Microsystems

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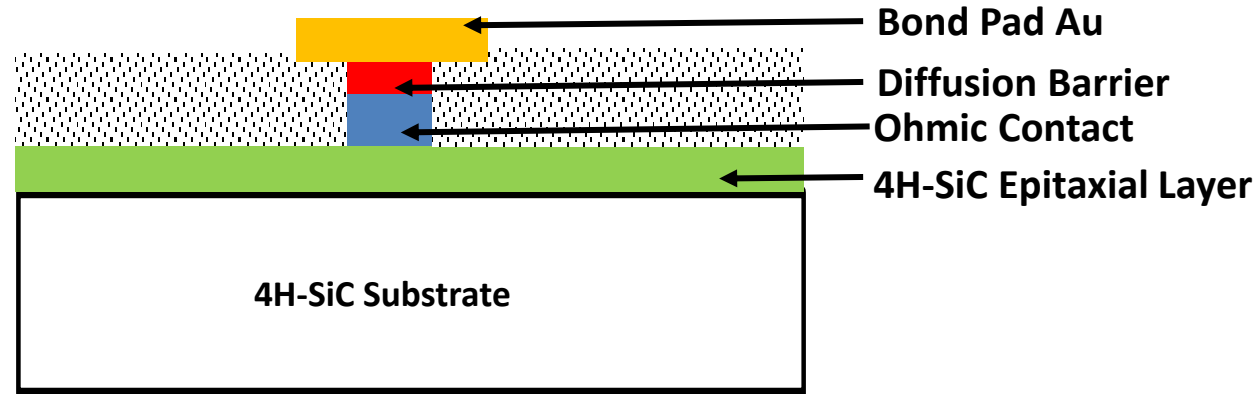
NASA Transformative Tools and Technologies Project



Problem to Address

Degradation of ohmic contacts to 4H-SiC sensors and electronics over time at high Temperature ($>600\text{ }^{\circ}\text{C}$) is driven primarily by two dominant failure mechanisms:

- **Bond pad Au and O migration toward the ohmic contact/SiC Interface, resulting in rectification.**
- **Inter-metallic mixing of diffusion barrier and underlying ohmic contact metallization, resulting in increased resistance.**

