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## Electron spin transport in quantum dots and point contacts

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# Appendix A

## Wafer inventory

In this Appendix we present the various heterostructures used in this thesis. All values for density and mobility were measured at 4.2 K with samples cooled down in the dark. We present the layer structure from top down.

### A.1 WSUMI301612

This wafer was purchased from Sumitomo Electric Industries, Ltd. Devices from this wafer were used for experiments on quantum fluctuations in the non-local resistance in Chapter 6 and for studies on ohmic contact formation to a 2DEG in Chapter 7. Quantum point contacts fabricated on this wafer never showed any sign of spin splitting in a large in-plane magnetic field.

- 2DEG depth: 75 nm
- Density:  $2.78 \times 10^{15} \text{ m}^{-2}$
- Mobility:  $19.5 \text{ m}^2/\text{Vs}$
- Layer structure:
  - 5 nm GaAs
  - 40 nm  $\text{Al}_{0.27}\text{Ga}_{0.73}\text{As}$  (n-doped with Si at  $2 \times 10^{18} \text{ cm}^{-3}$ )
  - 30 nm  $\text{Al}_{0.27}\text{Ga}_{0.73}\text{As}$
  - 800 nm GaAs

## A.2 WREUT1098

This wafer was grown in the group of D. Reuter and A. D. Wieck at the Ruhr-Universität in Bochum, Germany. Devices from this wafer were used for experiments on point contacts and quantum dots in Chapters 3 and 4, and for studies on ohmic contact formation to a 2DEG in Chapter 7.

- 2DEG Depth: 114 nm
- Density:  $1.5 \times 10^{15} \text{ m}^{-2}$
- Mobility:  $159 \text{ m}^2/\text{Vs}$
- Layer structure:
  - 5.5 nm GaAs
  - 71.9 nm  $\text{Al}_{0.32}\text{Ga}_{0.68}\text{As}$  (n-doped with Si at  $1 \times 10^{18} \text{ cm}^{-3}$ )
  - 36.8 nm  $\text{Al}_{0.32}\text{Ga}_{0.68}\text{As}$
  - 933 nm GaAs

## A.3 WREUT12570

This wafer was grown in the group of D. Reuter and A. D. Wieck at the Ruhr-Universität in Bochum, Germany. Devices from this wafer were used only for studies on ohmic contact formation to a 2DEG in Chapter 7.

- 2DEG Depth: 180 nm
- Density:  $4.54 \times 10^{15} \text{ m}^{-2}$
- Mobility:  $22.9 \text{ m}^2/\text{Vs}$
- Layer structure:
  - 5 nm GaAs
  - 70 nm  $\text{Al}_{0.35}\text{Ga}_{0.65}\text{As}$
  - 70 nm  $\text{Al}_{0.35}\text{Ga}_{0.65}\text{As}$  (n-doped with Si at  $1 \times 10^{18} \text{ cm}^{-3}$ )
  - 35 nm  $\text{Al}_{0.35}\text{Ga}_{0.65}\text{As}$
  - 650 nm GaAs

# Appendix B

## Device fabrication

In this Appendix we will describe the fabrication procedure for the devices that were used in this thesis.

### B.1 Alignment markers

- Preparation:
  - Clean in boiling acetone (10')
  - Rinse in IPA (30")
  - Spin dry
- Resist:
  - Spin 250 nm 950K PMMA (4% in Chlorobenzene) - 4000 rpm (60")
  - Bake at 180 °C (15')
- Exposure:
  - Beam voltage: 10 keV
  - Aperture: 10  $\mu\text{m}$
  - Working area: 200 x 200  $\mu\text{m}$
  - E-beam dose: 200  $\mu\text{C}/\text{cm}^2$
- Developing:
  - Develop in 1:3 MIBK / IPA (60")
  - Rinse in IPA (30")

- Spin dry
- Evaporation:
  - 5 nm Ti
  - 50 nm Au
- Lift-off:
  - Lift-off in acetone (several hours) / acetone spray
  - Rinse in IPA (30")
  - Spin dry

