# Comparison of two different ohmic contact fabrication recipes

Project Thesis Presentation

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# Project Goal

- Fabrication of ohmic contacts
- Wafers are slightly etched prior to evaporation of ohmics

  → Increase roughness of the surface
  → Influence on the annealing mechanism?

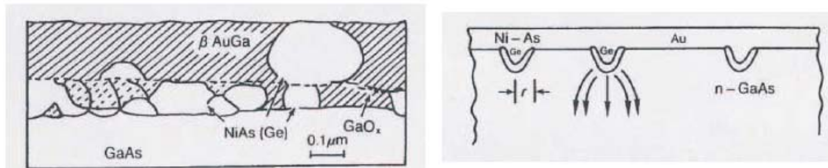
**→ Does the pre-etching have an influence on the ohmic contact resistance?**

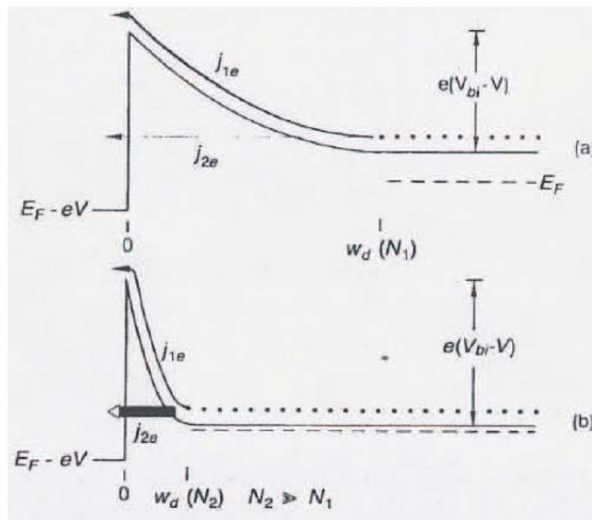
# Characteristics of ohmic contacts

- Ohmic contacts: A source of carriers with internal resistance $R_C$
- $R_C$ obeys Ohm's Law
- Metals used for ohmic contacts:

120 nm Au
60 nm Ge } eutectic, melts at 370ºC — - Ge: dopant (column IV below Si)
120 nm Au
60 nm Ge
85 nm Pt — - Pt: prevents „balling up“ of AuGe

