Process sheet for **stf_res_01**

Physics and Hardware for Intelligence project

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Abstract

Fabrication flow for the SPD/JJ integration process. WSi SNSPDs are integrated with Nb/Si/Nb, externally shunted JJs. This process includes the superconducting thin-film layer and associated Nb wiring and Au resistors, a ground plane, the JJ tri-layer stack and associated PdAu shunt resistor layer, and an upper Nb wiring layer.

The process starts with a thermally oxidized Si wafer with 160 nm SiO_2.

The entire wafer is clad with oxide, and openings are etched to the bond pads (**v4**). A Nb ground plane is deposited, and alignment marks are etched in this layer. Features are then etched in the ground plane (**m0**).

Insert screen shot of die and image distribution from stepper:

Contents

1 Deposit M1 (lower Nb wiring)

- Begin with oxidized Si substrate
- Deposit 120 nm Nb with the Lesker SNS tool
- Instructions for tool use: OneNote/a4/fab/SNS
- Recipe: Nb_wire_js.rcp
- Rate: 80 nm/min; check log book for latest rate
- Insert picture of log book entry

2 PM (alignment marks)

- Spin: SPR600 @ 3000 rpm
- Expose: 220 mJ/cm^2
- Develop: double puddle, 30 s, 30 s
- Run through spin rinse dry
- Inspect with microscope
- Etch with Oxford fluorine ICP RIE
  - Recipe: Nb PM He
    - SF_6: 30 sccm
    - RF: 25 W
    - ICP: 800 W
    - Pressure: 15 mTorr
    - He: 5 Torr
  - Etch: 70 s
  - Typical DC bias: 60 V @ 25 W RF
  - No endpoint monitoring
- Ash: 2 min

3 Pattern and Etch M1 (lower Nb wiring)

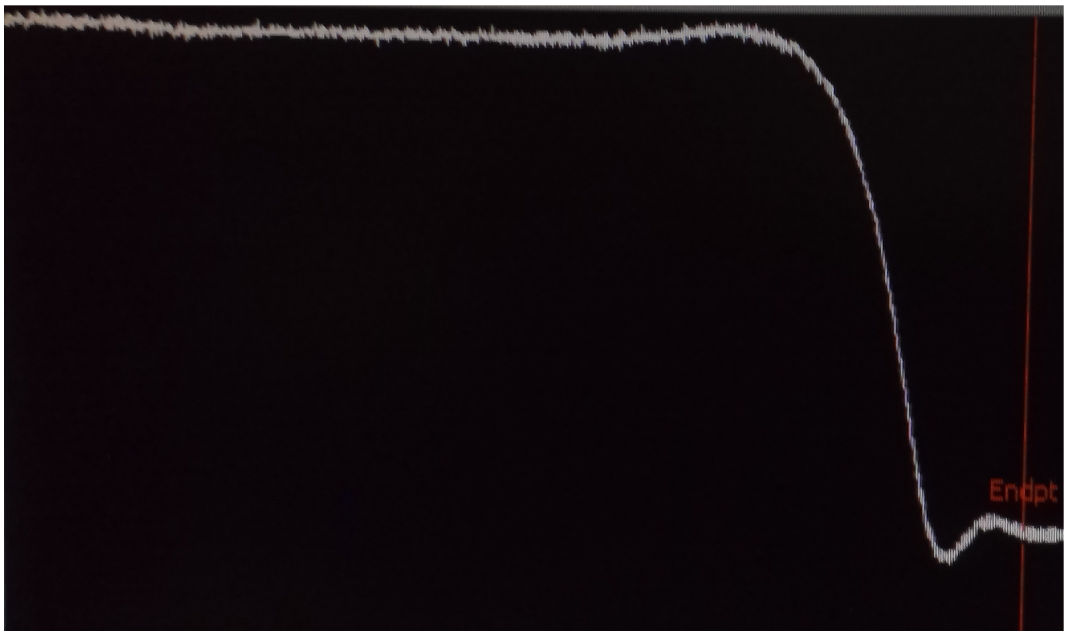

Figure 1: Typical endpoint signal of Nb etch. The small peak after the dip is interpreted as the end of the etch. Endpoint is called 10 s-20 s after that.

