Fabrication of low-density, low-disorder samples for coherent quantum transport in the fractional quantum Hall regime

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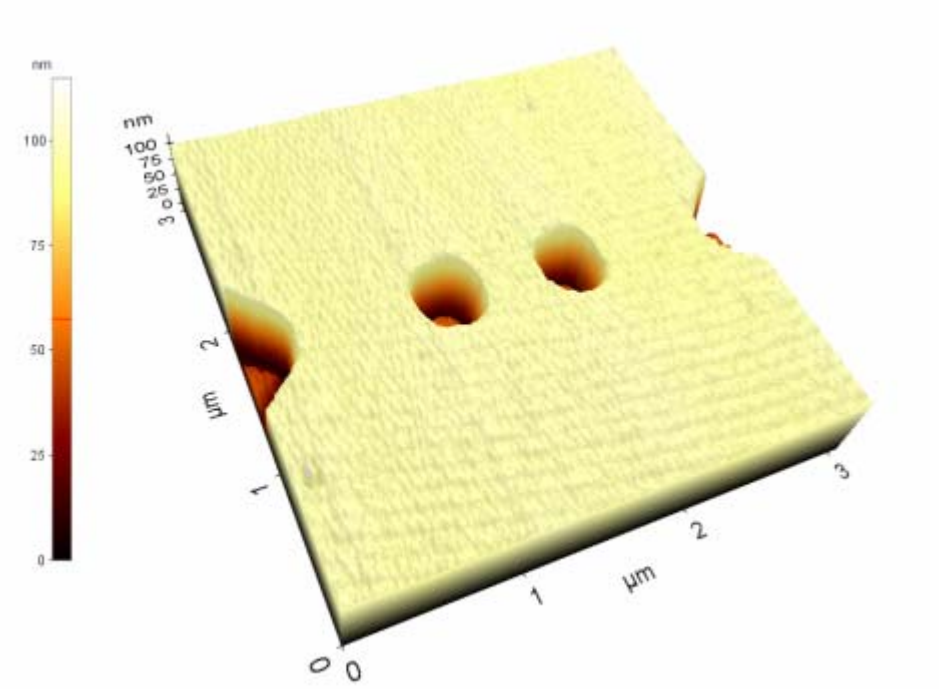
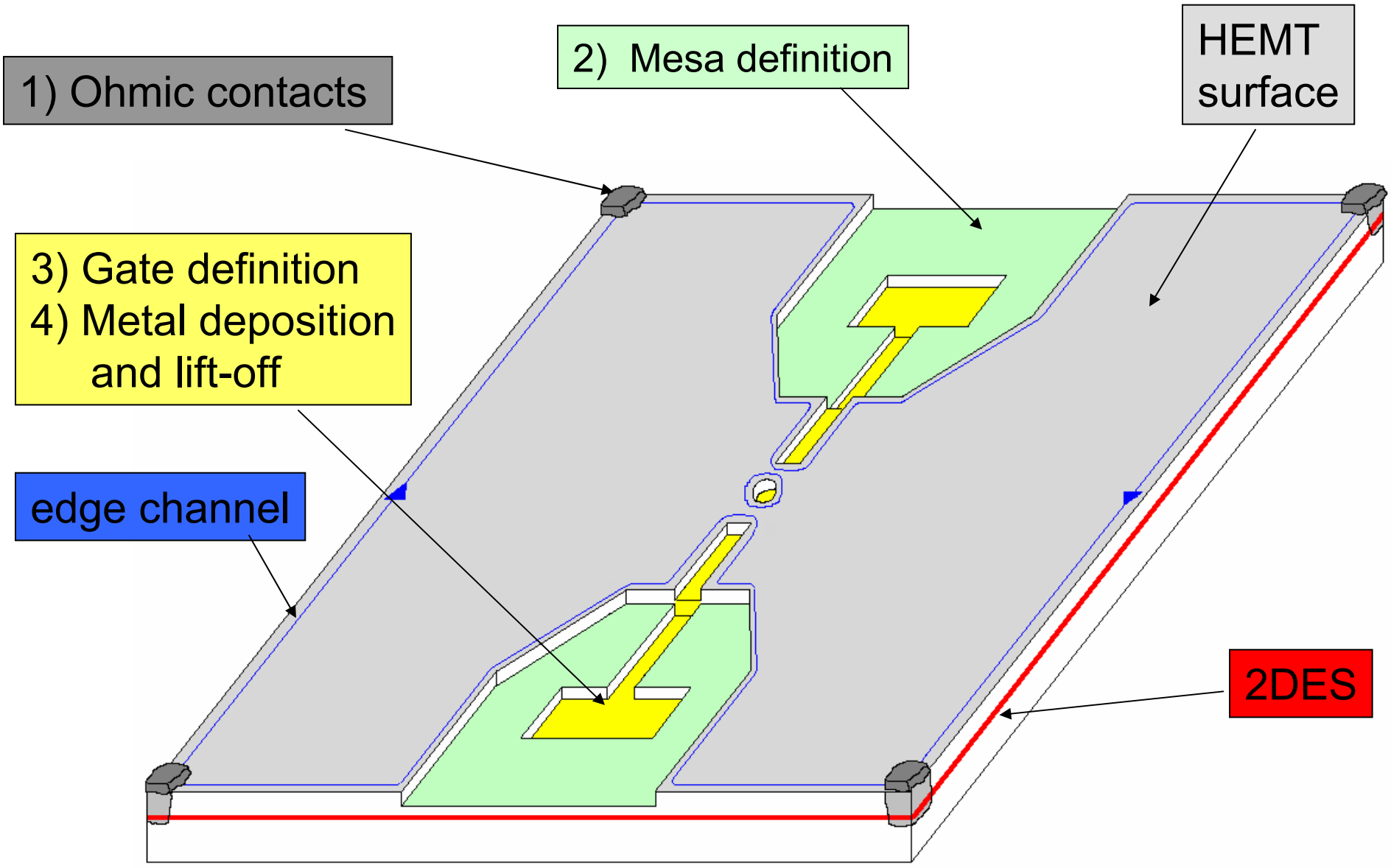
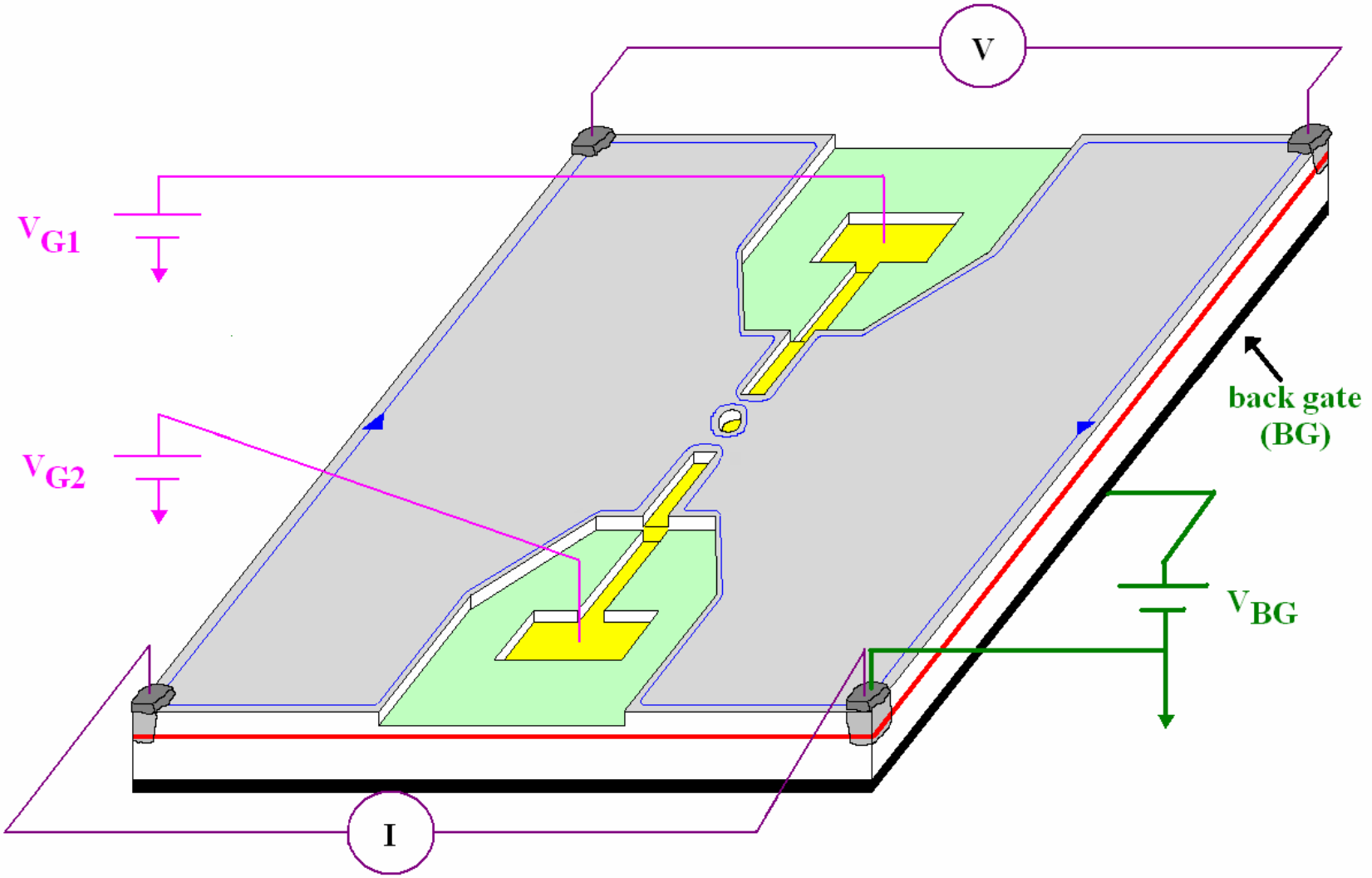