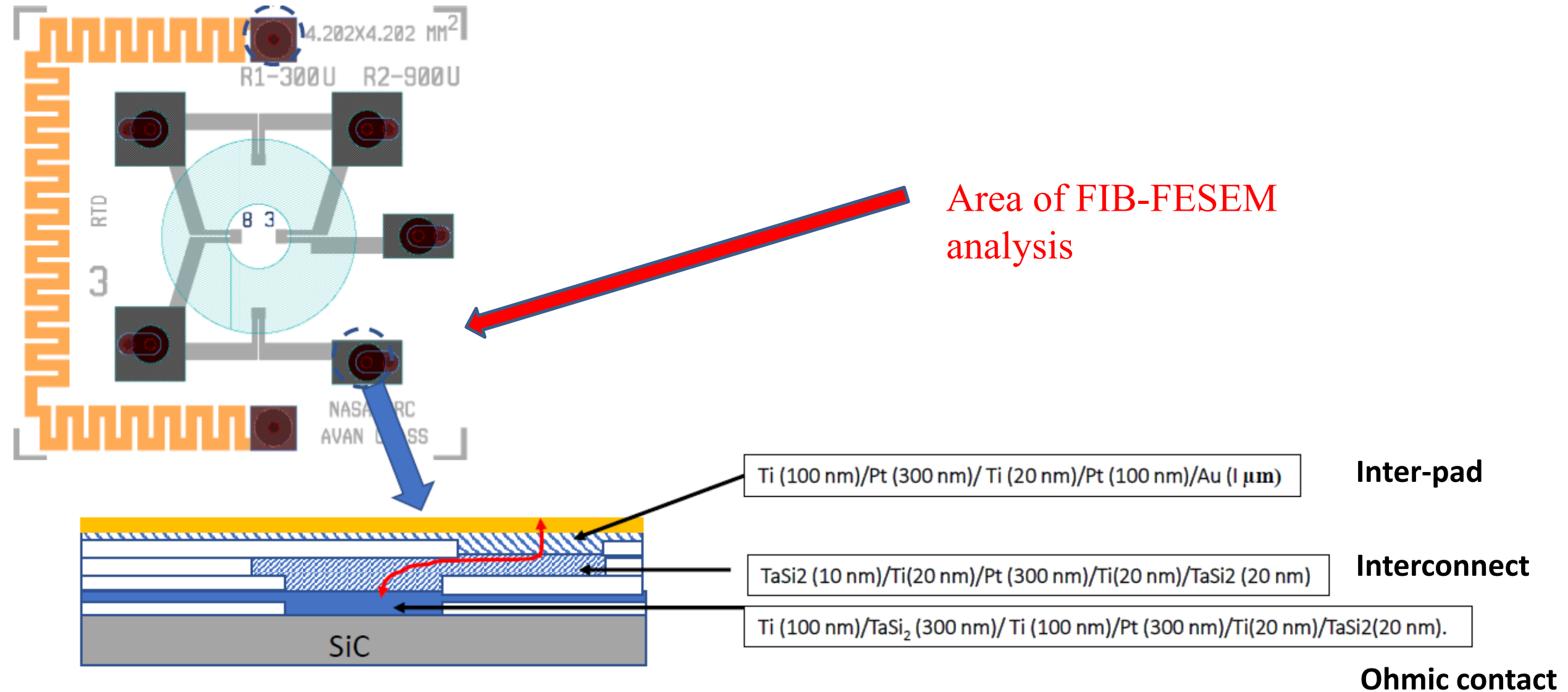




Objective

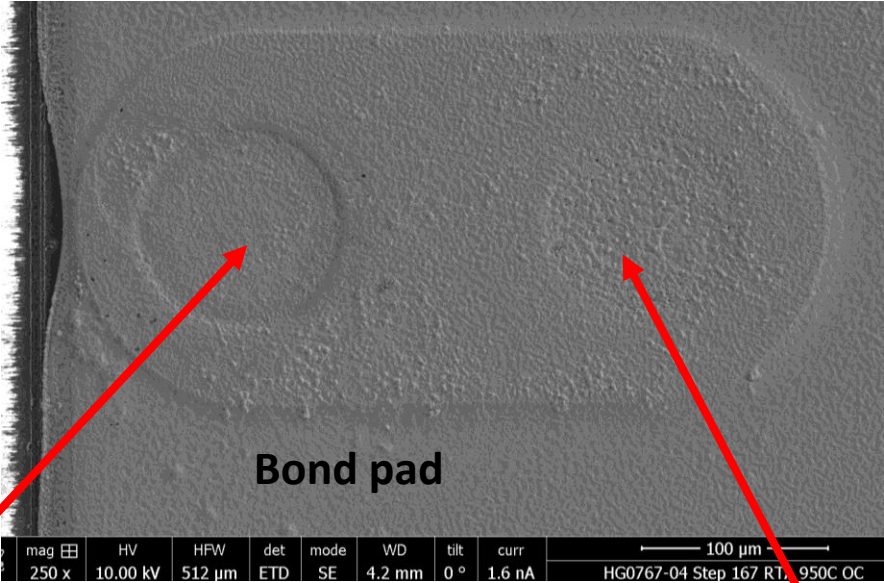
- **Developed and high temperature metallization scheme that can sustain silicon carbide (SiC) microsystem operation at 800 °C in the absence of protective packaging.**
- **Validate the effectiveness of the metallization in preventing Au And O migration to the epitaxial layer, with goal of achieving stable electrical operation up to 800 °C.**
- **Implement metallization scheme on functional device-SiC pressure sensor.**