- Spin: SPR600 @ 3000 rpm
- Expose: 220 mJ/cm^2
- Develop: double puddle, 30 s, 30 s
- Run through spin rinse dry
- Inspect with microscope
- Etch with PlasmaTherm
  - Recipe: 150mm_Nb_sloped_ManEP
    - SF_6: 40 sccm
    - O_2: 16 sccm
    - RF: cut after strikie
    - ICP: 500 W
    - Pressure: 6.5 mTorr
    - He: 4 Torr
    - Rate: $\sim$0.51 nm/s; $\sim$31 nm/min
    - Note: Selectivity over resist is poor; limit to 300 nm Nb to be etched
  - Etch: $\sim$230 s
  - No DC bias
  - Use endpoint; typical signal shown in Fig. 1
  - Insert picture of endpoint signal and log book entry
- Ash: 2 min
- Clean: acetone dirty 2 min, acetone clean 2 min, IPA, spin rinse dry
- Inspect with microscope
- Measure thickness with profilometer

4 STF (superconducting thin film)

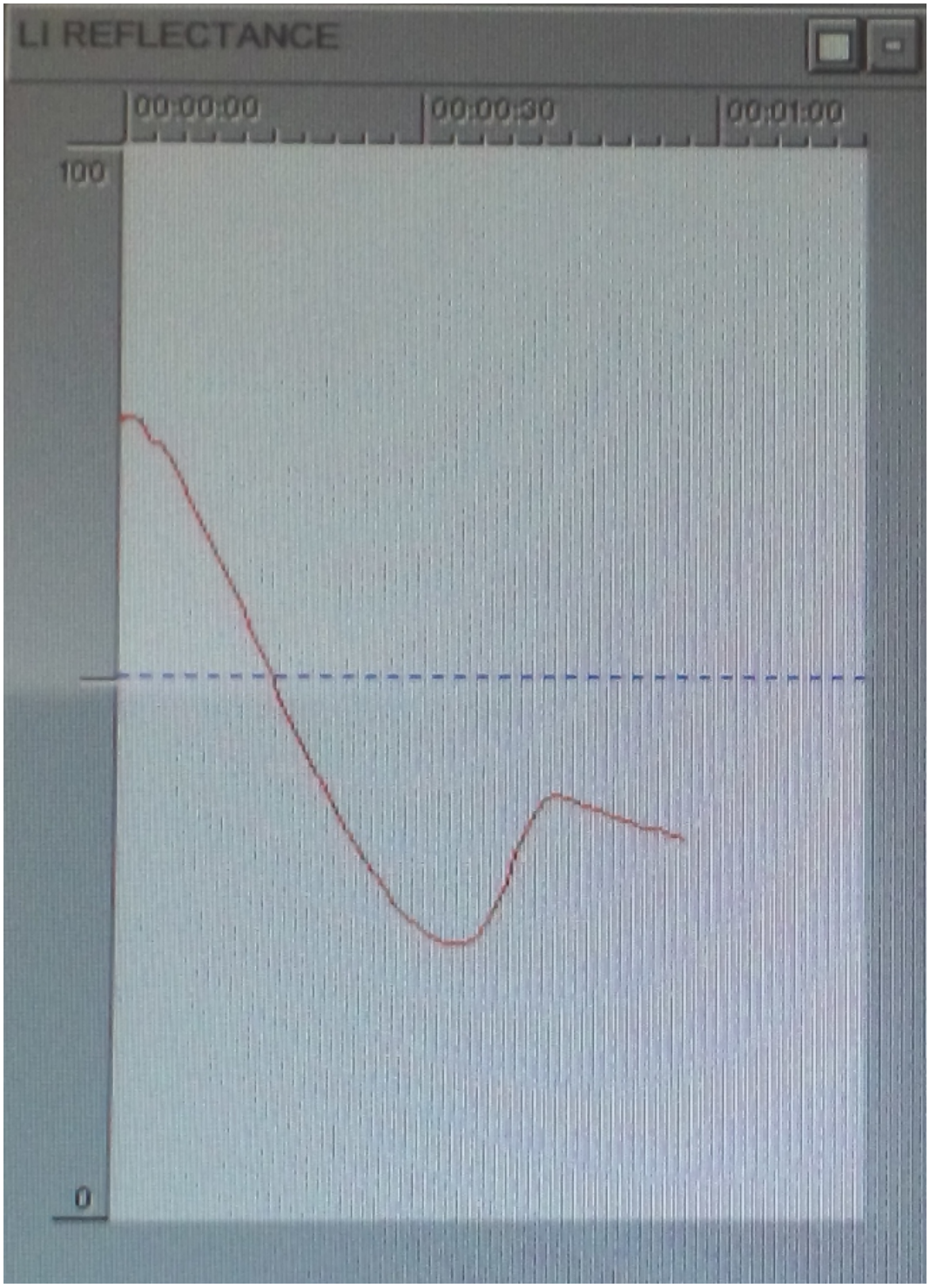

Figure 2: Typical endpoint signal of MoSi etch. The small peak after the dip is interpreted as the end of the etch. Overetch by 10 s-20 s after that peak.

