natcoretechnology

Multilayer Foil Metallization for All Back Contact Cells

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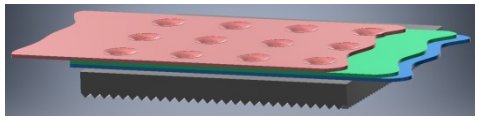
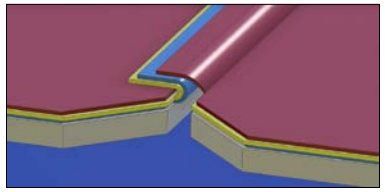
44th IEEE-PVSC Conference (June 30, 2017)

Overview

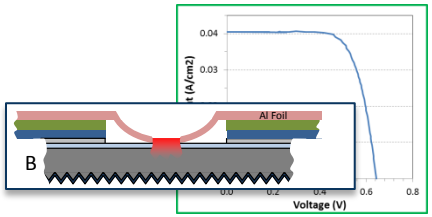
- Multilayer foil metallization



- Benefits of the concept
  - Cell fabrication / Low cost
  - Module construction

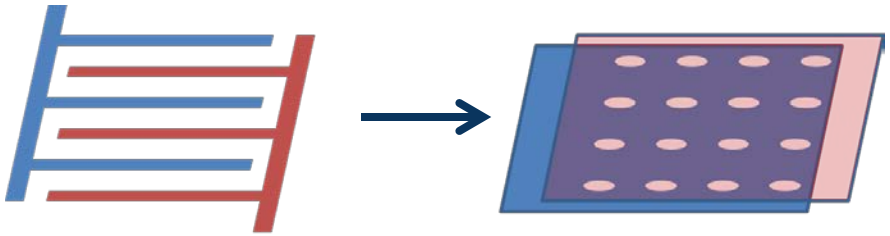


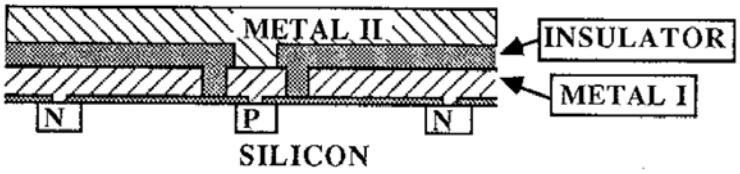
- Cell performance
  - Foil variations
  - Laser doped, carrier selective



Multilayer Metallization

- Interdigitated contacts
  - Single metal layer
  - Contacts “interpenetrate”
- Multilayer
  - Two metal layers separated by a dielectric
  - Each layer: ~ full area



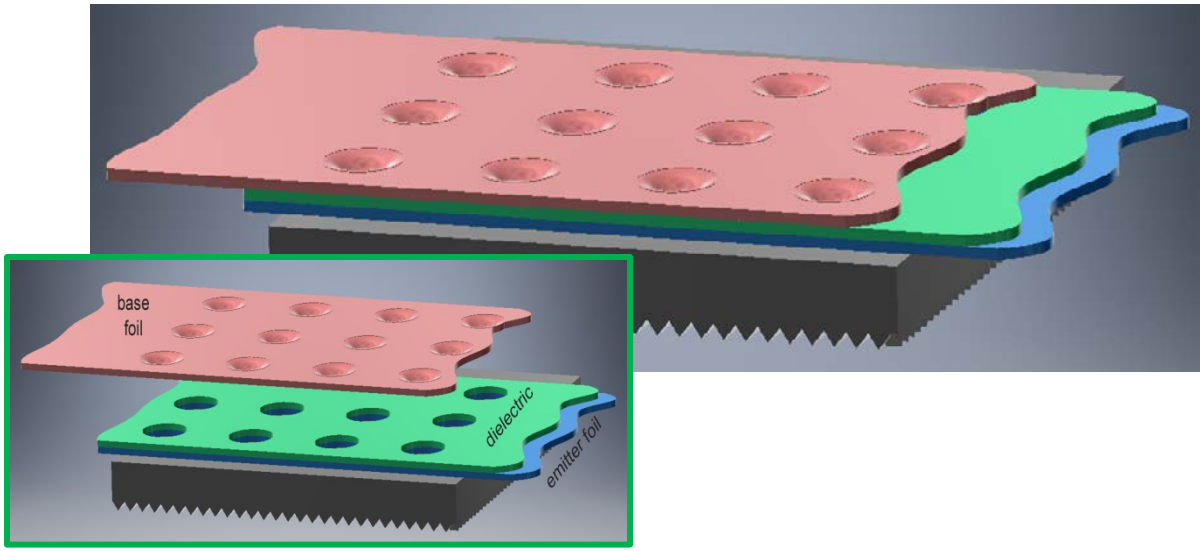


Verlinden, et al. (20th PVSC, 1988)

