Nickel Interlayer for Improved Silver Complex Inks Metallization in GaAs Photovoltaic Devices

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Introduction

- **Complex metal inks:** significant research interest in PV, as an alternative to traditional nanoparticle metal pastes, evaporation, or electroplating due to their low cost and comparable performance [1-4].
- **Previous work:** successfully screen-printed silver (Ag) inks on GaAs solar cells in Texas. However, replicating the exact process under standard conditions in Colorado failed to yield the same device performance [2].
- **Reason:** regional environmental/processing differences that shifted the ink's chemistry. Instead of curing into pure metal, the ink favored an electrochemical pathway that formed an unwanted oxidation layer right at the Ag/GaAs interface [4].
- **This work:** To prevent this oxidation, we propose a Nickel (Ni) interfacial layer to promote the electrochemical reduction of Ag onto the Ni surface rather than interfacial oxidation.

Experimental details

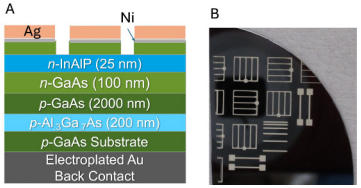


Figure 1. (A) Schematic illustration of the GaAs photovoltaic device incorporating a Ni interfacial layer and Ag finger grid. (B) Optical image of the screen-printed cell pattern.

- Complex metal inks were screen-printed on n-on-p GaAs PV device precursors.
- Ni complex ink was screen-printed first on Ar plasma-treated GaAs surface and cured under forming gas (5% H_2).
- Ag complex ink was printed onto Ni pattern and cured in N_2 at 300C for 30 min.

Results and Discussions

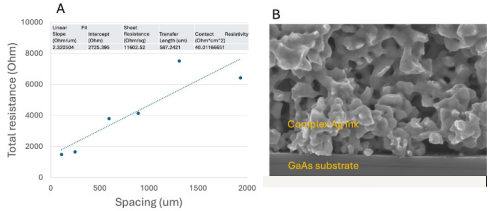


Figure 2. (A) TLM fitting of the Ag complex printed on a GaAs substrate. (B) SEM image of the printed metal on the GaAs substrate.

- Contact resistivity Ag ink on GaAs: very high ~4000 mΩ.cm^2.
- SEM image: high contact resistance caused by the presence of an interfacial oxide barrier between the complex Ag ink and the GaAs substrate.

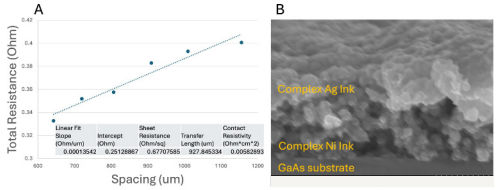
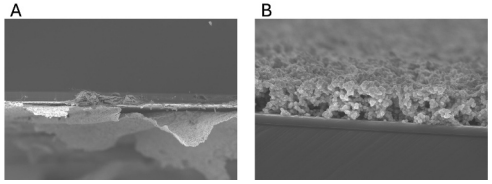


Figure 3. (A) TLM fitting of the Ag complex printed on a full area complex Ni layer on a GaAs substrate. (B) SEM image of the printed metals on the GaAs substrate.

- Contact resistivity Ag complex ink on full area Ni complex ink on GaAs: ~5.8 mΩ.cm^2. Ag/Ni interface is highly conductive with minimal resistance
- SEM image: no distinct interface between the two layers is observable.
- When properly patterned Ag on Ni with TLM measurements, contact resistivity is ~38 mΩ.cm^2.



- Ni need to be cured in forming gas: if O_2 is present, Ni oxidized, forms NiO_x phases which are less conductive and exhibits poor adhesion (peelings).

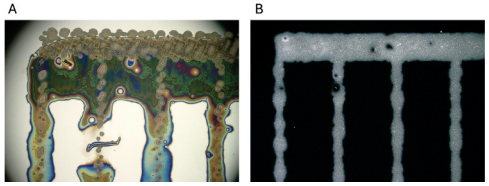


Figure 5. Optical images of screen-printed Ni layers: (A) without plasma treatment and (B) with plasma treatment.

- Surface treatment for complex Ni ink is proven to be as important as the curing process itself.
- Without plasma: Ni fingers exhibit widths of at least 500 µm.
- Whereas with plasma: narrower widths of approximately 150 µm.

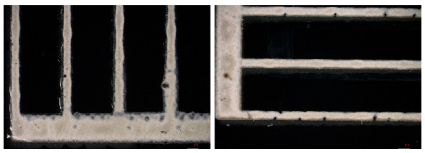


Figure 6. Optical images of screen-printed Ag/Ni stack with PV device pattern: (left) well aligned patterns and (right) mis-aligned patterns.

- Incorporated all developments above, we could screen-print GaAs PV devices with Ni interlayer and complex Ag on top with a proper, well-defined pattern.

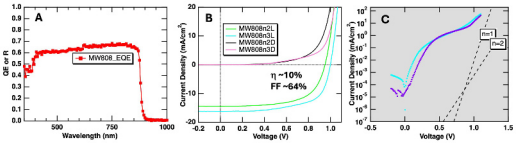


Figure 7. (A) EQE of the screen-printed front complex Ag/Ni metal grid GaAs devices. (B) Light and (C) dark JV curves of fabricated devices.

- EQE: good carrier collection efficiency similar to baseline GaAs devices.
- Light JV: Lower efficiency than baseline due to high shading with bigger fingers. Misalignment of Ni and Ag patterns also contributed to higher shading of the metal grid.
- Dark JV: at high voltages, devices transition from n=2 to n=1.

Conclusions

- We have demonstrated that incorporating a Ni interlayer significantly improves the contact between complex Ag metal and the GaAs substrate.
- The Ni layer provides a highly conductive interface, reduces contact resistivity, and prevents the formation of interfacial oxide barriers, leading to more uniform and reliable metal contacts.
- These findings highlight the potential of Ni interlayers for enhancing the performance and reproducibility of GaAs-based devices using printed metal inks.

References

[1] Truong et al., Energy and Environmental Materials, 2025.
[2] Selvidge et al., 52nd IEEE PVSC, 2024.
[3] Truong et al., 53rd IEEE PVSC, 2025.
[4] Selvidge et al., manuscript in preparation, 2026.

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