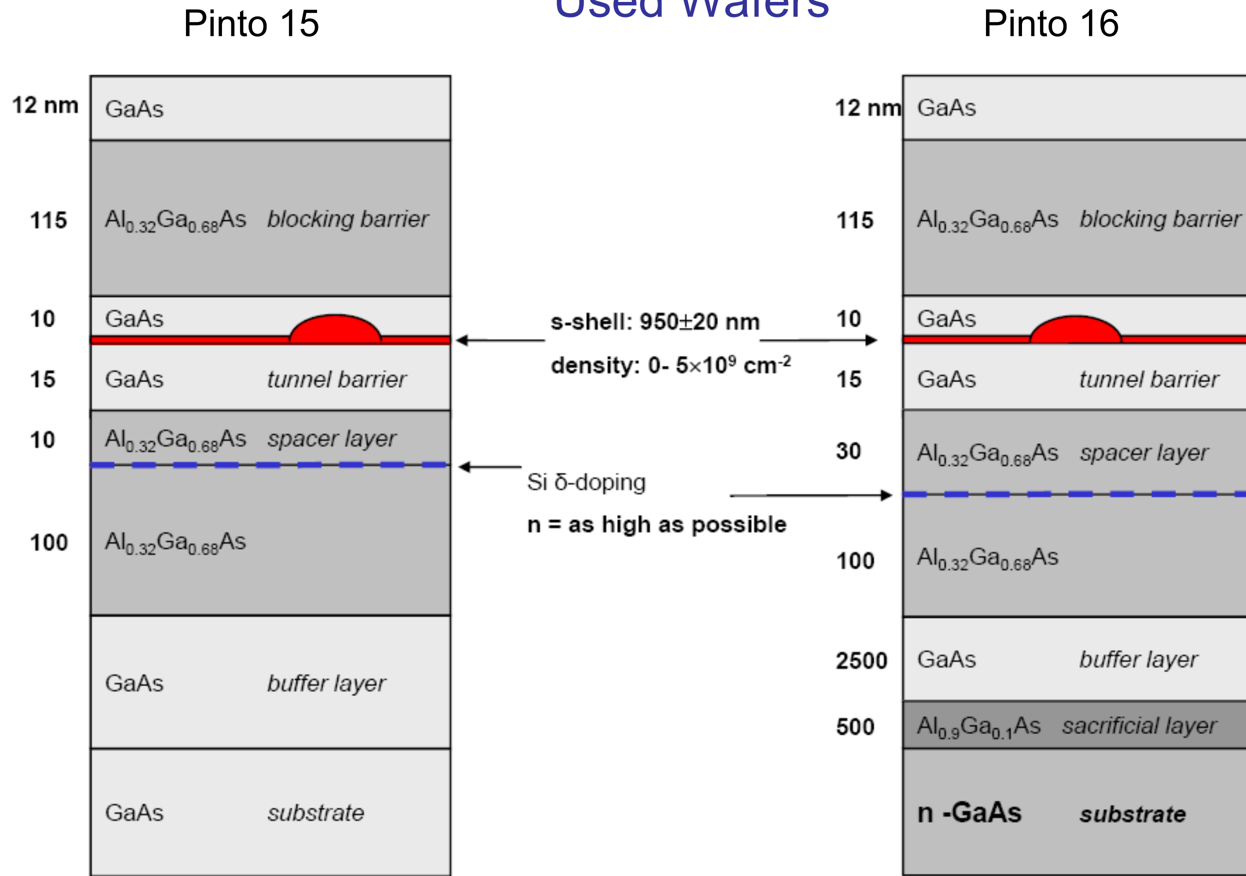
# Characteristics of Ohmic contacts



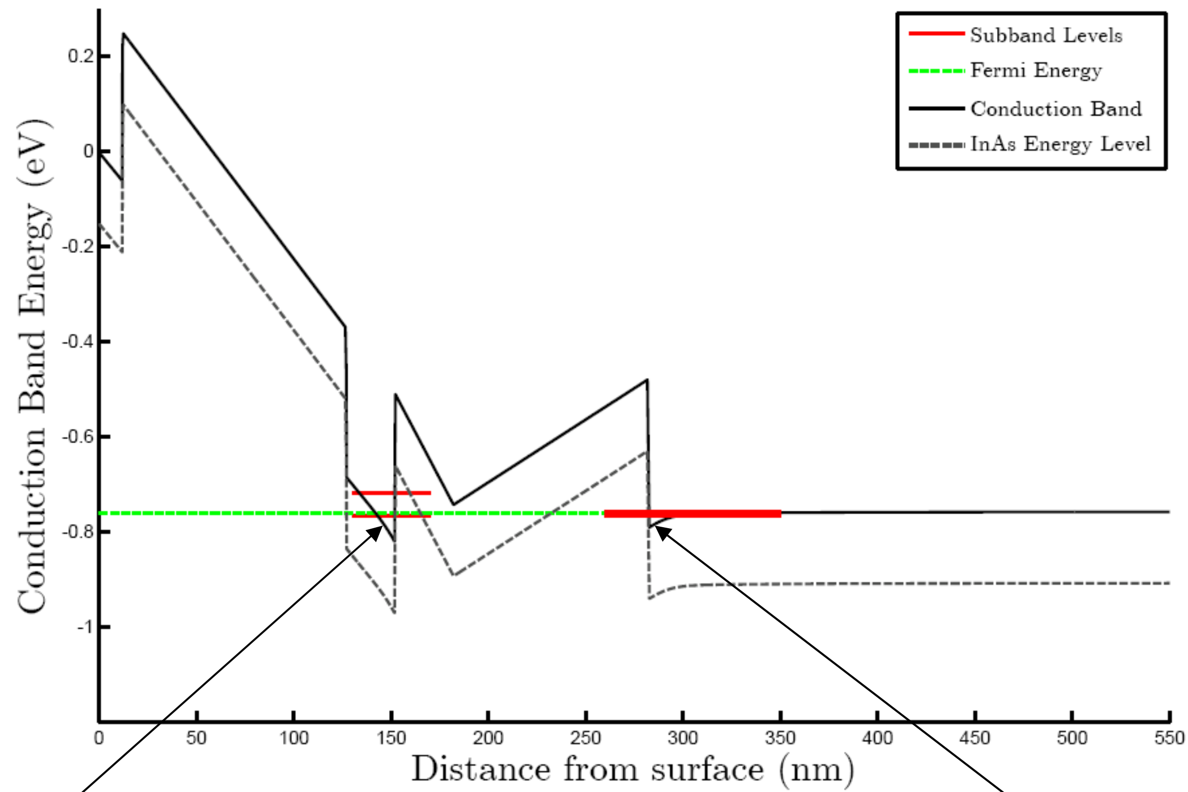

- Complicated mix between GaAs and metals
- Ge – rich portrusions: current through these spikes
- Metall – n-doped semiconductor: Schottky barrier
- Increase doping density → decrease barrier width → increase tunnel probability → ohmic contact

# Used Wafers




- Pinto 16: Low Density (LD) (without dots) & High density (HD) with dots
- Pinto 15: High Density (with dots)