- Multilayer metallization has merit
- Shorting is an issue
  - Especially deposited layers
  - Roughness, defects

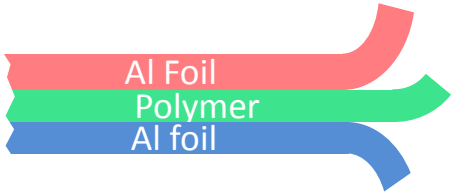
Foil Multilayer Metallization

Metallization is a foil laminate



Laminates

- Foil layers
- 10-20µm
- Bonded together
- Roll process



Major advantages

- Thick metal layers (>10µm) without deposition
- Shorting eliminated: thick dielectric, preformed foils
- Module connection advantages (at end)
- Production, patterning of laminate layer exists

Cost Implications

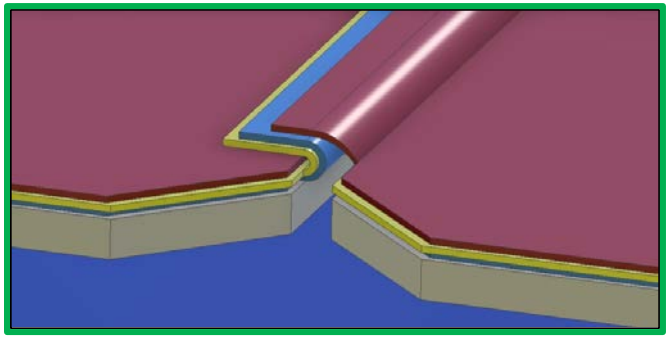
- Detailed cost models planned, however…

Foil Cost

- Replaces silver
- Existing market (Al foil):
  - 10^{11} m^2/year
  - Laminates well known / high volume
- Typical cost:
  - < $3 / kg → <1 ¢/cell

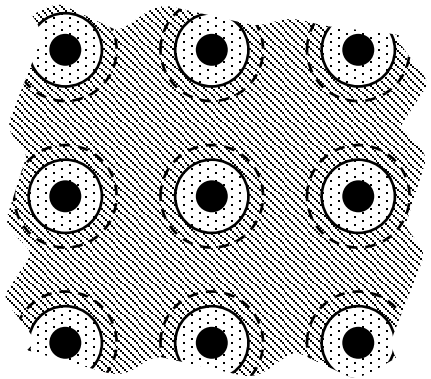
Module

- Low resistance for 156mm
- Cell interconnection without additional components

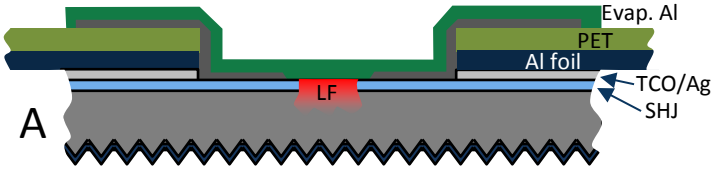


Technical Progress

- General cell structure:
  - Uniform emitter (SHJ)
  - Point base contacts

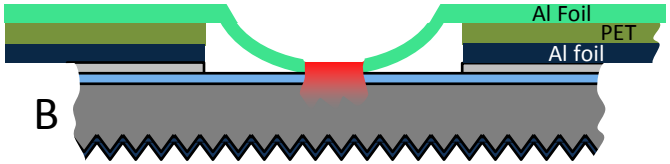


Demonstration cells



Foil Emitter

- Emitter and dielectric → perforated laminate foil
- Evaporated base contact (for performance)
- Laser vs. carrier selective

