Metal Contacts for the Hybrid Silicon Laser

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Department of Electrical and Computer Engineering

Outline

- Optical communication
- Hybrid Silicon Laser
  - Need for metal-semiconductor contacts
- Measurement technique
  - Two and four point probe method
- Anatomy of a metal contact
- Measurement results

Optical Communication

Fiber optic cables

- For *long* distance communication
- Niche technology
- Expensive components

What we want

- Adapt technology to everyday use
  Eg. Faster internet

Why is it important

- Replace existing copper cable
- Fast & efficient data communication

➡ **Make cheaper/better light sources**

Trans-Atlantic cable

Fiber optic cable array

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Hybrid Silicon Laser

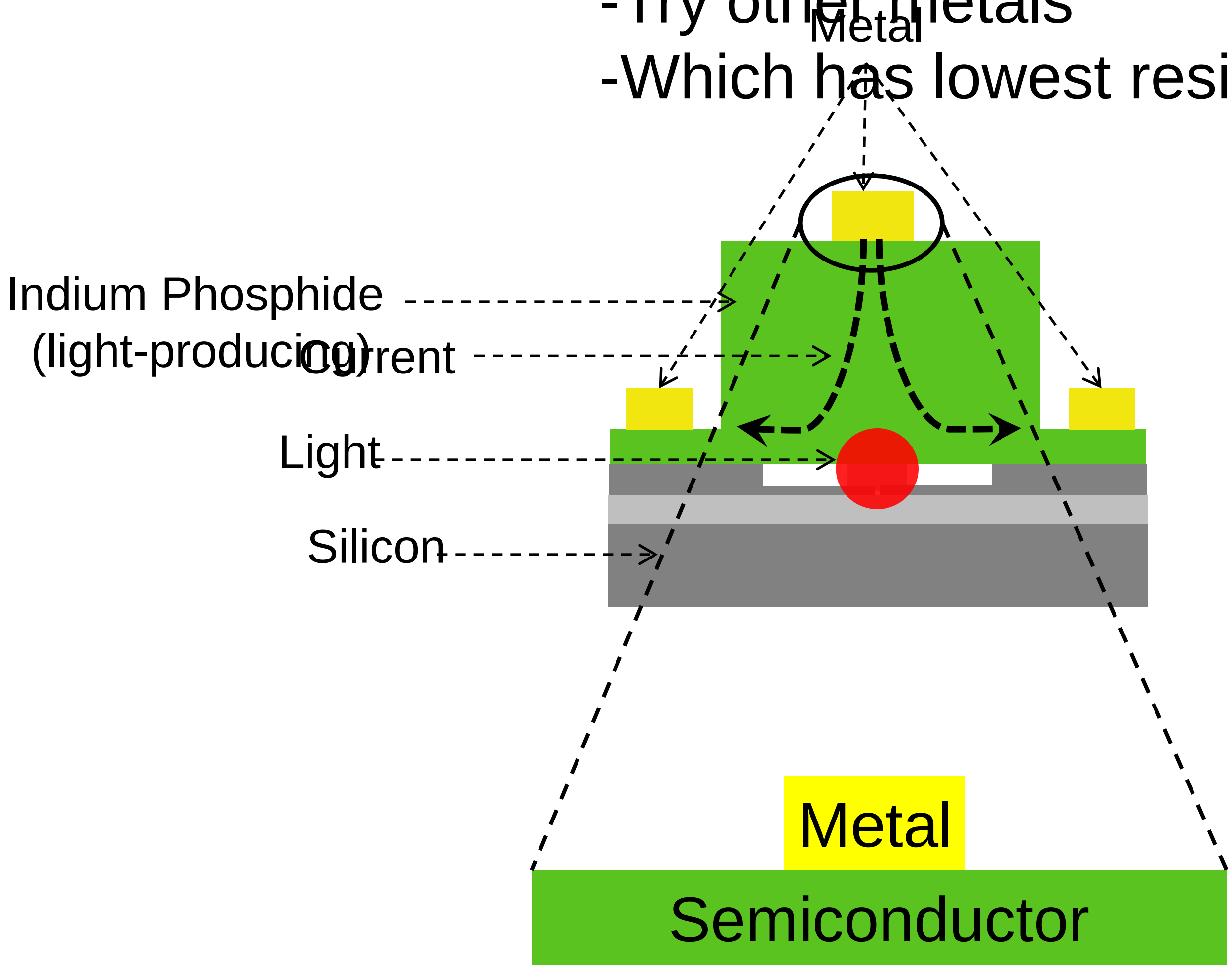
Problem: “Usual” gold contacts incompatible with Si

Aim: Convert electrical energy → light energy

What we’ll do: Study metal/semiconductor interface

-Try other metals

-Which has lowest resistance?