Ohmic Contact Bond Pad

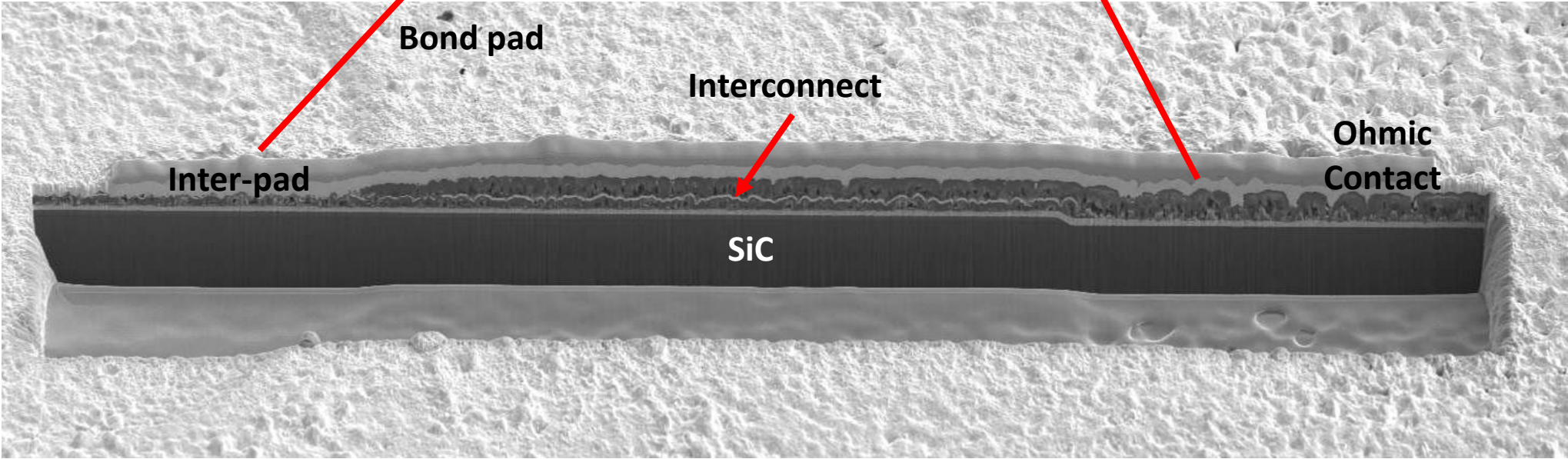


950°C/30 sec/RTA

HG0767-04 Cell 08-03 Step 167

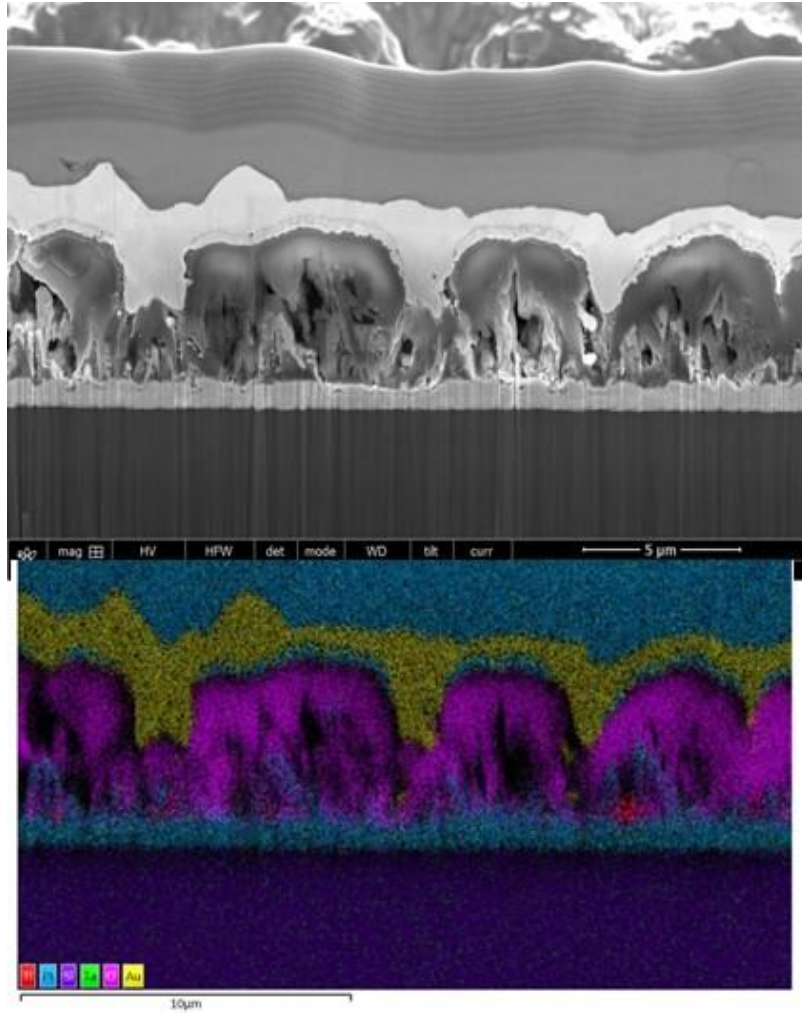


Bond pad top view



