Rapid patterning and advanced device structures for low cost manufacturable crystalline Si IBC cells

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BACKGROUND

- Interdigitated back contact (IBC) Si solar cells with a-Si passivation have demonstrated highest efficiency (>26%)
- Patterning process is critical for low cost manufacturable IBC
  - Multiple photolithography, alignment, etching steps increase costs and complexity of current IBC approaches
  - Traditional patterning of p, n and metal regions can disrupt surface passivation and increase SRV, reduce Voc

APPROACH AND GOAL

- Develop simplified IBC device with uniform back surface passivation: p and n regions created by laser fired contacts (LFC), emitters (LFE) or masking during PECVD deposition (at IEC)
- Evaluate various laser patterning and annealing methods: direct ablation, patterning sacrificial layer, pattern metal seed layers prior to plating, laser metal transfer, laser thermal annealing (at UVa)
- Goal at end of 3 years is a 25% IBC solar cell with Voc> 740 mV fabricated with PECVD passivation and emitter, laser fired contacts, laser processing and patterning, Cu plating

PROPOSED DEVICE STRUCTURES

- Two variations for simplified IBC: either heterojunction emitter HJE (PECVD a-Si p/i) or laser fired emitter LFE (Al/Ga+laser)
- HJE is well established for high V_{OC}, but needs more processing steps (masked deposition)

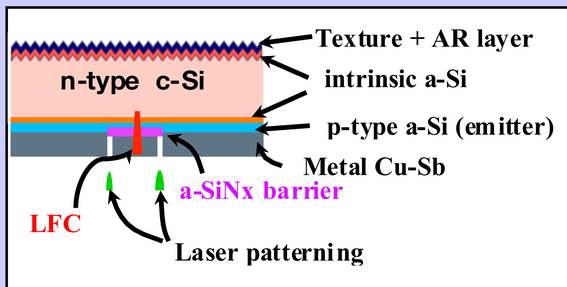


Figure 1. HJE-LFC with a-SiN barrier (purple) deposited by shadow mask in PECVD after i/p a-Si HJ emitter deposition. Base contact formed by LFC (red) of a Cu-Sb metal stack fired through a-SiNx/p-/i-a-Si multilayer stack.

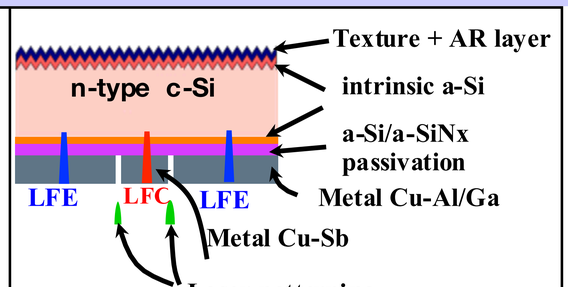
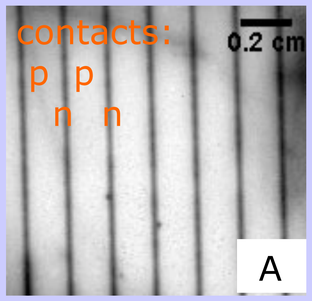
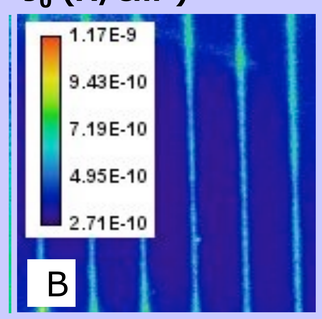


Figure 2. LFE-LFC solar cell with a-Si/a-SiNx passivation layer (purple). Base contact is formed by LFC (red) of a Cu-Sb metal stack. The emitter is formed by LFE (blue) of Al or Ga.

IBC CELL WITH LASER FIRED CONTACTS (LFC)

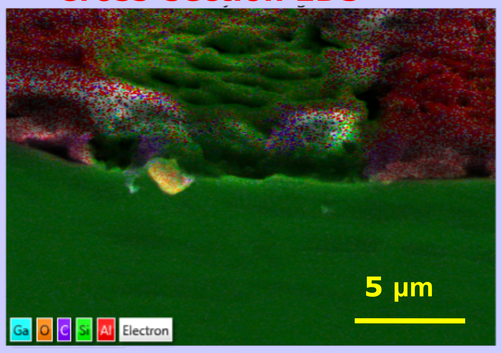
- A. Electroluminescence (EL) image of IBC cell with localized LFC on narrow (dark) n-strips (like Fig 1).
- B. EL converted to map of recombination current J_o (this conference[1])
- No evidence of localized defects from LFC



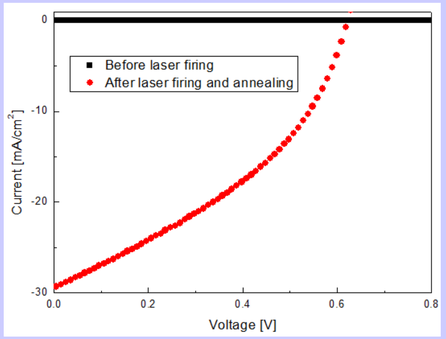


LASER FIRED EMITTER (LFE) WITH AL+GA DOPING LAYER

Cross-section EDS

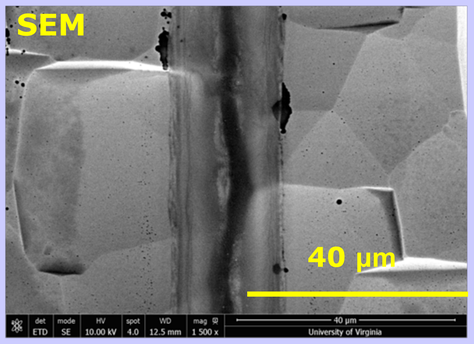


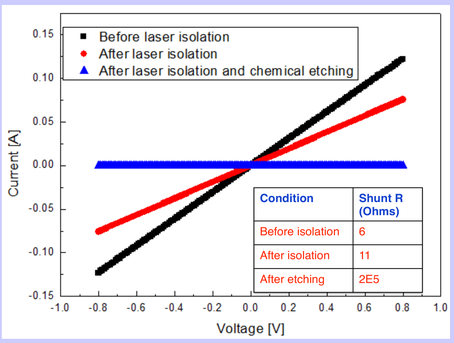
I-V curves



- Achieved LFE device Voc=630 mV which can be further optimized
- Ga+Al laser doping demonstrated better performance than Al doping

2-STEP LASER PATTERNING OF AL





- Complete isolation has been demonstrated using laser processing followed by chemical etching with negligible damage to Si

1 N. Ahmed, et al "Electroluminescence Analysis For Separation of Series Resistance From Recombination Effects in Silicon Solar Cells with Interdigitated Back Contact Design"

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