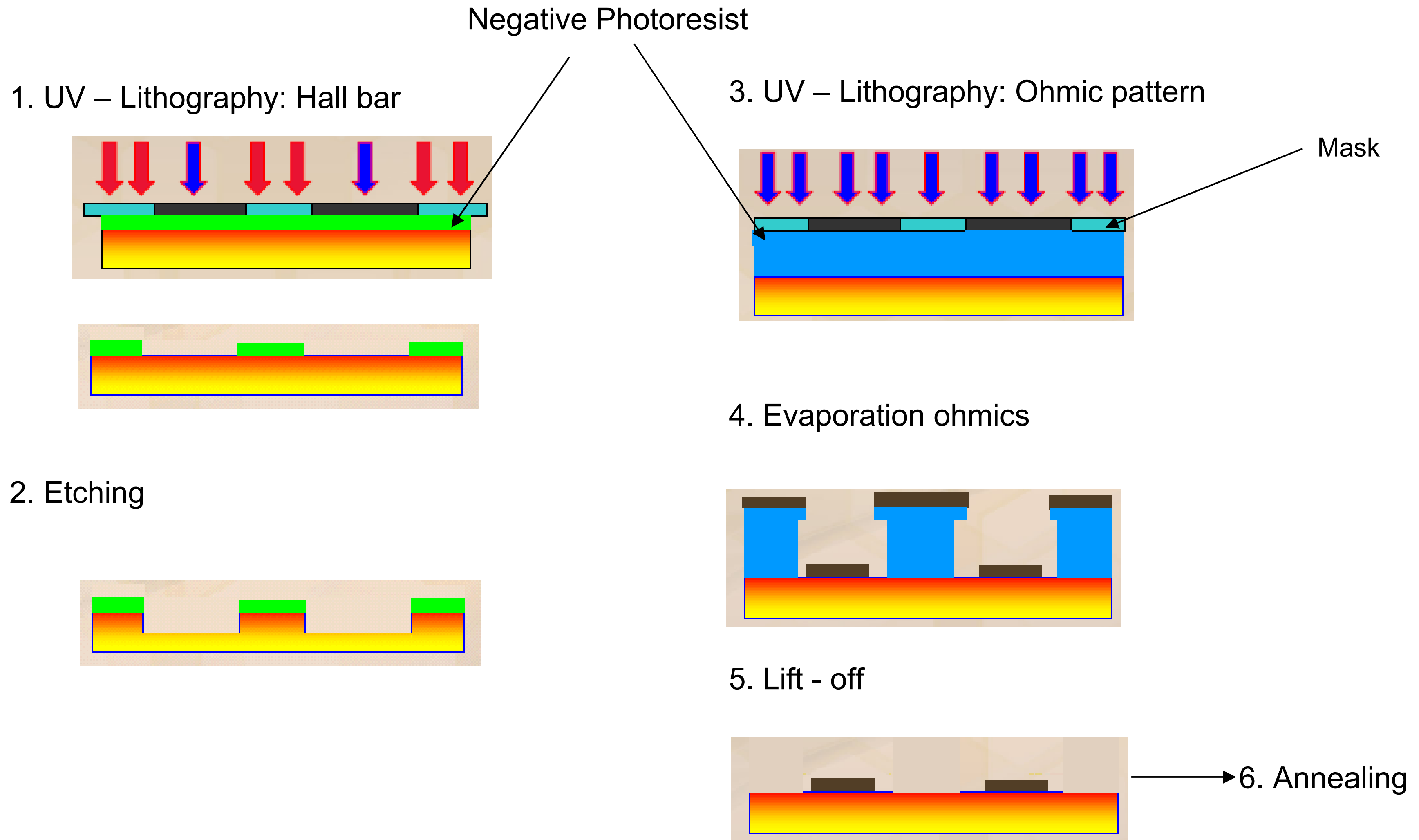
# Band – diagram of Pinto 16



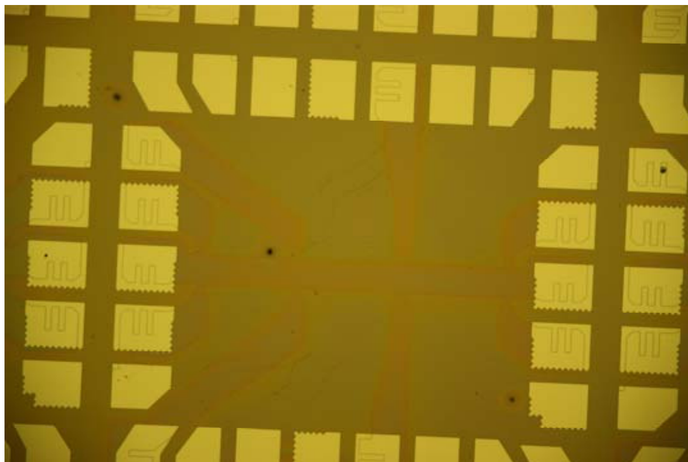

Inverted 2DEG

2DEG

# Fabrication: Overview

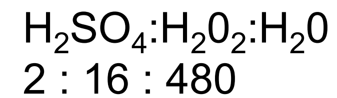


# Fabrication



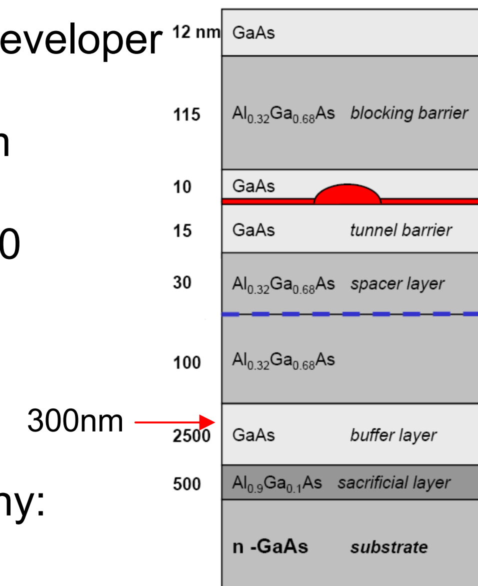
- UV – Lithography: Hall bar
- Hard contact 1.4 bar
- 7.0s (Intensity: 63 mW/cm$^2$)
- Developed in developer