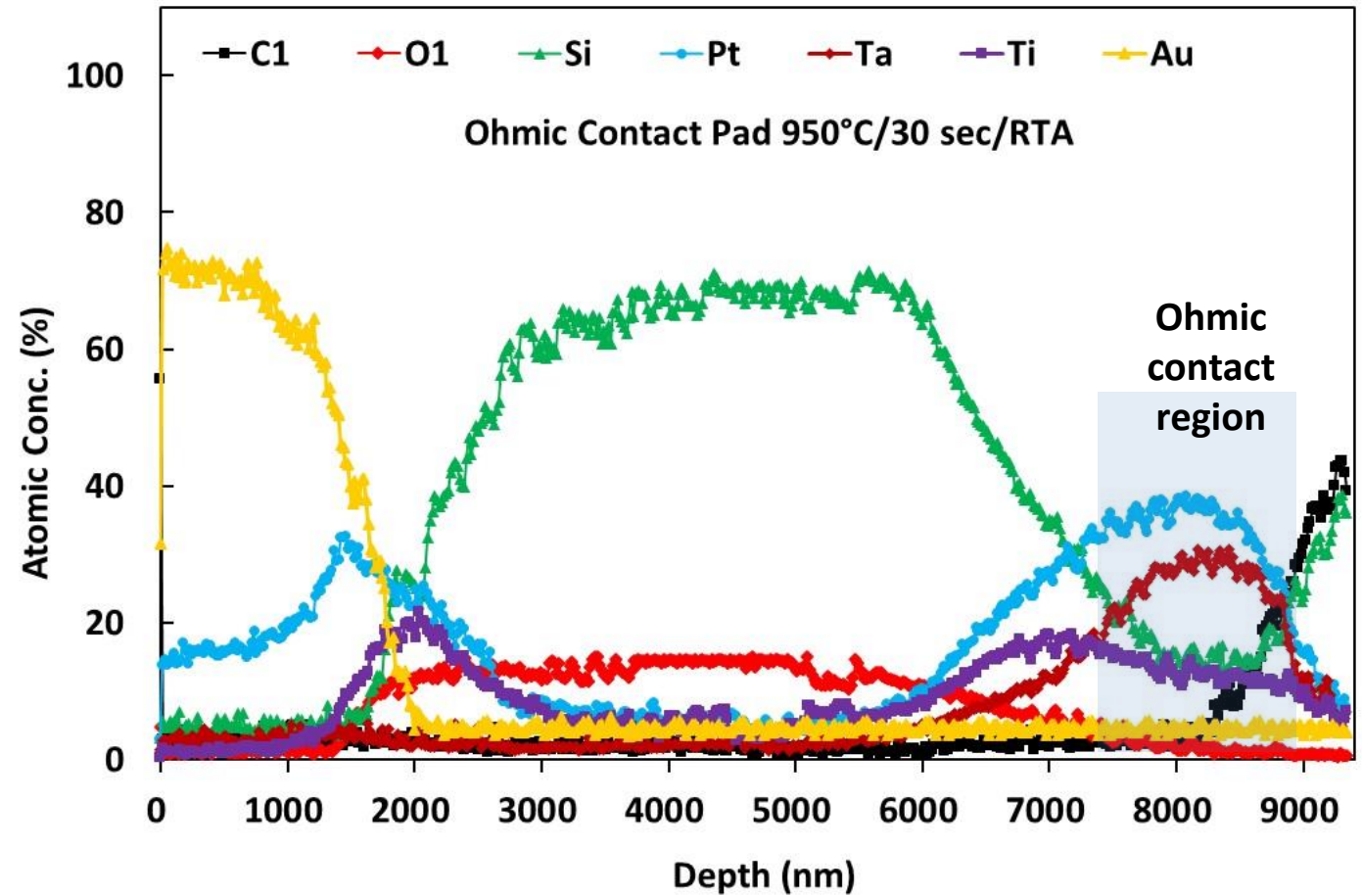
950°C/30 sec/RTA-AES Depth Profile

Ti
Pt
Si
Ta
O
Au



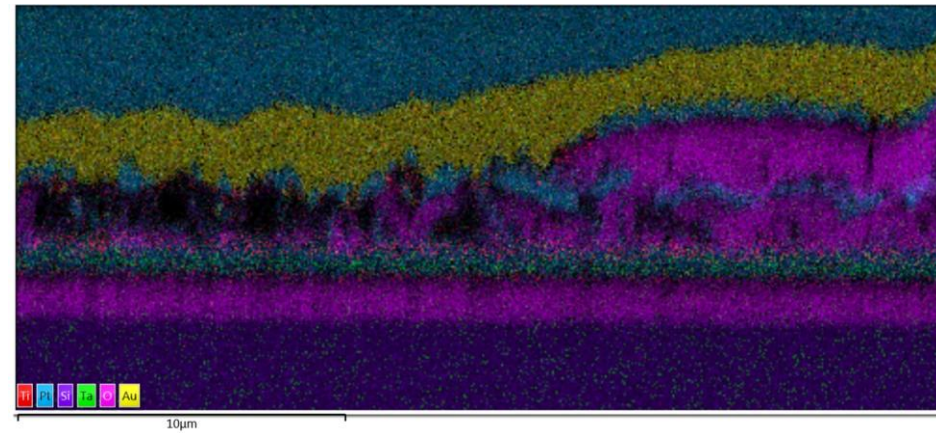
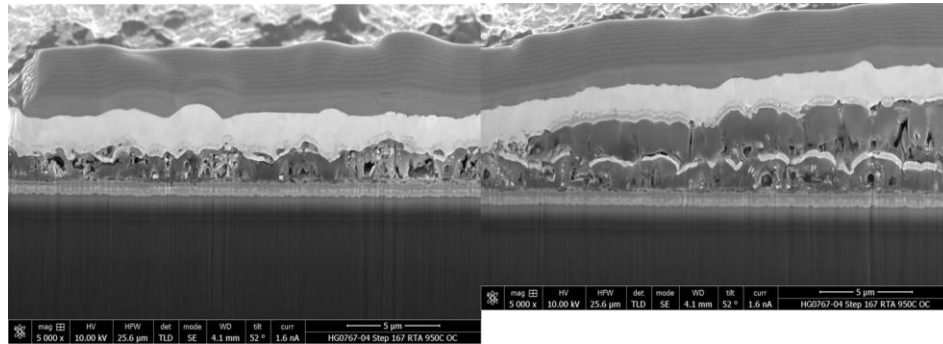
HG0767-04 Step 167 OC Pad RTA 950C/30 s