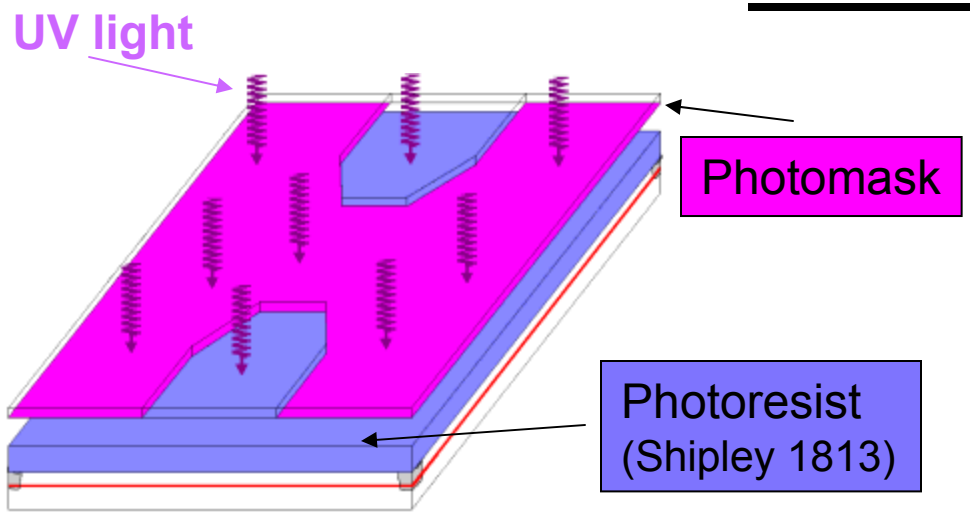
Processing Steps



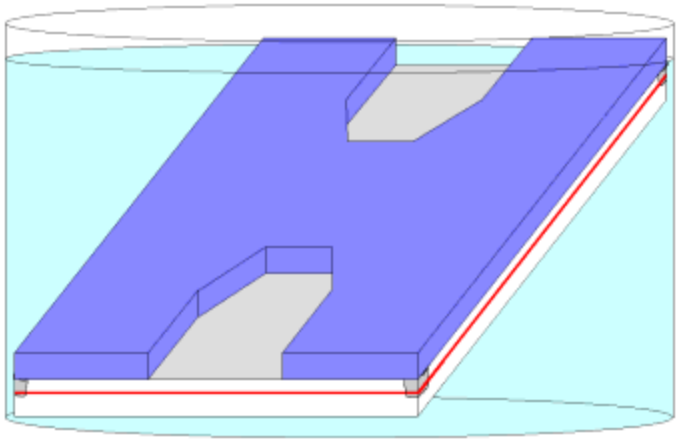
Electrical connections



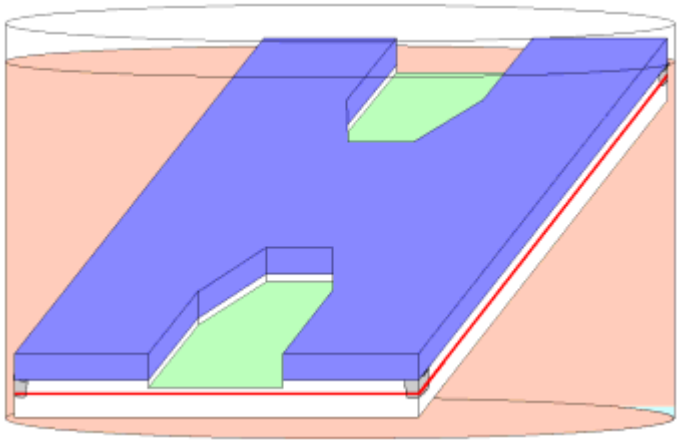
Mesa definition



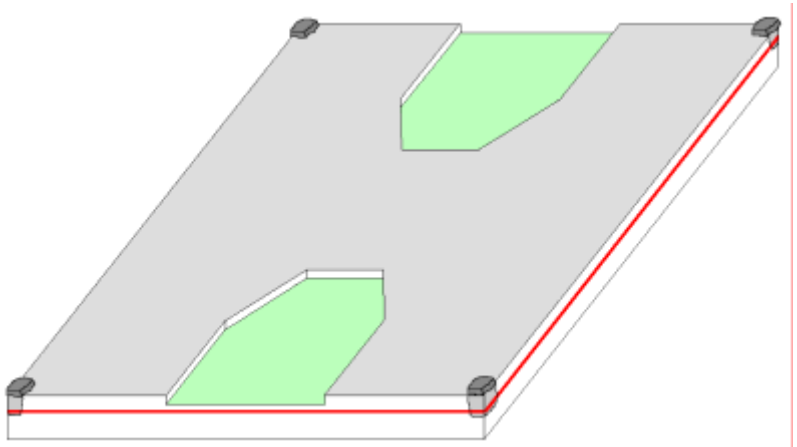
a) Expose mesa pattern



b) Develop photoresist
(Shipley 352)