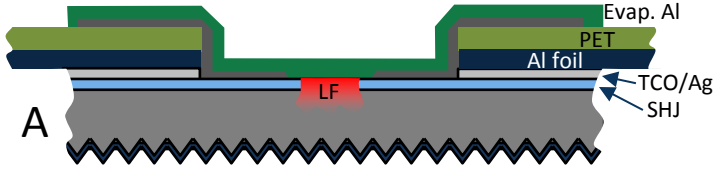


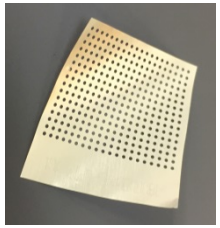
Foil Emitter & Base

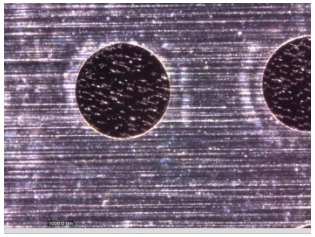
- True bilayer foil cell
- Base contact by laser firing through foil

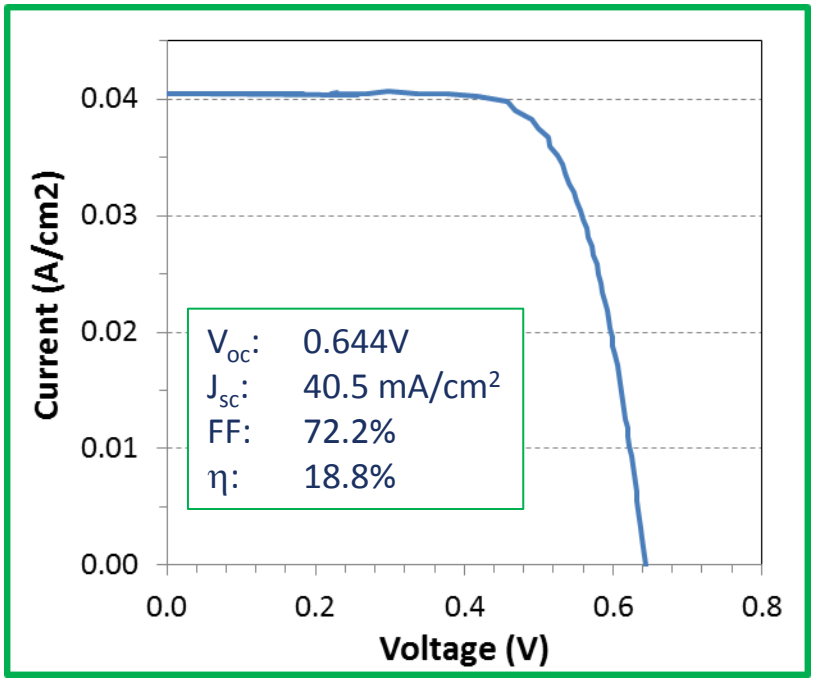
Foil Emitter Cells – Laser Base Contact

- General features:
  - Patterned Al-foil/PET laminate emitter connection
  - Base contact:
    - 1mm pitch / laser fired
  - Optimized laser fire:
    - 532nm / 600ns
- Results:
  - Low shunt current:
    - Laminate insulator works well
    - SHJ layer isolation
  - Need to reduce laser-induced damage