→ Etching 300 nm



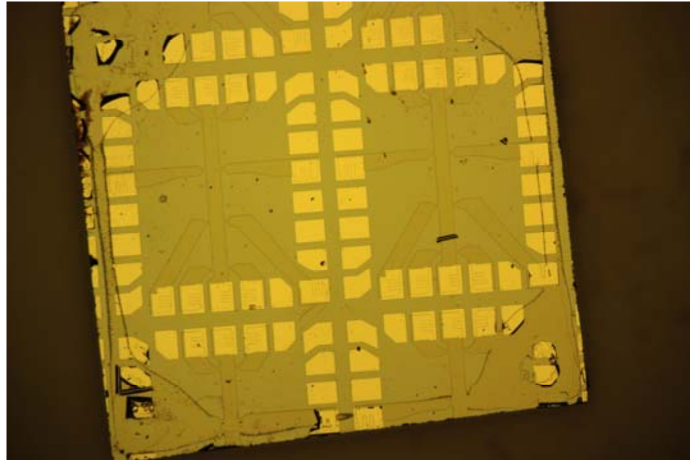
$H_2SO_4:H_20_2:H_20$
2 : 16 : 480

- UV - Lithography: ohmic contacts




Pinto 16

# Fabrication



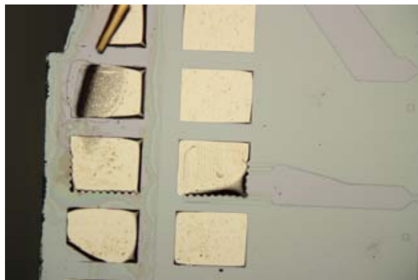
- Clean resist in $O_2$ – Plasma → HCl dip
  → Etch 5 nm $H_2SO_4$:$H_2O_2$:$H_2O$ 1 : 8 : 1000
- Evaporation:

| | |
|---|---|
| 120 nm | Au |
| 60 nm | Ge |
| 120 nm | Au |
| 60 nm | Ge |
| 85 nm | Pt |

- Lift – off: 30 min warm NMP
- Annealing at different temperatures:

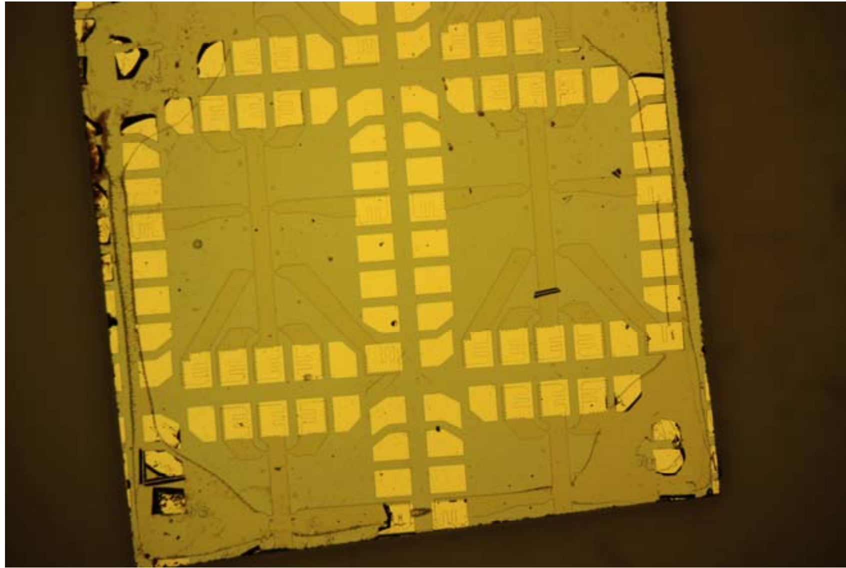
melting Au/Ge: 2 min. 370 °C

1min: 420°C, 450°C, 480°C, 510°C

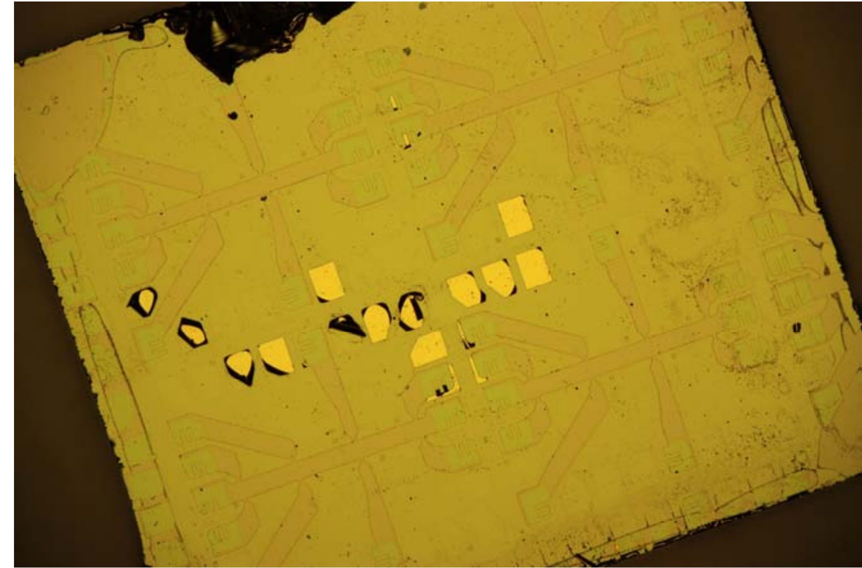


→ Wire bonding with Al wire

# Lift – off



Pinto 16 LD treated with HCl

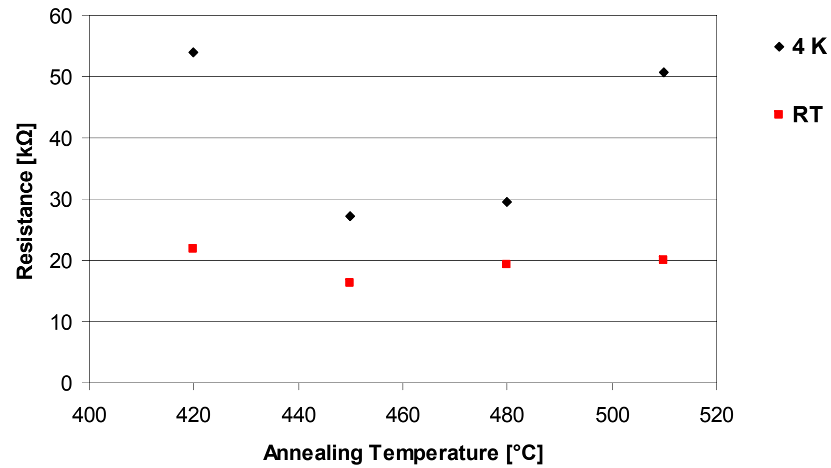


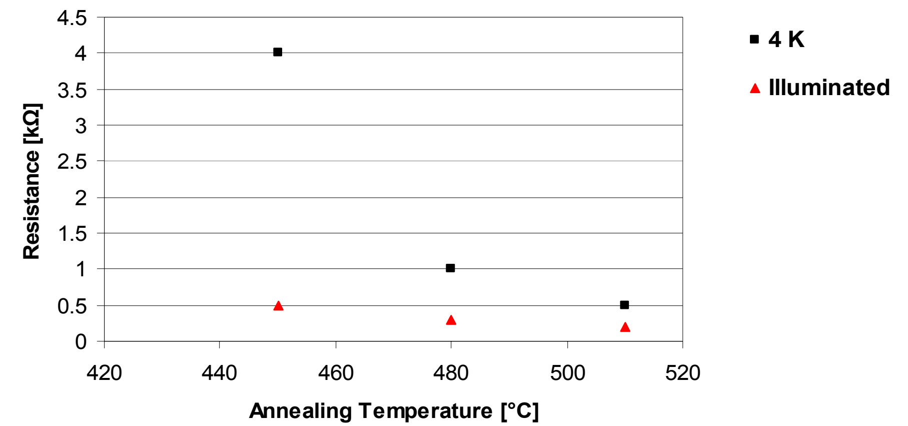
Pinto 16 LD etched prior to evaporation

## Measurement Setup

- Dipstick
- Helium Dewar: ~ 4 Kelvin
- Battery measurement: Applying known DC Voltage → Measure current
- Lock – in measurement: Applying known AC Current → Measure Voltage
- Illumination to increase charge carrier density of the 2DEG