- Ash 5 min
- Deposit MoSi in AJA

- Recipe: MoSi _ jms
  - RF plasma clean for 150 s at 80 W
  - Typical DC voltage: 100 V
  - Deposit MoSi: 50 s
  - Voltage: 460 V
  - Current: 440 mA
  - Deposit a-Si: 66 s
  - Voltage: 183 V
- Pattern
  - Spin: SPR600 @ 3000 rpm
  - Expose: 220 mJ/cm^2
  - Develop: double puddle, 30 s, 30 s
  - Run through spin rinse dry
  - Inspect with microscope
  - Etch with Oxford Fl
    - Recipe: opto-WSi-v2-lowHeForCarrier
      - SF_6: 1 sccm
      - Ar: 80 sccm
      - RF: strike at 30 W, cut to 10 W as quickly as possible
      - ICP: 600 W
      - Pressure: 10 mTorr
      - He: 5 Torr
      - Rate: $\sim$8 nm/min
    - Etch: $\sim$60 s-70 s
    - DC bias: 67 V
    - Use endpoint; typical signal shown in Fig. **??**
    - Insert picture of endpoint signal and log book entry
  - Ash: 2 min
  - Clean: acetone dirty 2 min, acetone clean 2 min, IPA, spin rinse dry
  - Inspect with microscope

5 R1 (Au resistors)

- Pattern for liftoff
  - Ash: 3 min
  - Spin: LOR3A @ 2000 rpm
  - Clean wafer backside if necessary with EBR
  - Bake: 150 ℃ for 5 min
  - Spin: SPR660 @ 3000 rpm, no P20 (recipe: OPTO/3IN-SPR660-NO-3000-LOR IDI)
  - Expose: 220 mJ/cm^2
  - Bake: 110 ℃
  - Develop: double puddle, 30 s, 30 s
  - Run through spin rinse dry
  - Inspect with microscope
- Deposit Au in Lesker Lab18
  - Load wafer in load lock
  - Pump down
  - Run Plasma clean from vacuum fast
  - Record DC voltage in log book (typical: 245 V)
  - Plasma clean runs in load lock
  - Transfer wafer to process chamber
  - Deposit: 4 nm Ti
  - Typical dep params: 0.2 nm/s; 78 mA
  - Deposit: 120 nm Au
  - Typical dep params: 1 nm/s; 58 mA
  - Deposit: 4 nm Ti
  - Transfer wafer to load lock
  - Vent load lock
  - Insert picture of log book entry
- Perform liftoff
  - Begin heating NMP (PG remover) to 150℃
  - Soak in acetone as long as possible
  - Transfer wafer to dirty acetone beaker
  - Sonicate in dirty for 5 min
  - Exchange acetone
  - Sonicate in dirty for 5 min
  - Exchange acetone
  - If all material is visibly lifted off, move to clean acetone beaker
  - If not, repeat until removed, but at least 10 min sonics in dirty acetone with acetone exchange at 5 min
  - Sonicate in clean for 5 min
  - Spray wafer with acetone spray bottle into sink
  - Place wafer in hot NMP
  - Soak wafer in hot NMP for 20 min
  - Spray wafer with IPA into sink
  - Rinse wafer in beaker with IPA
  - Run through spin rinse dry

6 R2 (PdAu resistors)

- Pattern for liftoff
  - Ash: 3 min
  - Spin: LOR3A @ 2000 rpm
  - Clean wafer backside if necessary with EBR
  - Bake: 150 ℃ for 5 min
  - Spin: SPR660 @ 3000 rpm, no P20 (recipe: OPTO/3IN-SPR660-NO-3000-LOR IDI)
  - Expose: 220 mJ/cm^2
  - Bake: 110 ℃
  - Develop: double puddle, 30 s, 30 s
  - Run through spin rinse dry
  - Inspect with microscope
- Deposit PdAu in Lesker Lab18
  - Load wafer in load lock
  - Pump down
  - Run Plasma clean from vacuum fast
  - Record DC voltage in log book (typical: 245 V)
  - Plasma clean runs in load lock
  - Transfer wafer to process chamber
  - Deposit: 4 nm Ti
  - Typical dep params: 0.2 nm/s; 78 mA
  - Deposit: 135 nm PdAu
  - Typical dep params: 1 nm/s; 79 mA
  - Deposit: 4 nm Ti
  - Transfer wafer to load lock
  - Vent load lock
  - Insert picture of log book entry
- Perform liftoff
  - Begin heating NMP (PG remover) to 150℃
  - Soak in acetone as long as possible
  - Transfer wafer to dirty acetone beaker
  - Sonicate in dirty for 5 min
  - Exchange acetone
  - Sonicate in dirty for 5 min
  - Exchange acetone
  - If all material is visibly lifted off, move to clean acetone beaker
  - If not, repeat until removed, but at least 10 min sonics in dirty acetone with acetone exchange at 5 min
  - Sonicate in clean for 5 min
  - Spray wafer with acetone spray bottle into sink
  - Place wafer in hot NMP
  - Soak wafer in hot NMP for 20 min
  - Spray wafer with IPA into sink
  - Rinse wafer in beaker with IPA
  - Run through spin rinse dry