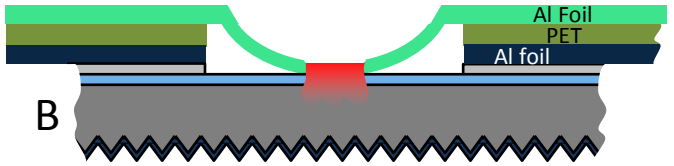


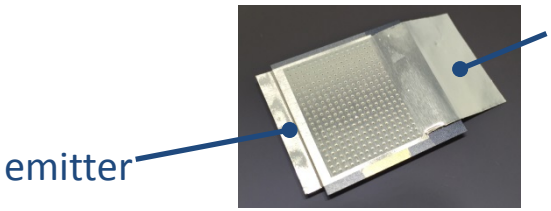


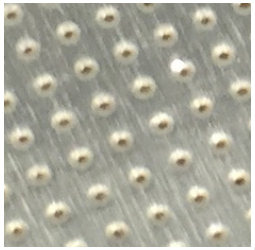


Full foil device

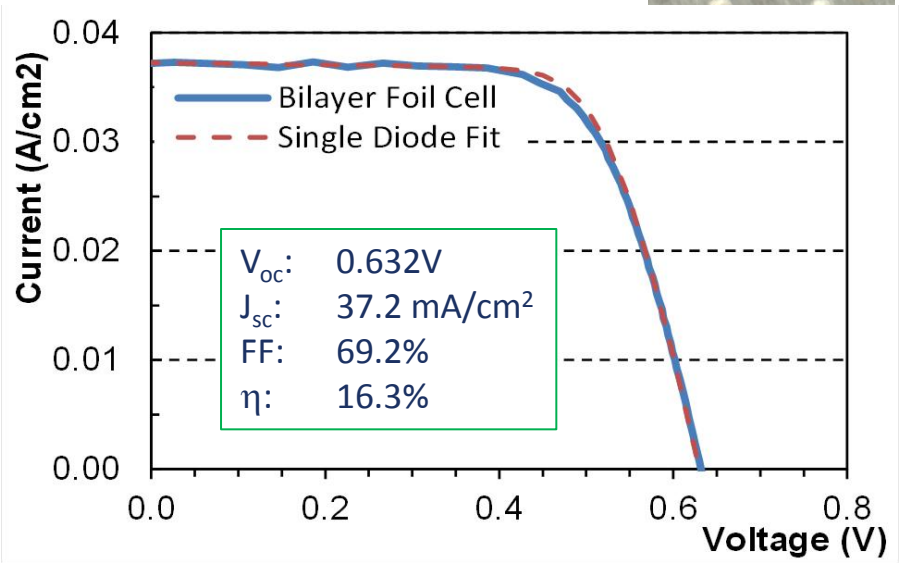
- General features:
  - Patterned Al-foil/PET laminate emitter connection
  - Phosphorus treated foil: forms n+ silicon contact







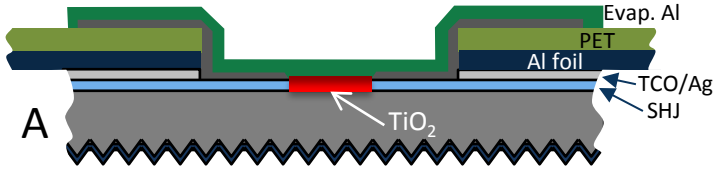
- Results:
  - Demonstration of bilayer foil device → both contacts
  - Damage due to laser firing
    - Lower Voc / performance
    - Non-optimum firing through Al foil

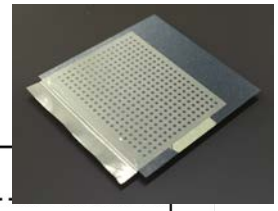


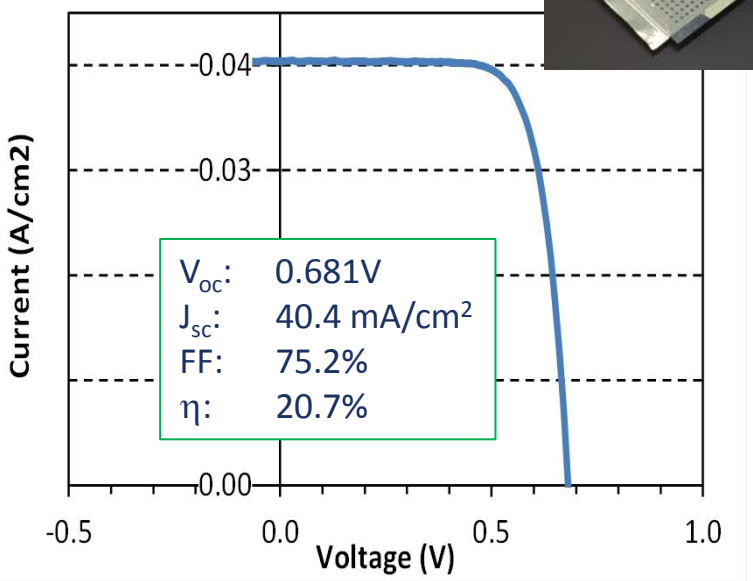
Carrier Selective Base Contacts

- General features:
  - TiO_2 carrier selective contact
  - Evaporated base contact