AES depth profile

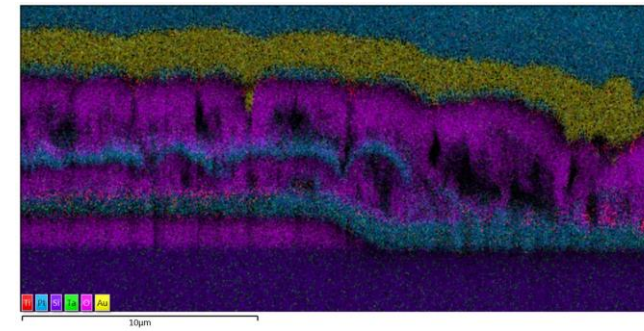
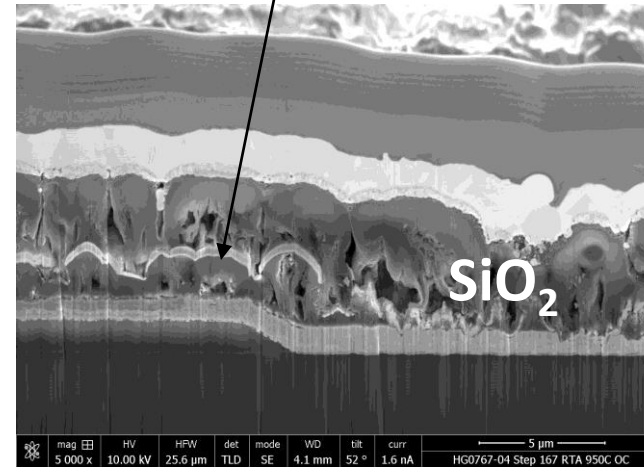


950°C/30 sec/RTA

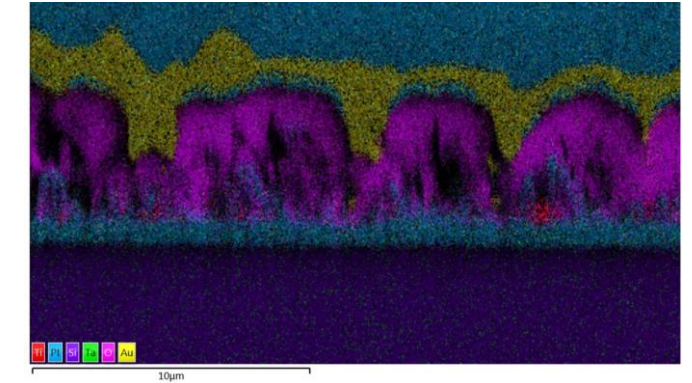
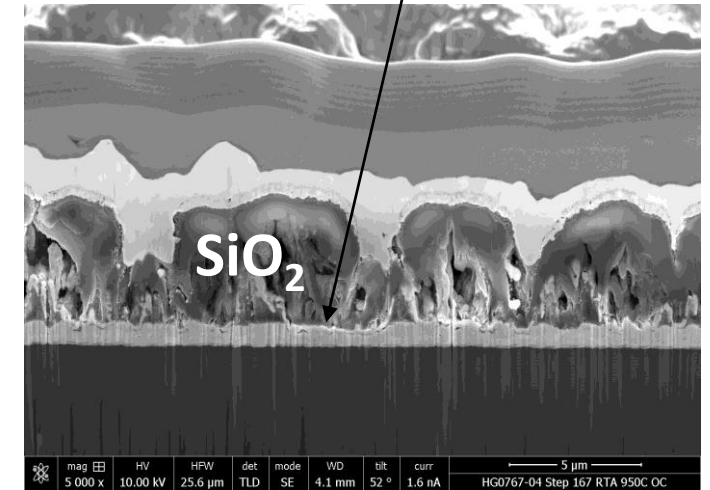
Inter-pad