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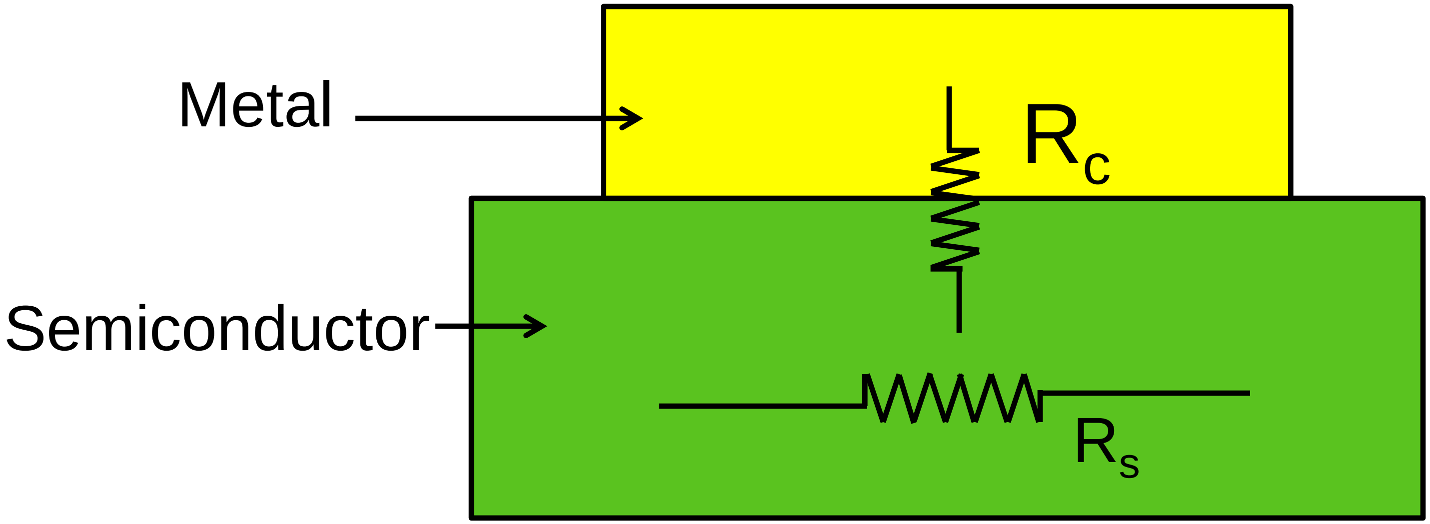
What Do We Want to Measure?



