Metal Gates for p-type GaAs Heterostructures

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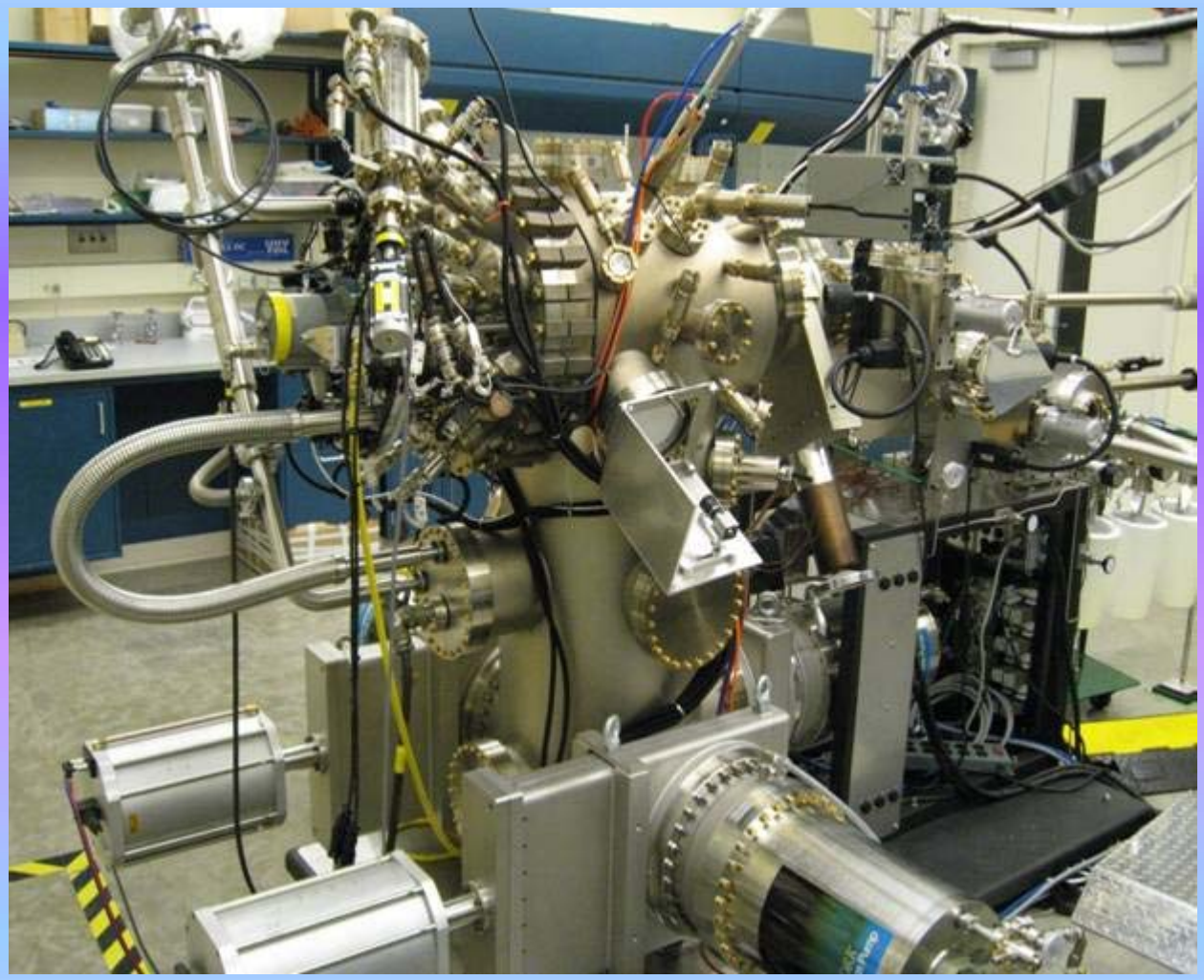