Interconnect

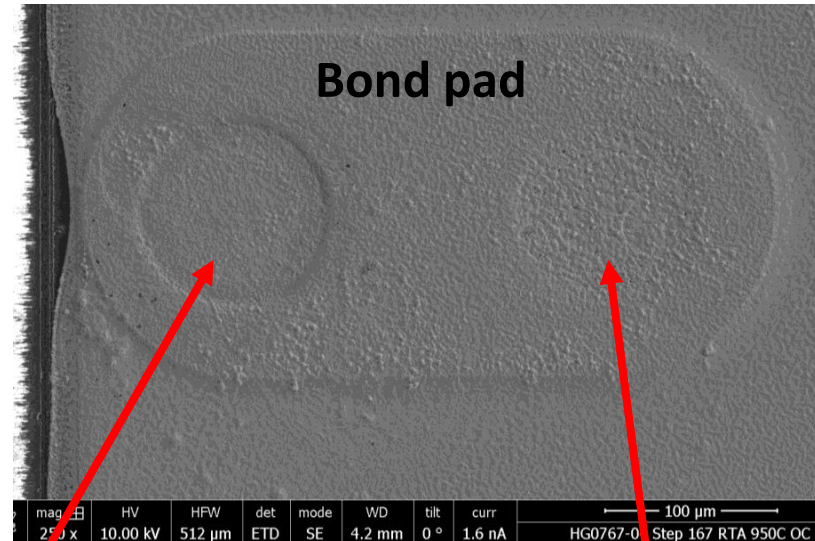


Ohmic Contact

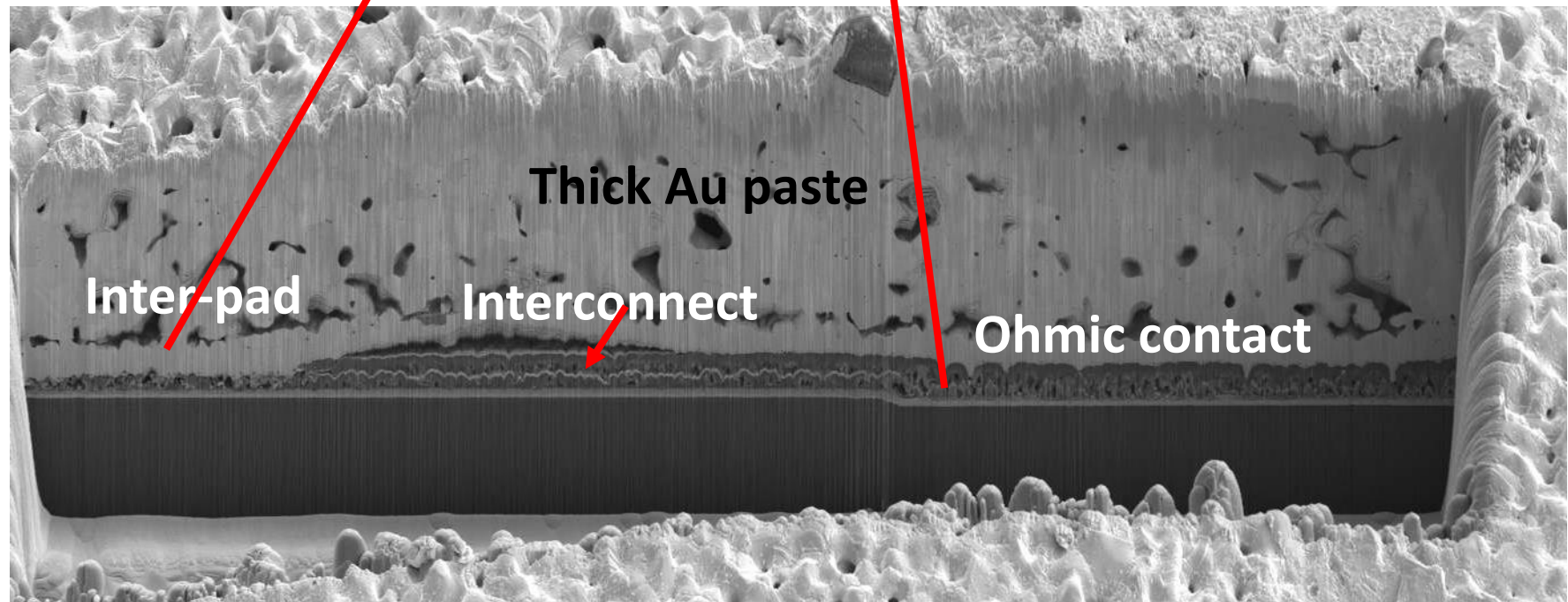


Ti
Pt
Si
Ta
O
Au

Au Paste 800°C/30 min, Air



HG0767-04 Cell 08-08 Step 178

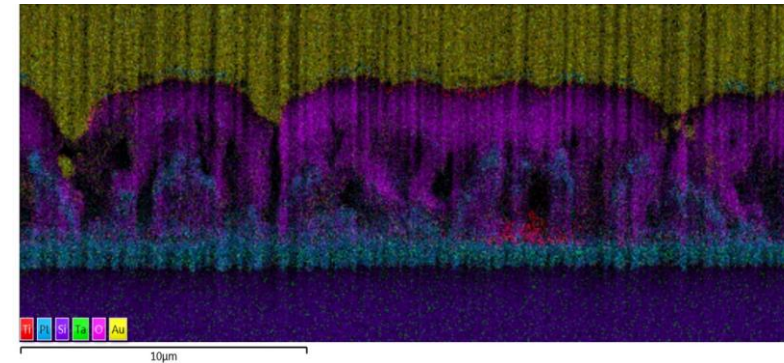