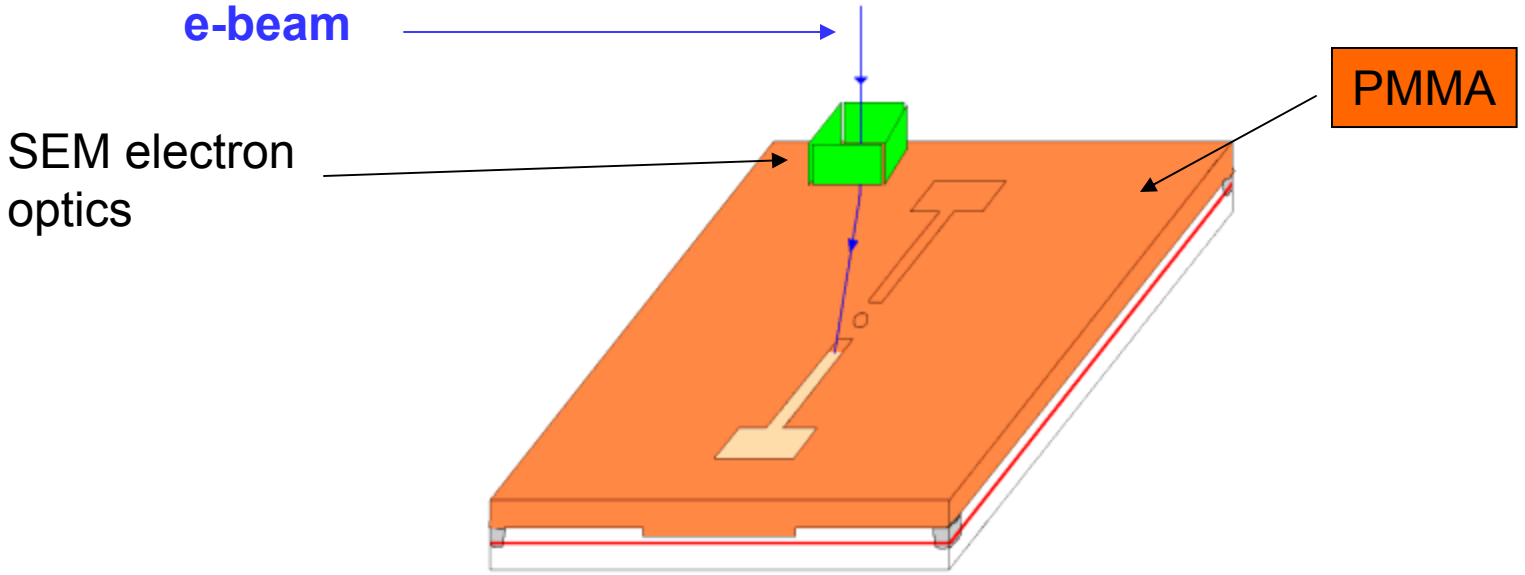


c) Etch sample
(1 H_2SO_4:8 H_2O_2:100 H_2O)

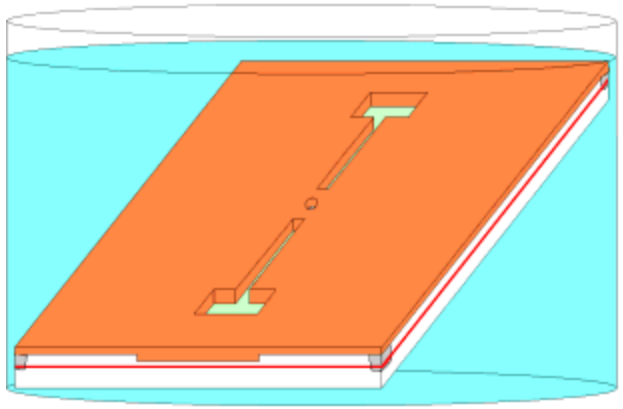


d) Remove photoresist
(acetone)

Gate definition

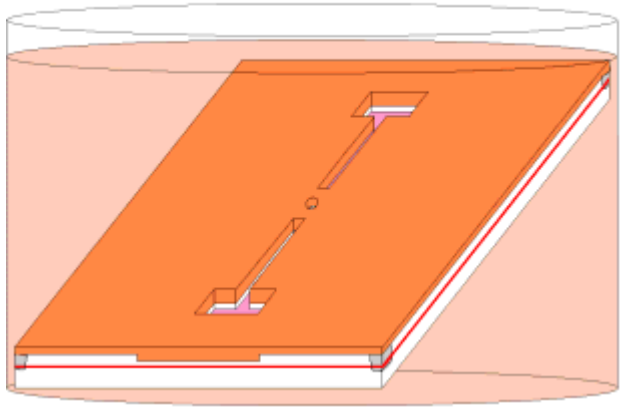


a) Expose pattern with e-beam



b) Develop PMMA

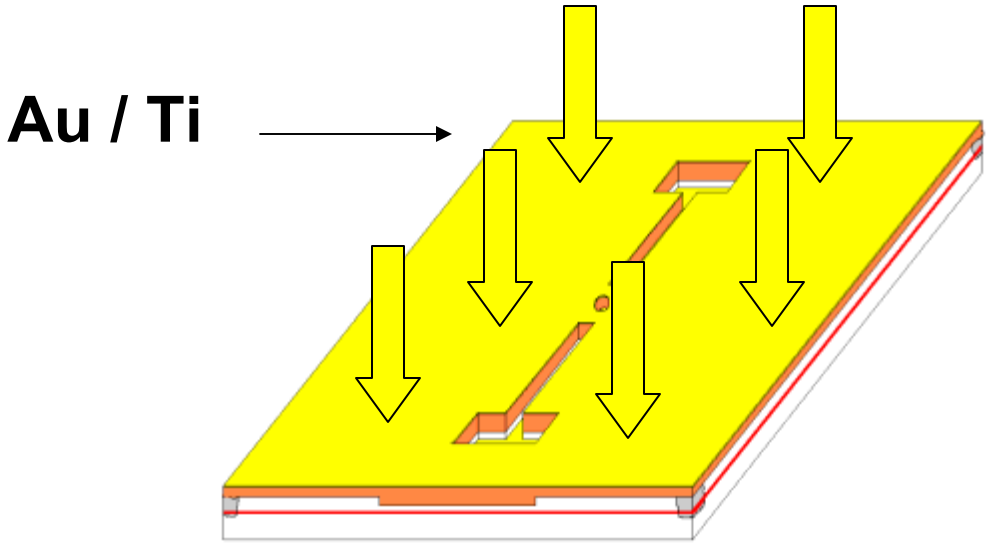
(1 MIBK:3 IPA)