## B.2 Mesa etching

- Preparation:
  - Clean in boiling acetone (10')
  - Rinse in IPA (30")
  - Spin dry
- Resist:
  - Spin 70 nm 950K PMMA (2% in Ethyl lactate) - 4000 rpm (60")
  - Bake at 180 °C (15')
- Exposure:
  - Beam voltage: 10 keV
  - Aperture: 120  $\mu\text{m}$
  - Working area: 2000 x 2000  $\mu\text{m}$
  - E-beam dose: 150  $\mu\text{C}/\text{cm}^2$
- Developing:
  - Develop in 1:3 MIBK / IPA (35")
  - Rinse in IPA (30")
  - Spin dry

- Etching:
  - Etch in a 1:1:50 solution of  $H_2SO_4$  /  $H_2O_2$  /  $H_2O$  (50"). The etching rate is approximately 2 nm/s
  - Rinse in  $H_2O$  (30")
  - Spin dry
- Cleaning:
  - Clean in boiling acetone (10')
  - Rinse in IPA (30")
  - Spin dry

## B.3 Ohmic contacts

- Preparation:
  - Clean in boiling acetone (10')
  - Rinse in IPA (30")
  - Spin dry
- Resist:
  - Spin 400 nm 50K PMMA (9% in Chlorobenzene) - 4000 rpm (60")
  - Bake at 180 °C (15')
  - Spin 70 nm 950K PMMA (2% in Ethyl lactate) - 4000 rpm (60")
  - Bake at 180 °C (15')
- Exposure:
  - Beam voltage: 10 keV
  - Aperture: 120  $\mu\text{m}$
  - Working area: 2000 x 2000  $\mu\text{m}$
  - E-beam dose: 200  $\mu\text{C}/\text{cm}^2$
- Developing:
  - Develop in 1:3 MIBK / IPA (60")

- Rinse in IPA (30")
- Spin dry
- Evaporation:
  - 120nm AuGe
  - 30nm Ni
  - 20nm Au
- Lift-off:
  - Lift-off in acetone (several hours) / acetone spray
  - Rinse in IPA (30")
  - Spin dry
- Annealing:
  - Anneal in  $N_2$  atmosphere (50 ml/s) in the oven at 450 °C for typically 5 minutes (see Chapter 7 for more details)

## B.4 Fine gates

- Preparation:
  - Clean in boiling acetone (10')
  - Rinse in IPA (30")
  - Spin dry
- Resist:
  - Spin 70 nm 950K PMMA (2% in Ethyl lactate) - 4000 rpm (60")
  - Bake at 180 °C (15')
- Exposure:
  - Beam voltage: 30 keV
  - Aperture: 10  $\mu\text{m}$
  - Working area: 200 x 200  $\mu\text{m}$

- E-beam dose:  $450 \mu\text{C}/\text{cm}^2$
- Developing:
  - Develop in 1:3 MIBK / IPA (35")
  - Rinse in IPA (30")
  - Spin dry
- Evaporation:
  - 5 nm Ti
  - 15 nm Au
- Lift-off:
  - Lift-off in acetone (overnight) / acetone spray
  - Rinse in IPA (30")
  - Spin dry

## B.5 Large gates

- Preparation:
  - Clean in boiling acetone (10')
  - Rinse in IPA (30")
  - Spin dry
- Resist:
  - Spin 400 nm 50K PMMA (9% in Chlorobenzene) - 4000 rpm (60")
  - Bake at 180 °C (15')
  - Spin 70 nm 950K PMMA (2% in Ethyl lactate) - 4000 rpm (60")
  - Bake at 180 °C (15')
- Exposure:
  - Beam voltage: 10 keV
  - Aperture: 120  $\mu\text{m}$



- Working area: 2000 x 2000  $\mu\text{m}$
- E-beam dose: 200  $\mu\text{C}/\text{cm}^2$
- Developing:
  - Develop in 1:3 MIBK / IPA (60")
  - Rinse in IPA (30")
  - Spin dry
- Evaporation:
  - 5 nm Ti
  - 150 nm Au
- Lift-off:
  - Lift-off in acetone (several hours) / acetone spray
  - Rinse in IPA (30")
  - Spin dry