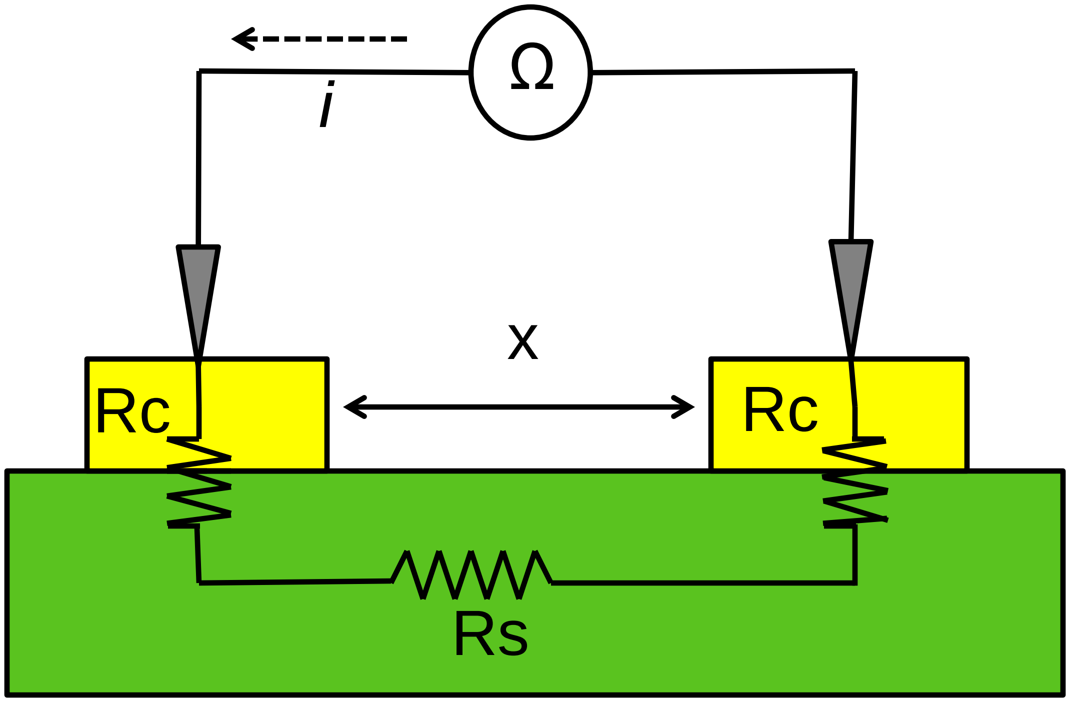
We want R_c: Contact Resistance

– R_s: Inherent resistance of semiconductor

What we actually record: *Specific* contact resistance (ρ) – takes into account area through which current flows.