Molecular beam epitaxy system where GaAs wafers are grown

Goals

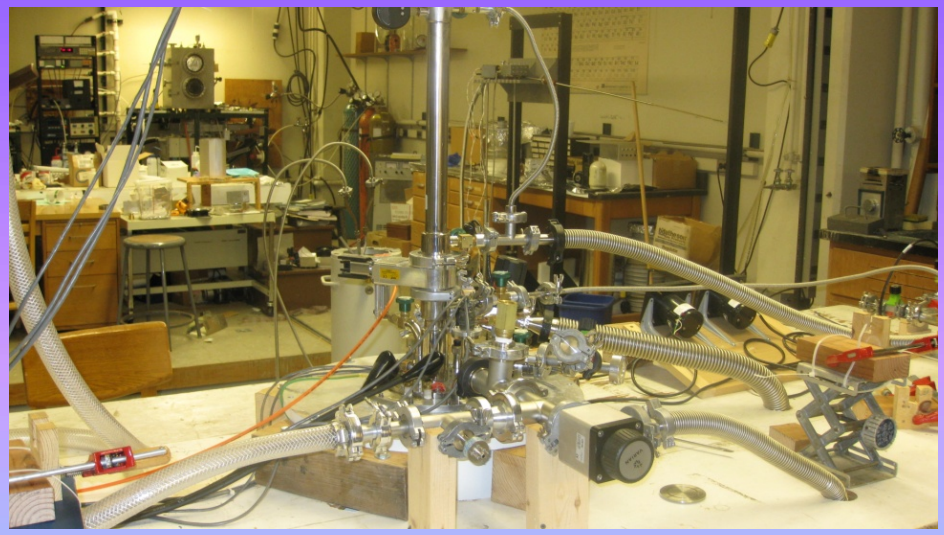
- GaAs/AlGaAs wafers – two-dimensional hole gas
- Create metal gated structures on p-type GaAs/AlGaAs wafers
  - Manipulate the two-dimensional hole gas
  - Shallow vs. deep wafers
- Conditions to test:
  - Different gate metals
  - Gate oxide
  - Photolithography vs. e-beam lithography

Overview

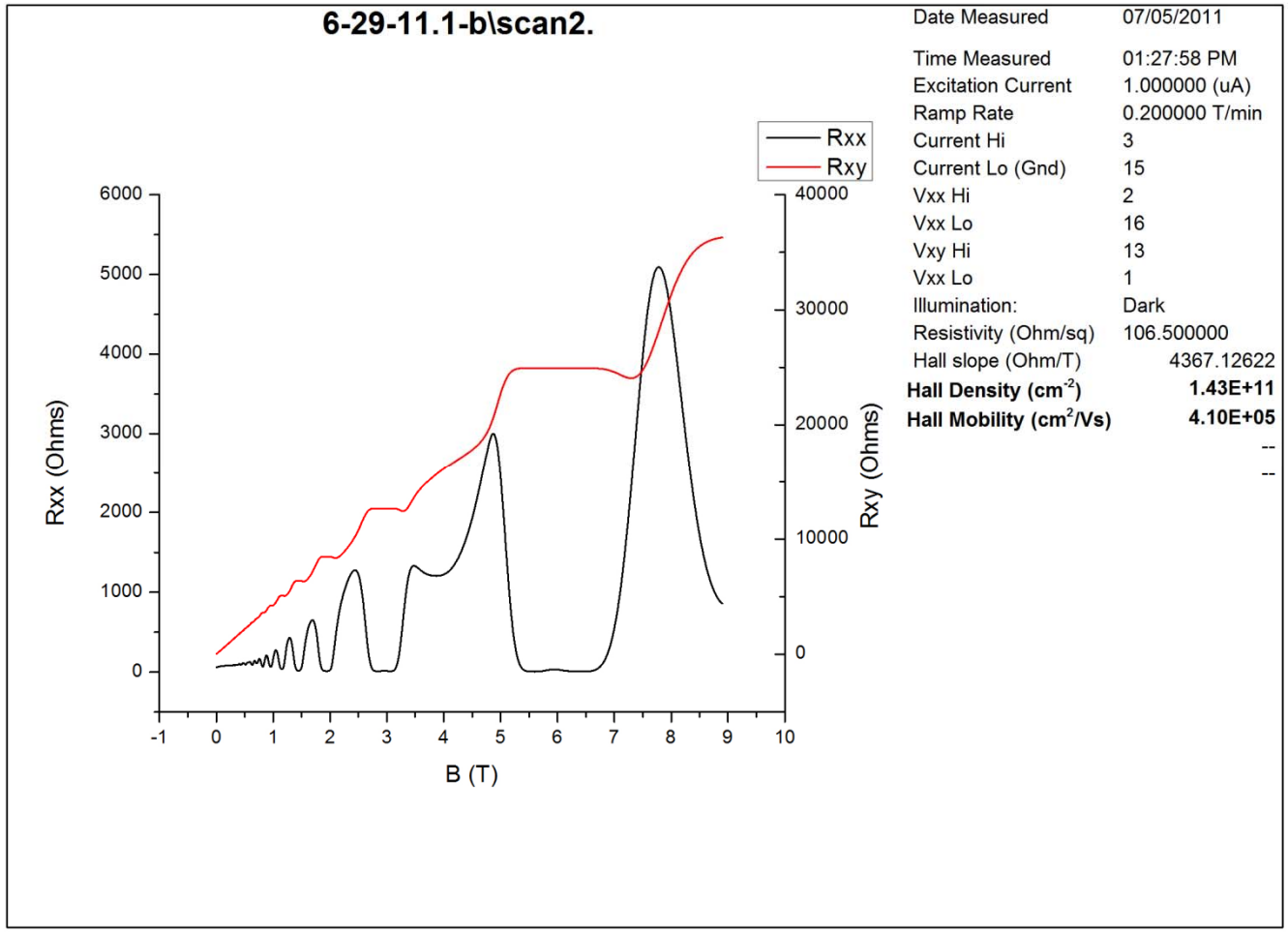
- 1. Characterize wafers
- 2. Ohmic contacts
- 3. Etching
- 4. Metal gates