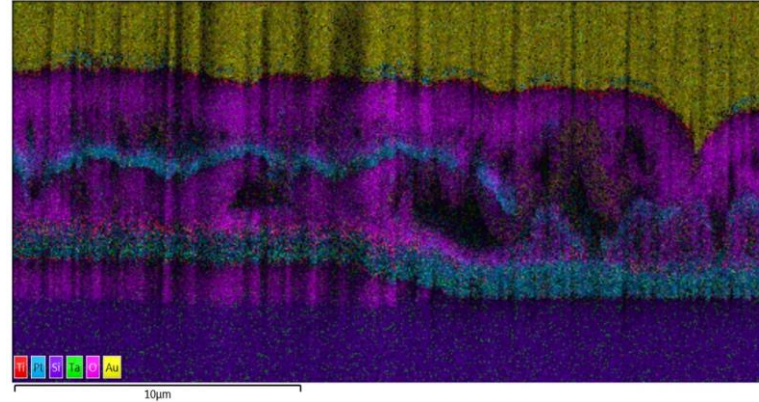
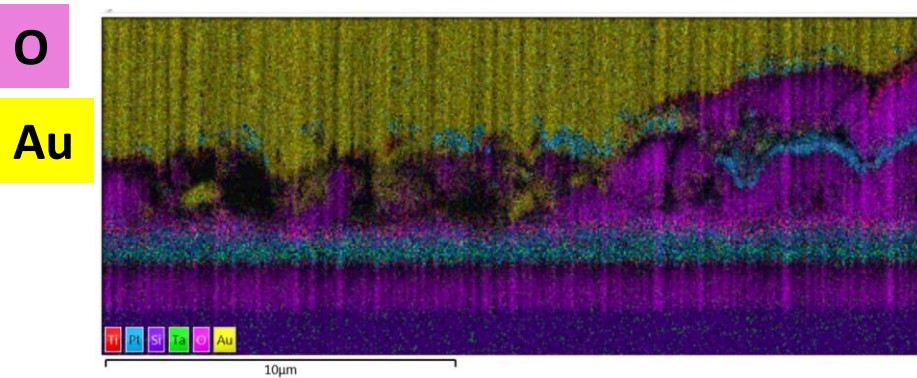
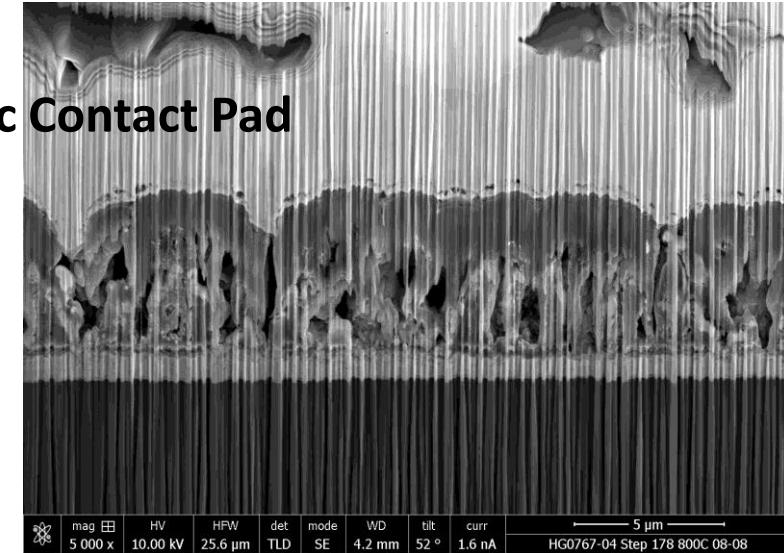
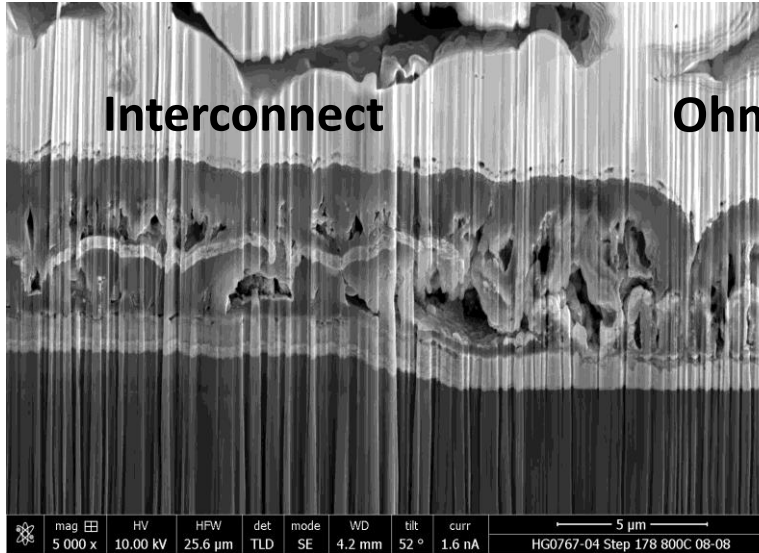
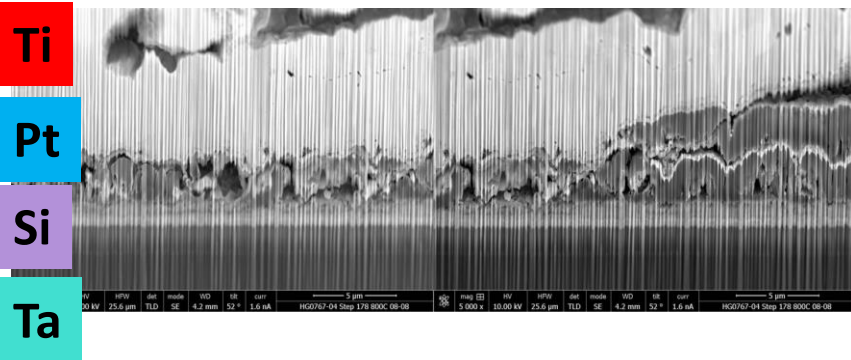