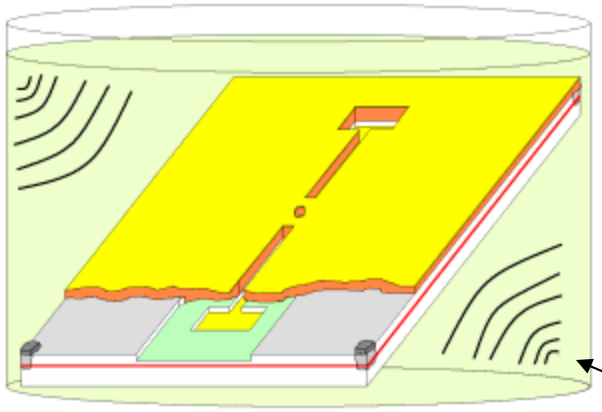
c) Etch

(1 H_2SO_4:8 H_2O_2:100 H_2O)

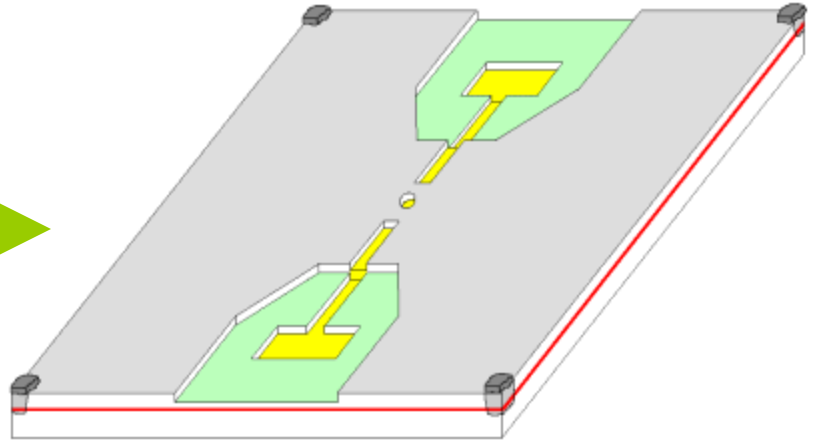
Metal deposition and lift-off



a) Metal deposition (e-beam)



b) Lift-off
(acetone + ultrasound)



c) Final device

Typical device fabrication procedure (M61Dd - Quantum Interferometer)

Process Step	Sub-step	Description	Process time	Equipment
Mesa definition	4-cycle cleaning	- TCE → acetone → methanol → DI H_2O. 1 min/step - Double water bath. Cleaner at 90 V (Variac)	10 min	Branson 2200 Ultrasonic cleaner
	Mounting	- On 1"x1" glass slide. Glued with 1813 resist - Dried on hot plate at 95 °C for 10 min - Gradual heating and cooling	30 min	Thermolyne type 1900 hot plate
	Resist spinning	- 1813 photoresist at 4000 RPM for 30 s	5 min	Headway Research EC101DT spinner
	Resist baking	- In oven at 95 °C for 30 min - Gradual heating and cooling	50 min	Fisher 500 series Isotemp oven
	Exposure	- With optical microscope. Intensity = 2/3 max - Exposure time = 6 min	15 min	Nikon Eclipse ME600 microscope
	Developing	- In 352 developer at RT for 45 s	10 min	
	Etching	- In $1H_2SO_4$:$8H_2O_2$:100 H_2O at 1.5 °C - etch 80 nm (etch rate = 2.4 nm/s)	30 min	
	Resist removal	- 30 s in acetone + ultrasonic bath until sample comes off glass slide. - 1 min additional acetone + ultrasonic bath - Double water bath. Cleaner at 90 V (Variac)	5 min	Branson 2200 Ultrasonic cleaner
Ohmic contacts		- Gas composition: 0.3 cfh H_2 + 0.8 cfh N_2 - 7 min at 410 °C.	60 min	BIORAD RC2400 Alloying Furnace

Total time = 4 hours approx.

Typical device fabrication procedure (continuation)

Process Step	Sub-step	Description	Process time	Equipment
Gate definition	**4-cycle cleaning**	- 1 min/step. TCE → acetone → methanol → DI H_2O - Double water bath. Cleaner at 90 V (Variac)	10 min	Branson 2200 Ultrasonic cleaner
	Mounting	- On Macor holder. Glued with PMMA. - Dried on hot plate at 140 °C for 10 min - Gradual heating and cooling	30 min	Thermolyne type 1900 hot plate
	Mark alignment	- E-beam: E=20 keV, I=52 pA, Aperture=15 μm - To align gate pattern respect to mesa	60 min	- LEO 1550 SEM - ELPHY Quantum nanolithography system
	Resist spinning	- PMMA C 4% at 5000 RPM for 45 s	5 min	Headway Research EC101DT spinner
	Resist baking	- In oven at 170 °C for 30 min - Gradual heating and cooling	50 min	Fisher 500 series Isotemp oven
	Exposure	- E-beam: E=20 keV, I=52 pA, Aperture=15 μm - Dose=120 $\mu C/cm^2$ (nominal dose) for small features with proximity effect correction (α=1.4 nm, β=1.00 μm, η=0.7, N=7). - Dose=170 $\mu C/cm^2$ for large gate patterns	90 min	- LEO 1550 SEM - ELPHY Quantum nanolithography system
	Developing	- In 1 MIBK:3 IPA at 21 °C for 55 s	30 min	
	Postbaking	- In oven at 95 °C for 30 min - Gradual heating and cooling	50 min	Fisher 500 series Isotemp oven
	Etching	- In $1H_2SO_4$:$8H_2O_2$:100 H_2O at 1.5 °C - etch 100 nm (etch rate = 2.4 nm/s)	30 min	