Measuring Resistance

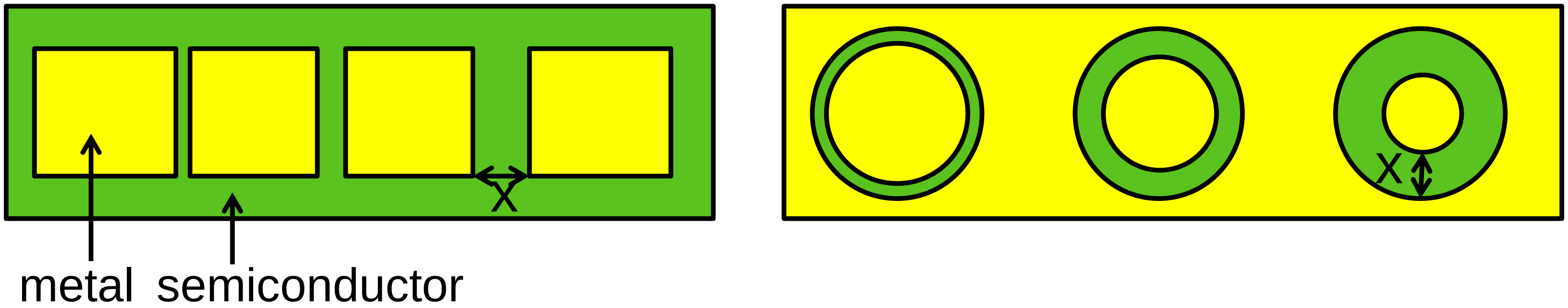
- We want to measure R_c

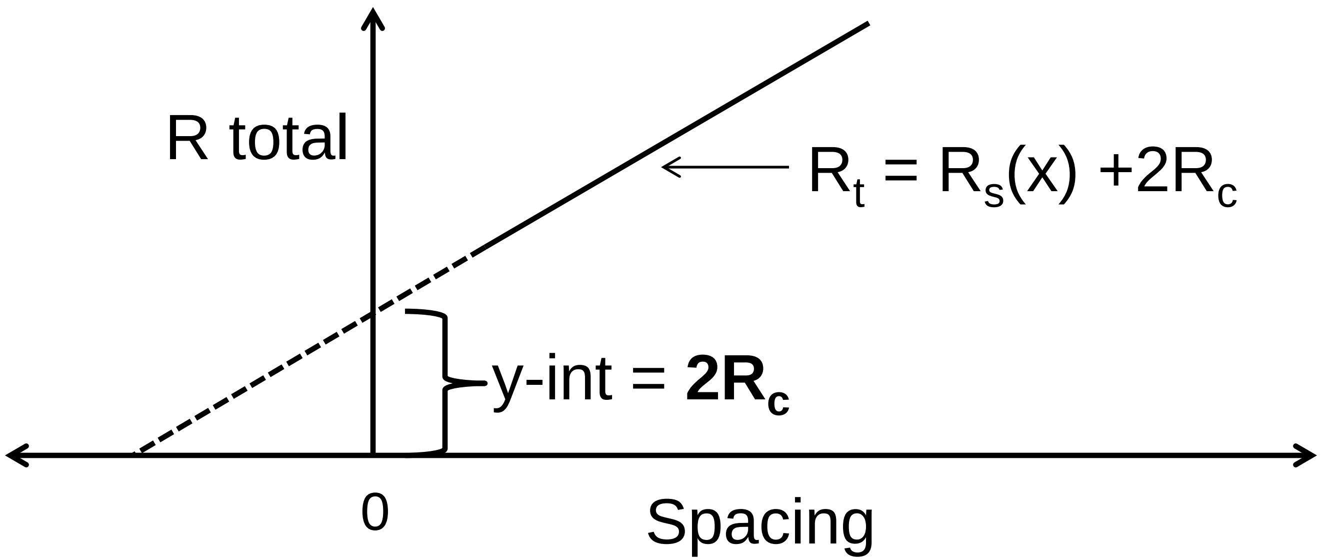


- Measured Resistance = $2R_c + R_s$

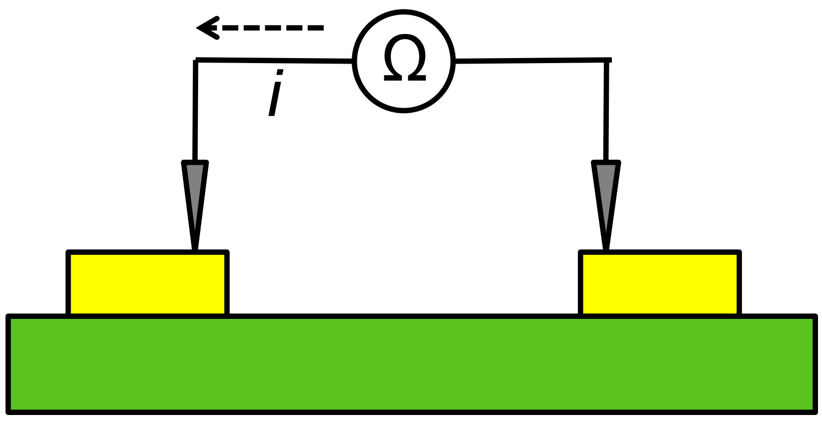
Finding Contact Resistance (R_c)