# Results




- Annealing temperature of 480°C and 510°C show lowest resistance for Pinto 16 LD
- Illumination decreases resistance

## Results II

Pinto 16 LD :
(HCl dip)

annealed at 480°C: ~ 1.0 kΩ → illumination: ~ 0.3 kΩ
annealed at 510°C: ~ 0.5 kΩ → illumination: ~ 0.2 kΩ

Pinto 16 LD :
(etched 5 nm before evaporation)

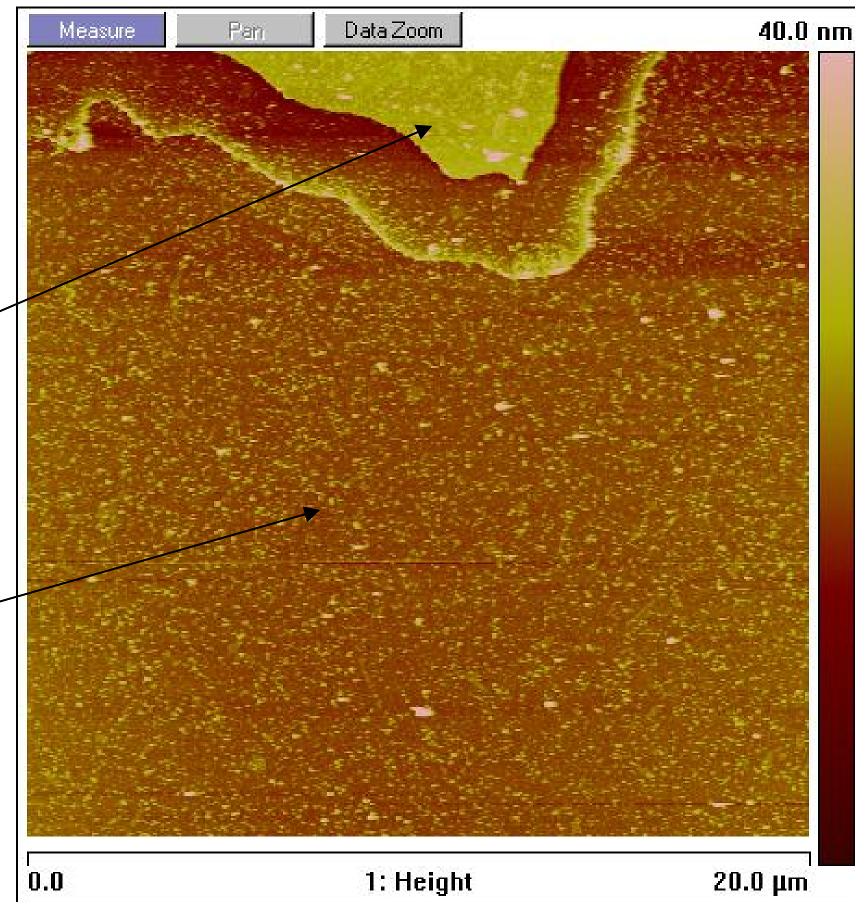
annealed at 480°C: ~2.0 kΩ → illumination: ~ 0.6 kΩ
annealed at 510°C: ~1.9 kΩ → illumination: ~ 0.4 kΩ

