Safety and Tool Contamination Issues When Using Indium Trichloride for Indium Implants in Varian E500 Implanters

Danny Rosenblatt
Maxim Integrated Products
NCCAVS Junction Technology Group
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Outline

- InCl3 procurement and MSDS
- Changing InCl3 Sources
- E500 In+ vaporizer source parameters
- Post-indium clean-up implants
- Source and implanter cleanup
- Activation of In implants

InCl3 Procurement and MSDS

- Maxim has qualified:
  - Indium Corporation of America
  - American Elements
- Purchased 5 g bottles of InCl3 for E500
- Inhalation danger: Use respirator at all times. When removing old source, use SCBA. Odor from vaporizer is extremely irritating to lungs (most likely chlorine fumes)
- Eye contact danger: wear safety goggles
- Ingestion danger: wear gloves, change frequently
- Skin contact danger: wear complete bunny suit

Changing InCl3 Sources

- Maxim uses W arc chambers, so MoO and MoF contamination is not a concern
- Typical source lasts 3 weeks – run indium 6X a week
- Always have new source ready
- Maxim does not outgas the empty vaporizer
- Source failure almost always occurs after indium implants, when first cleanup implant (B+) is run
- Remove old source
- Clean source bushing thoroughly
- Install new source, pull out vaporizer
- Open 5 g bottle, quickly (but carefully) pour InCl3 into vaporizer with funnel
- Minimize exposure of InCl3 to air – it is extremely hydroscopic

Changing InCl3 Sources (cont.)

- Quickly install vaporizer and start pumping down source (within 5 minutes of opening InCl3 bottle)
- Pump down new source for 30 minutes
- Bring up an Ar+ beam
- Outgas filament
- Condition InCl3 by heating vaporizer slowly
- Make sure source pressure remains below 5E-5 Torr
- Large burst of water vapor at 80C – 100C as waters of hydration are released
- Continue to heat InCl3 up to 320C
- Turn off vaporizer, let cool to 100C
- Turn off Ar+ beam
- Run “Indium Cleanup 1” and “Indium Cleanup 2” recipes (see below for details)
- Return tool to production (In+, B+, BF2+, As+, P+)

E500 In+ Vaporizer Source Parameters

- InCl3 vaporizer temperature: 320C
- Arc voltage: 60 V
- Arc current: 500 mA
- Extraction voltage: 40 kV
- Source magnet current: 20 A
- Setup cup current: 115 uA
- Integrated beam current: 75 uA
- Beam width: 35 mm

Post-Indium Clean Up Implants

- Derived from various Varian BKM and IIT papers and Maxim experiments
- Cool vaporizer from 320C to < 100C (20 min)
- Indium Clean #1: Implant 25 dummy wafers with B11, 1.50E14, 150 keV, 400 uA integrated beam current, 50 scans, total time 25 min
- Indium Clean #2: Implant the same dummy wafers with As75, 2.00E14, 80 keV, 350 uA integrated beam current, 100 scans, total time 45 min
- Total cool down and clean up time is 90 minutes
- Effectiveness of clean up implants judged by parametric test data, not analytical data
- Clean up requirements may be different for every technology at every company!

E500 Source Cleanup

- Place source in exhausted fume hood
- Remove slug from InCl3 vaporizer
- Clean vaporizer with wipes and isopropyl (no water!)
- Clean arc chamber – additional black flakes are present from indium operation
- Maxim does not use an oven to bake the clean vaporizer
- Dispose of indium waste along with As, B, P waste
- Place all implant waste in 55 gallon drum
- Waste disposal company picks up waste

Activation of In Implants

- Solid Solubility of B in Si: 1E21 cm-3
- Solid Solubility of In in Si: 4E17 cm-3
- Rules out In for USJ for S/D and SDE
- In is useful for VtN and NHALO implants
- These are shallow but lightly doped
- Can improve short channel effect starting at 180 nm technology