- R_s depends on spacing (x)
- Vary spacing to construct graph





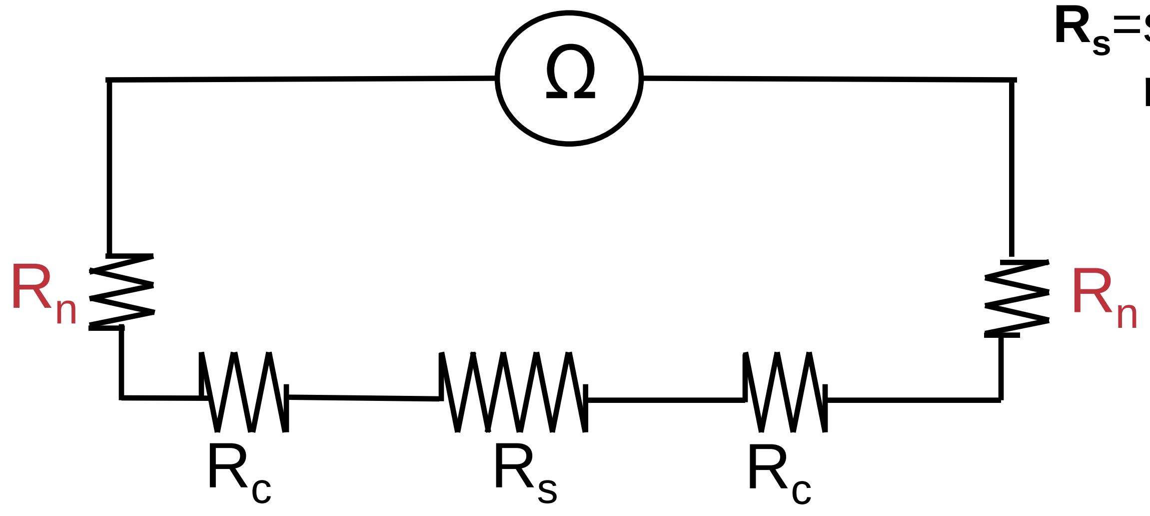
Two Point Probe Method



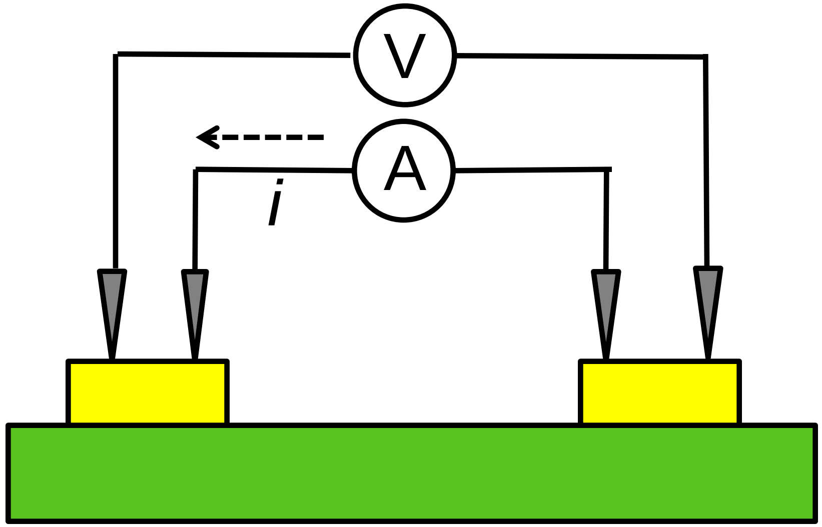
R_n=needle resistance

R_c=contact resistance

R_s=semiconductor resistance