→ Resistance increased when pre-etching the sample

# Roughness

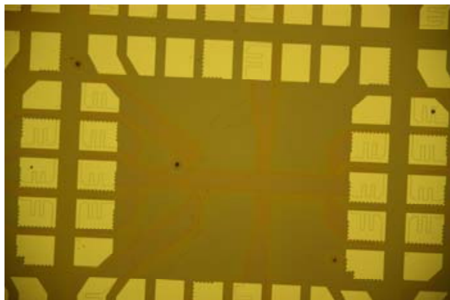
- Etched wafers show higher resistance of the ohmic contacts
- AFM figures to compare roughness between etched part and part covered by photoresist

(AFM figures recorded when lift – off failed)




Covered photoresist
rms:~ 2.0 nm

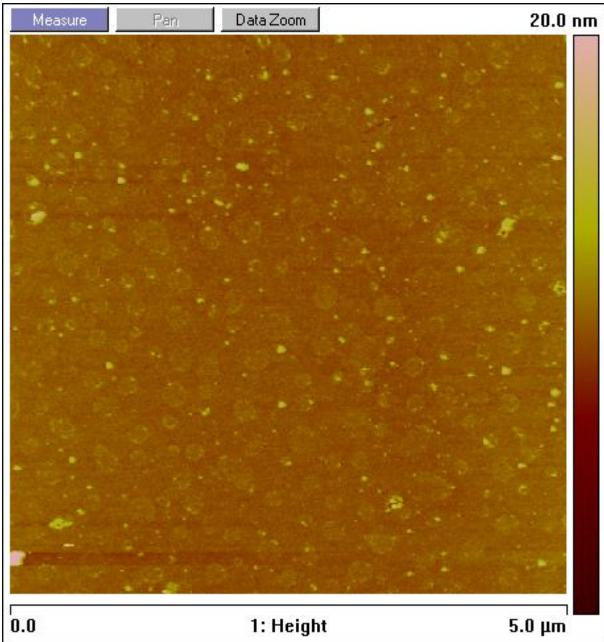
etched
rms:~ 2.5 nm

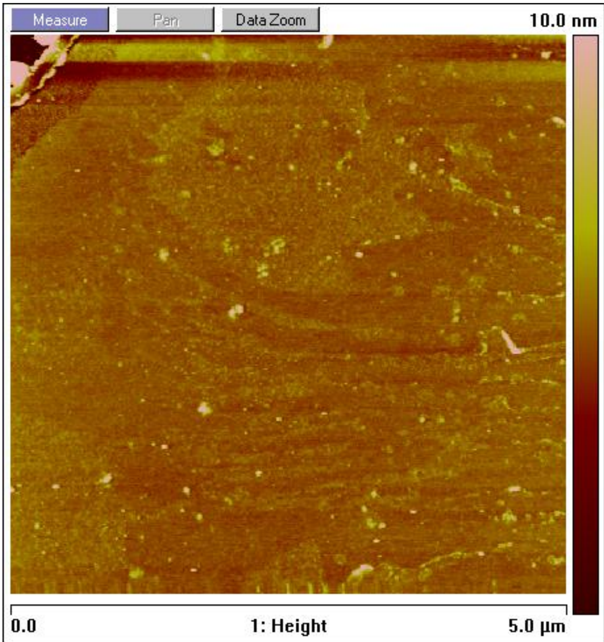


# Roughness

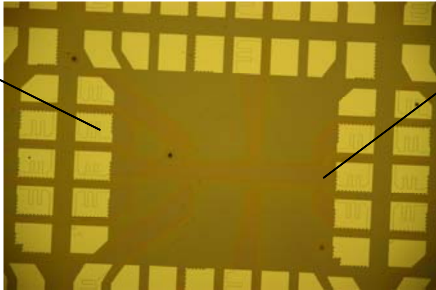
Zoom in on pre etched area

Zoom in on mesa




rms:~0.36 nm



rms:~0.21 nm

# Conclusion

- Lift – off is generally more sensitive when etching the sample before evaporation
- Resistance is strongly dependent on annealing temperature: 480 ºC and 510 ºC show low ohmic resistances
- pre – etched areas show larger surface roughness
- Pre-etching of wafer yields larger resistances compared to HCl dip
  → Not expected!

## Thanks to

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