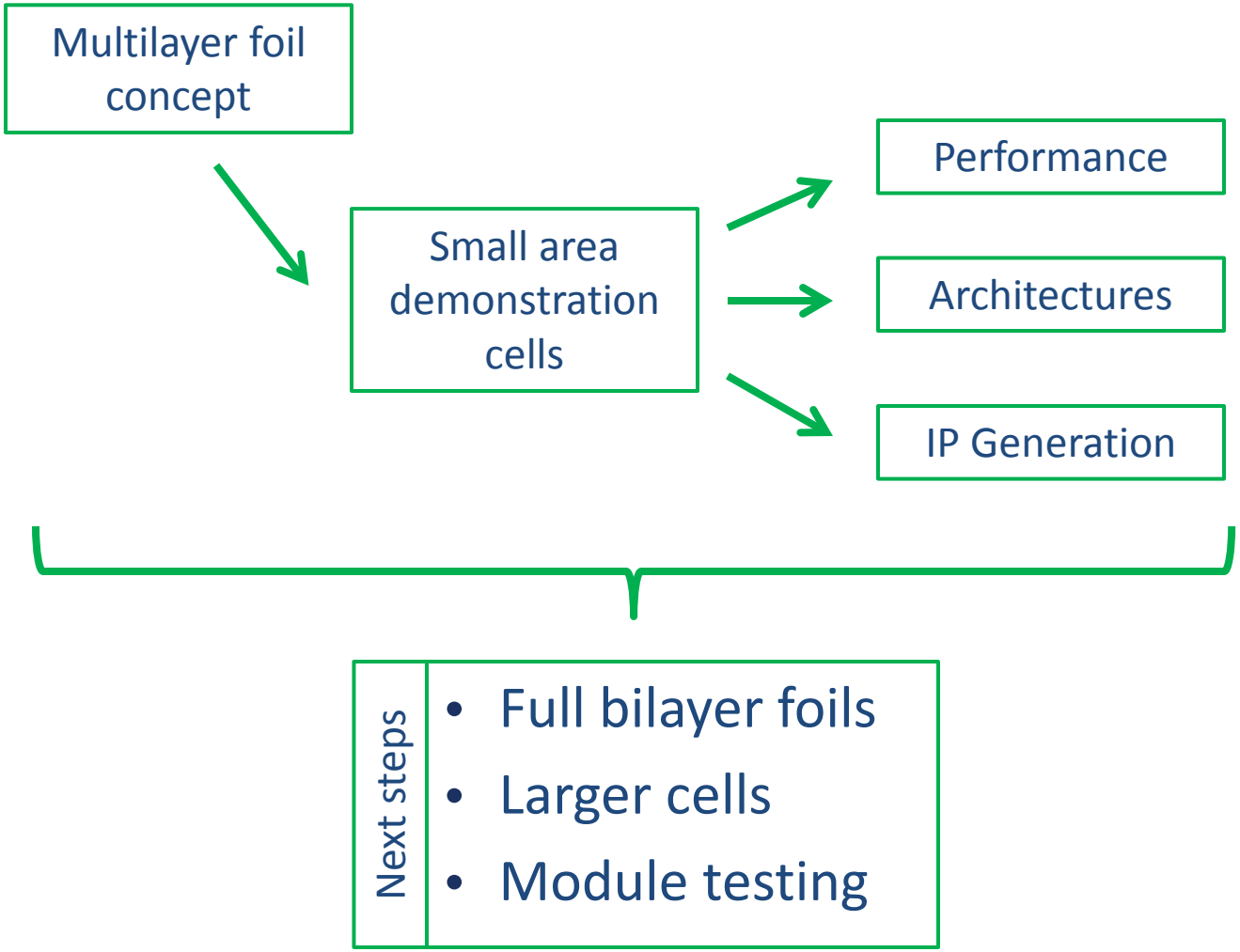
- Results:
  - Separate tests demonstrate ohmic contact (TLM, I-V)
  - Improvements show up in V_{oc} and fill factor







Technical Strategy



Foil Cell Advantages

- Series Resistance
  - Al foils → exhibit bulk Al conductivity
  - Calculations: ~0.2 mW/cm^2 loss @ 40 mA/cm^2 (per foil, 156mm, 20μm)
  - Increased foil thickness: Low cost and low process impact