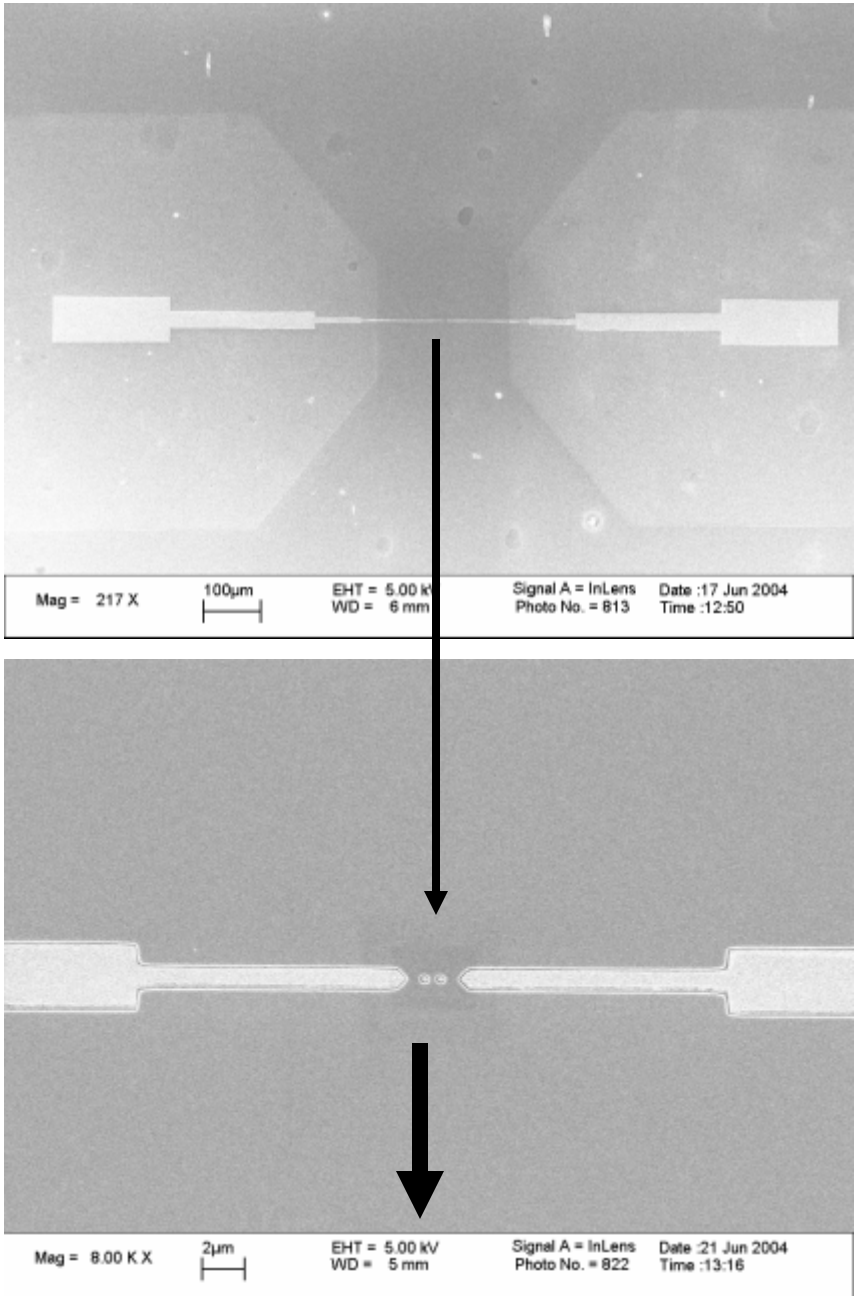
Total time = 6 hours approx.