1. Wafer Characterization

- Cut samples out of wafers
- Solder contacts onto samples
- Anneal contacts
- Graph magnetoresistance to obtain carrier mobility and density

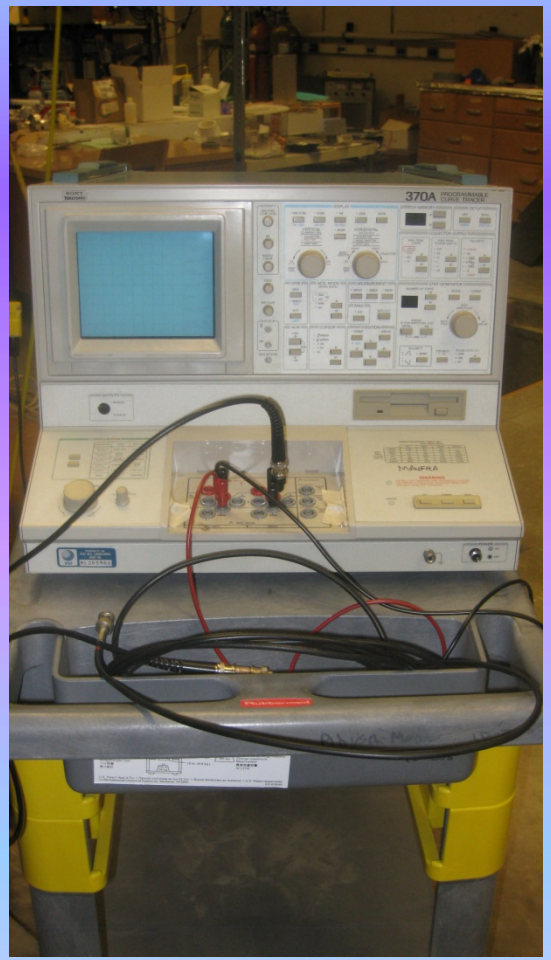


Transport Data for a Shallow Wafer

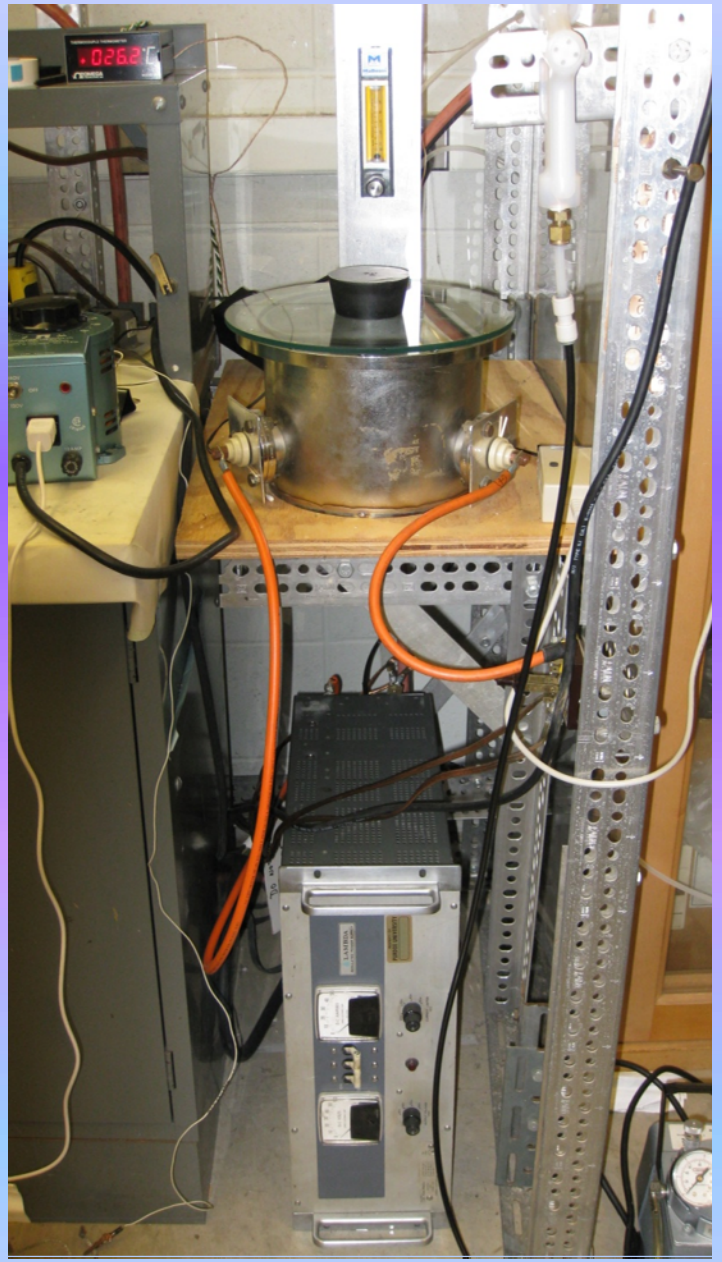


2. Ohmic contacts

- Test Au/Be contacts and annealing conditions:
  - Evaporate contacts onto sample using metal mask
  - Cut large sample into smaller samples
  - Anneal contacts at various times
  - Test contact resistances



Thermal evaporator



Annealer

Au/Be Contact Data

Sample	Annealing time	Au/Be thickness	Room temp. resistance (ohms)	4 K resistance (ohms)
3-10-05.1 (deep)	5 – 15 minutes	120 nm	11-14 k	40-100
6-29-11.1 (shallow)				
	5 minutes	61 nm	30-70 k	Non-ohmic
	16 minutes	137 nm	40-80 k	80-100 k
	5 minutes	137 nm	60-100 k	Insulating
	5 minutes	112 nm	60-140 k	Insulating
10-21-03.1 (deep)	5 minutes	112 nm	40-90 k	Insulating

Au/Be Contact Problems

- Highly inconsistent results with the deep samples
- Consistently do not work with the shallow samples
- Factors involved:
  - Equipment cleanliness
  - Annealing time and temperature
  - Evaporation rate
  - Thermal evaporator vacuum
  - Au/Be thickness

3. Etching

- Photolithography tests
  - Photoresist
  - Exposure time
  - Developing time
- 30 seconds exposure found to be optimal for the MA-N2403 photoresist (10 second developing time)

Next Steps

- Resolve Au/Be contact inconsistencies
- Deposit gate metal
- Testing