Bond Pad Au Paste 800°C/30 min, Air

Inter-pad

Interconnect

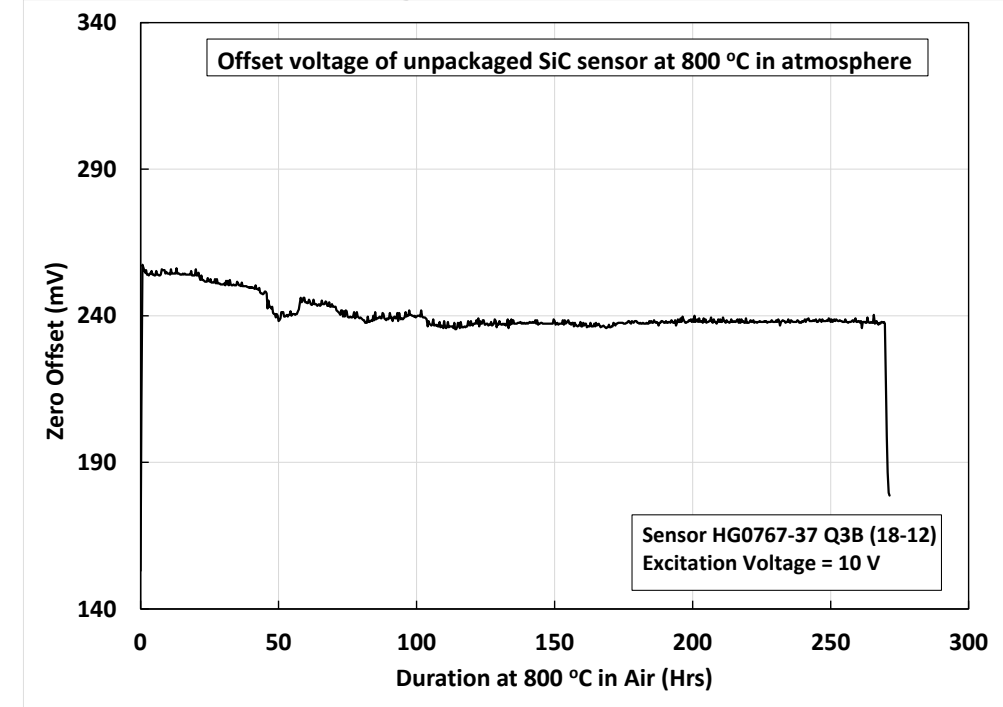
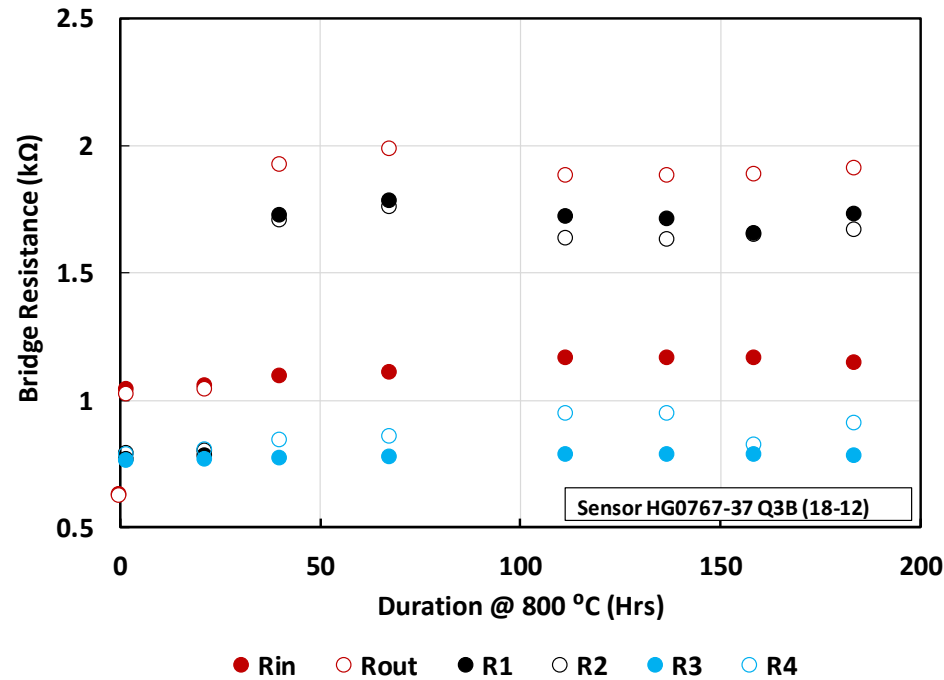
Ohmic Contact Pad





Results: Electrical Analysis

Using 4H-SiC Wheatstone Bridge



Key Observations

- Changes in Bridge Resistance During First 100 Hrs. Correlate Well with Period of Active Au and O Migration Into The Pt/Ti Barrier Layer.
- Bridge Resistance and Zero Offset Simultaneously Leveled off after First 100 Hrs, Remaining Relatively Stable Thereafter.
- Significant Abatement of Further Au and O Diffusion Through the Barrier.



Conclusion

- Investigated the preservation of Ti/TaSi₂ ohmic contact to n-type 4H-SiC by preventing Au And O migration.
- Introduction of an interconnecting metallization augmented the Ti/Pt diffusion barrier to effectively prevented O and Au migration to the ohmic contact layer.
- EDS and AES analyses used to confirm results.
- Validation demonstrated on functional and unpackaged 4H-SiC sensors in an atmospheric oven, representing the most extreme of conditions.
- Results confirms the application of the scheme on SiC sensors and electronics to support reliable operation at 800 °C.



Acknowledgements

Technical Staff of the NASA GRC Microfabrication Laboratory



Thank you!