Typical device fabrication procedure (continuation)

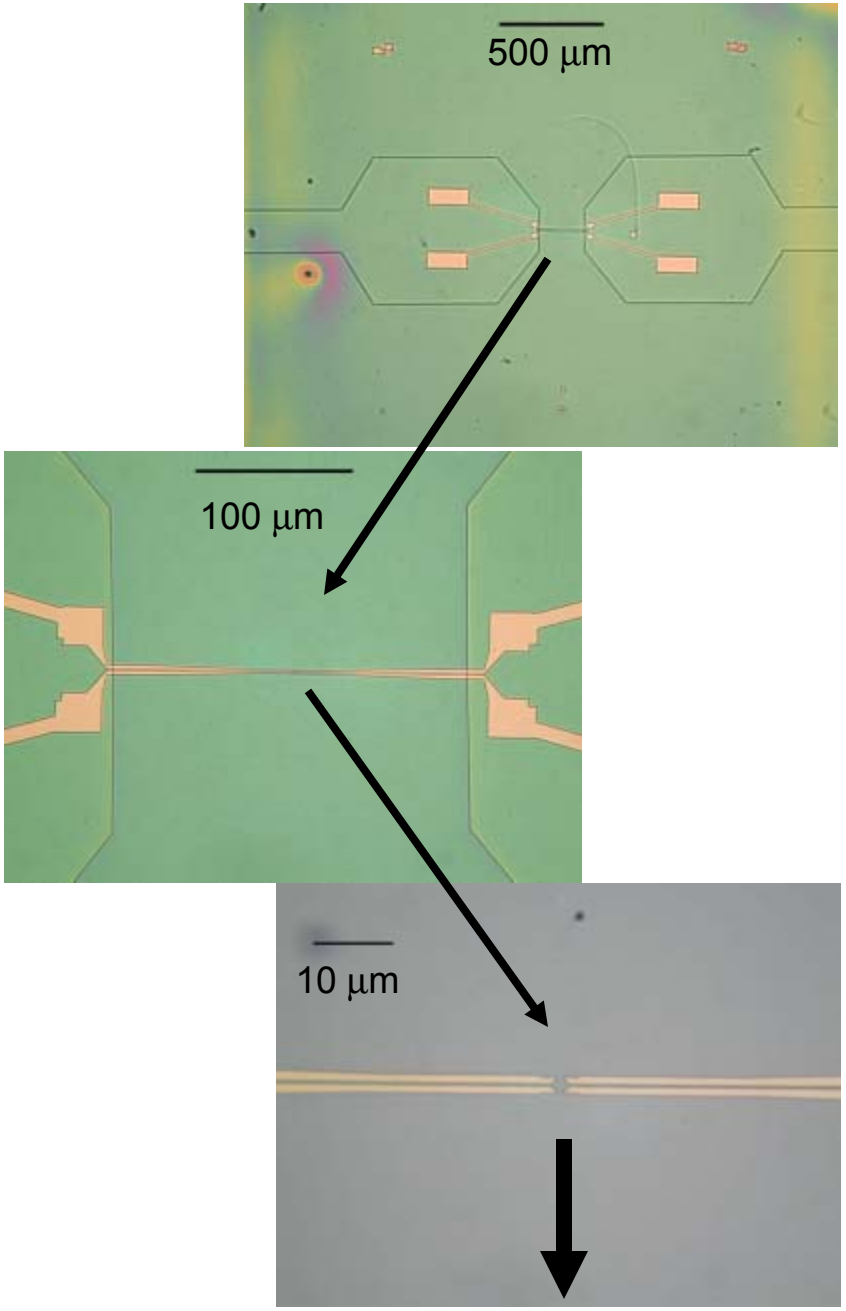
Process Step	Sub-step	Description	Process time	Equipment
Metal deposition and lift-off	**Metal Evaporation**	- Uses E-beam evaporator - Double radiation shield for sample - 5 nm Ti. I=57 mA, Rate = 0.15 nm/s - 45 nm Au. I=140 mA, Rate=0.30 nm/s	60 min	BOC Edwards Auto 306 system
	Lift-off	- 30 s in acetone + ultrasonic bath until sample comes off Macor holder - 1 min additional acetone + ultrasonic bath - Double water bath. Cleaner at 90 V (Variac)	5 min	Branson 2200 Ultrasonic cleaner