- Module fabrication:
  - Typical module construction: tabbing
  - Back contact cells:
    - Direct (cell-cell) connection
    - Circuitized backplanes

Foil Cell ← → Simplified Cell Interconnection

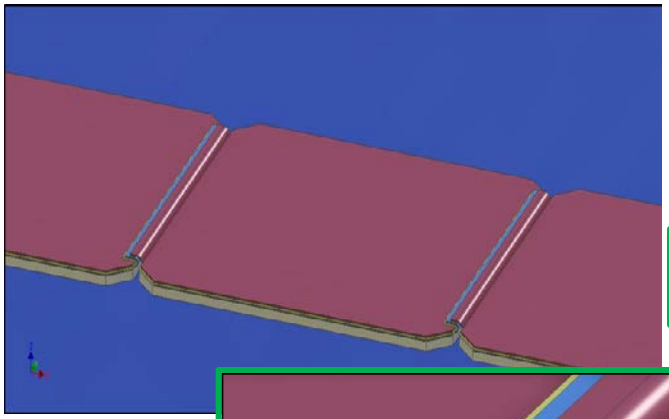
Cell Interconnection

- Various strategies for foil cell interconnection

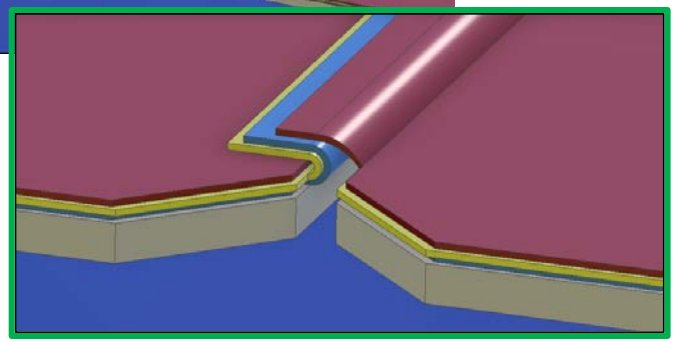
Connection components formed during foil manufacture

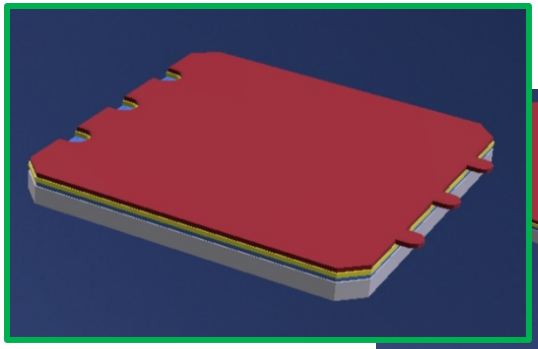
With laser welding no additional conductors / solder

Low series resistance



Fold





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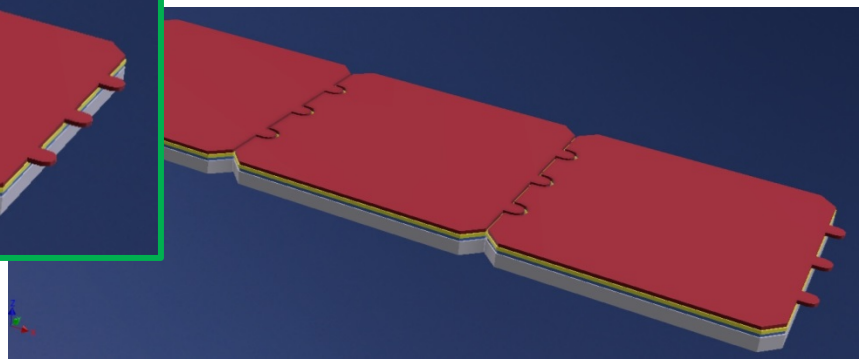

Conclusions

- Foil multilayer metallization: A novel strategy for back contact cell metallization
- Cell demonstrations
  - Leverage preformed aluminum/insulator laminates
  - Point contact structures: >20% efficiency
- Advantages:
  - Lowest cost metallization / High volume fabrication
  - With the high efficiencies of back contact approaches
  - Simplified cell-cell connections in module