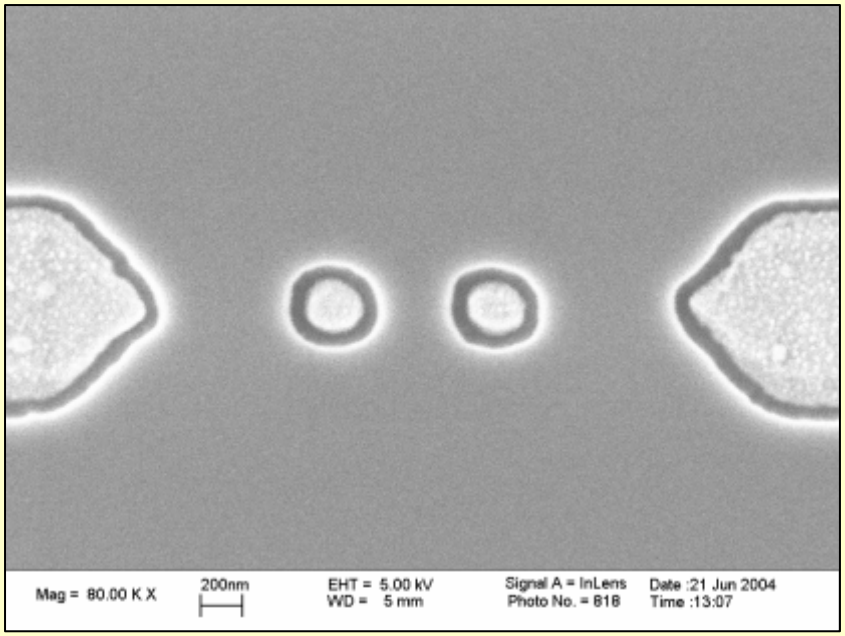
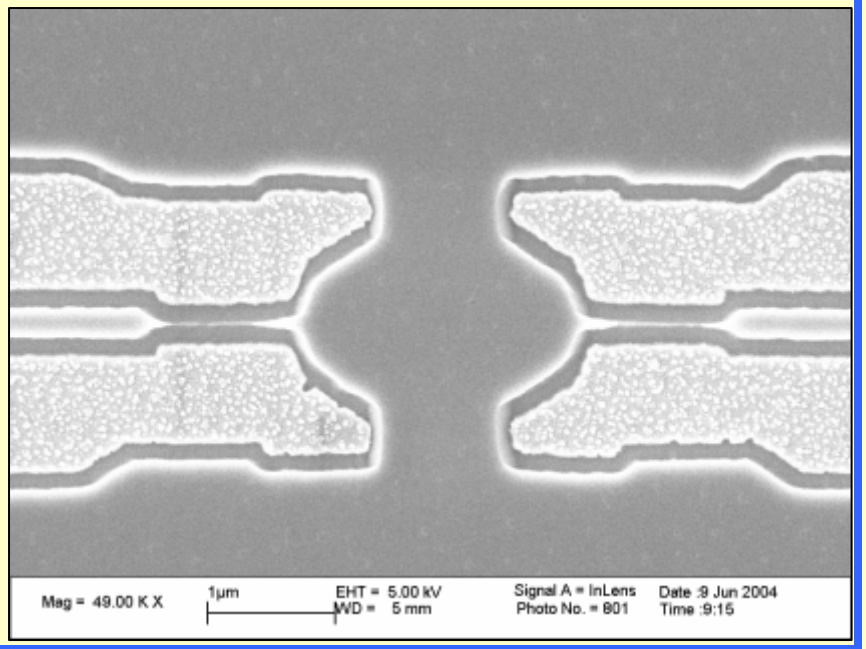
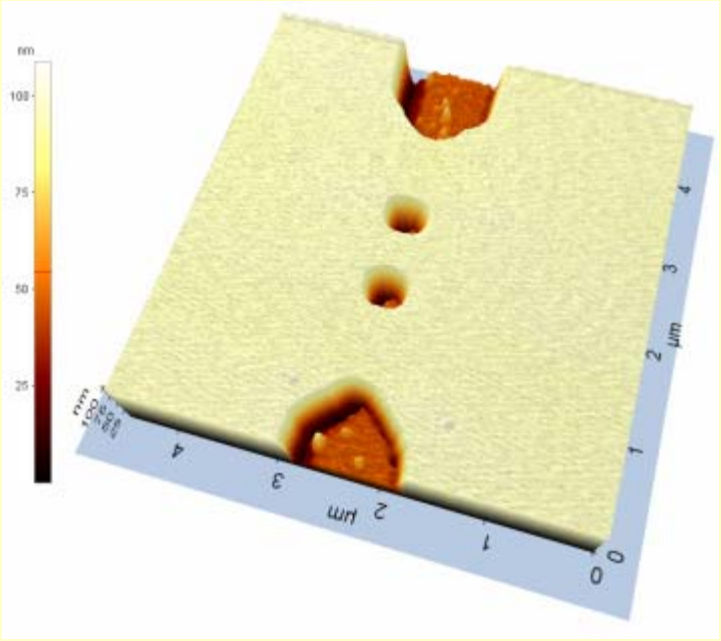
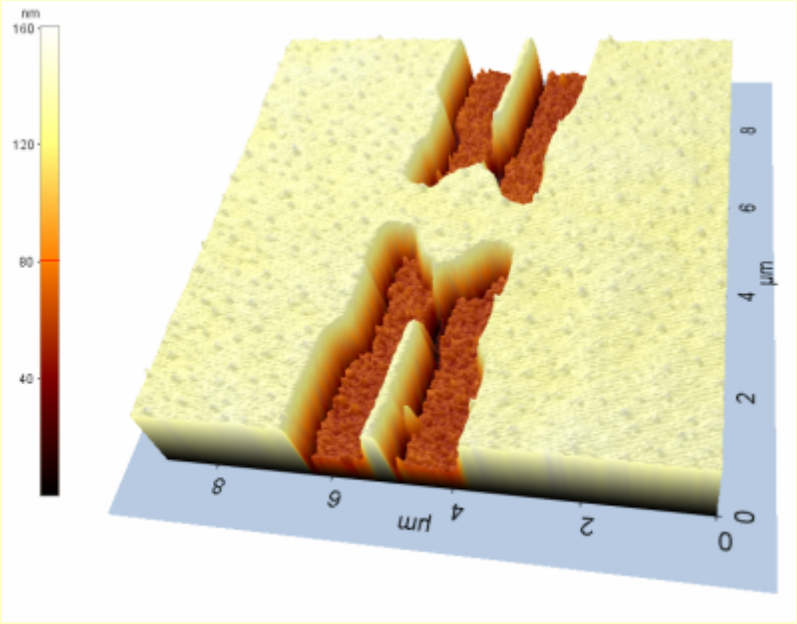
Total time = 1 hour approx.

Double Antidot



Quantum Interferometer



	Double Antidot	Quantum Interferometer
SEM		
AFM		

Acknowledgements

- Dr. Wei Chen (SEM, Stony Brook University)

- Machine Shop Crew
  (Stony Brook University)