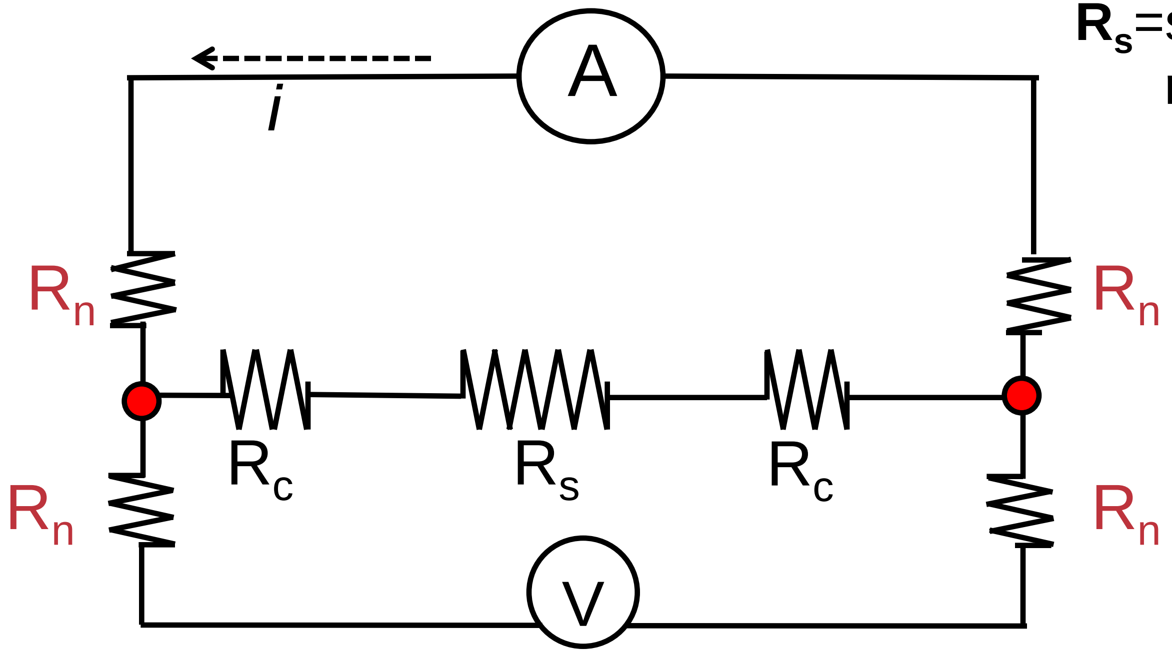
Four Point Probe Method



R_n=needle resistance

R_c=contact resistance

R_s=semiconductor resistance



$i = 0$

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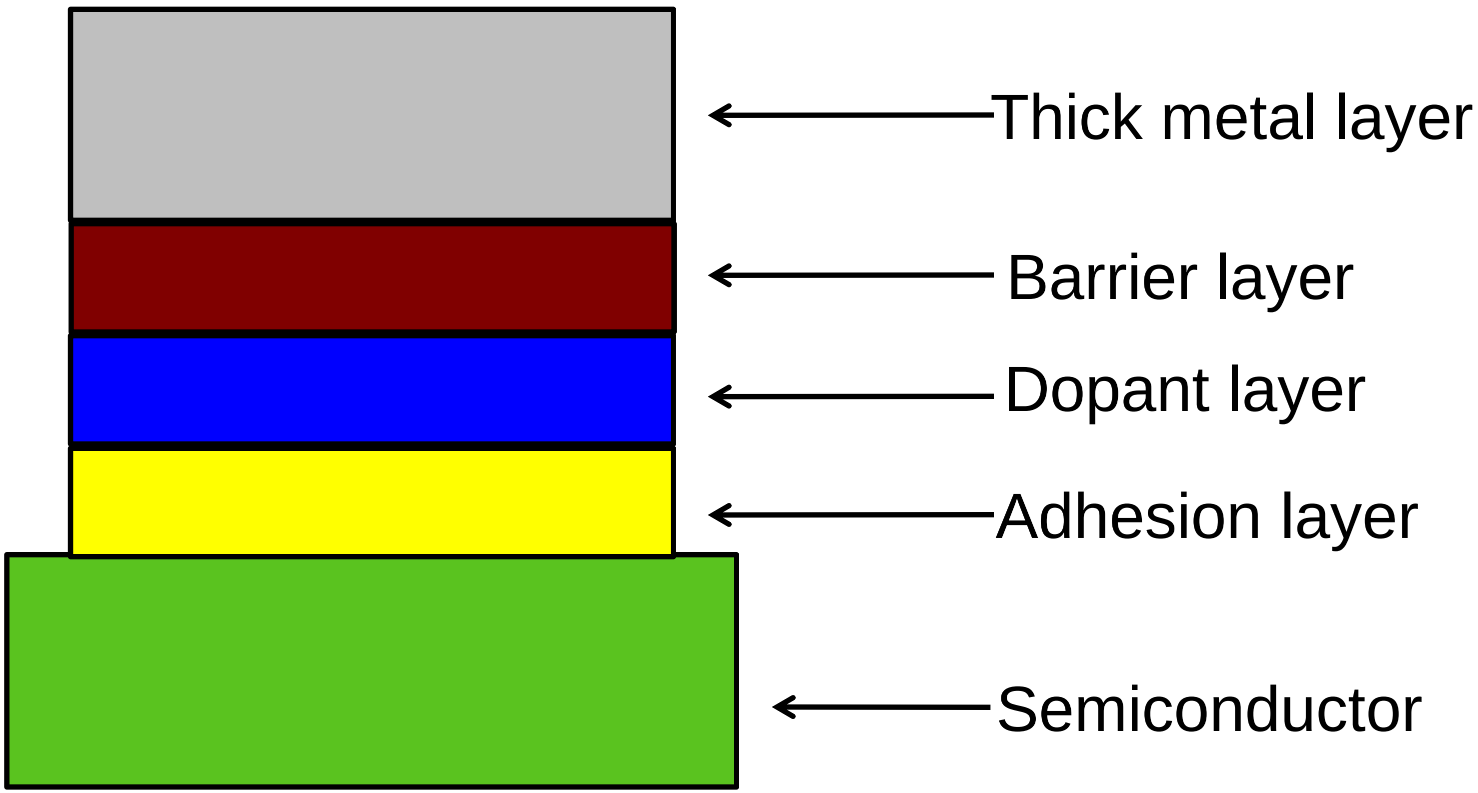
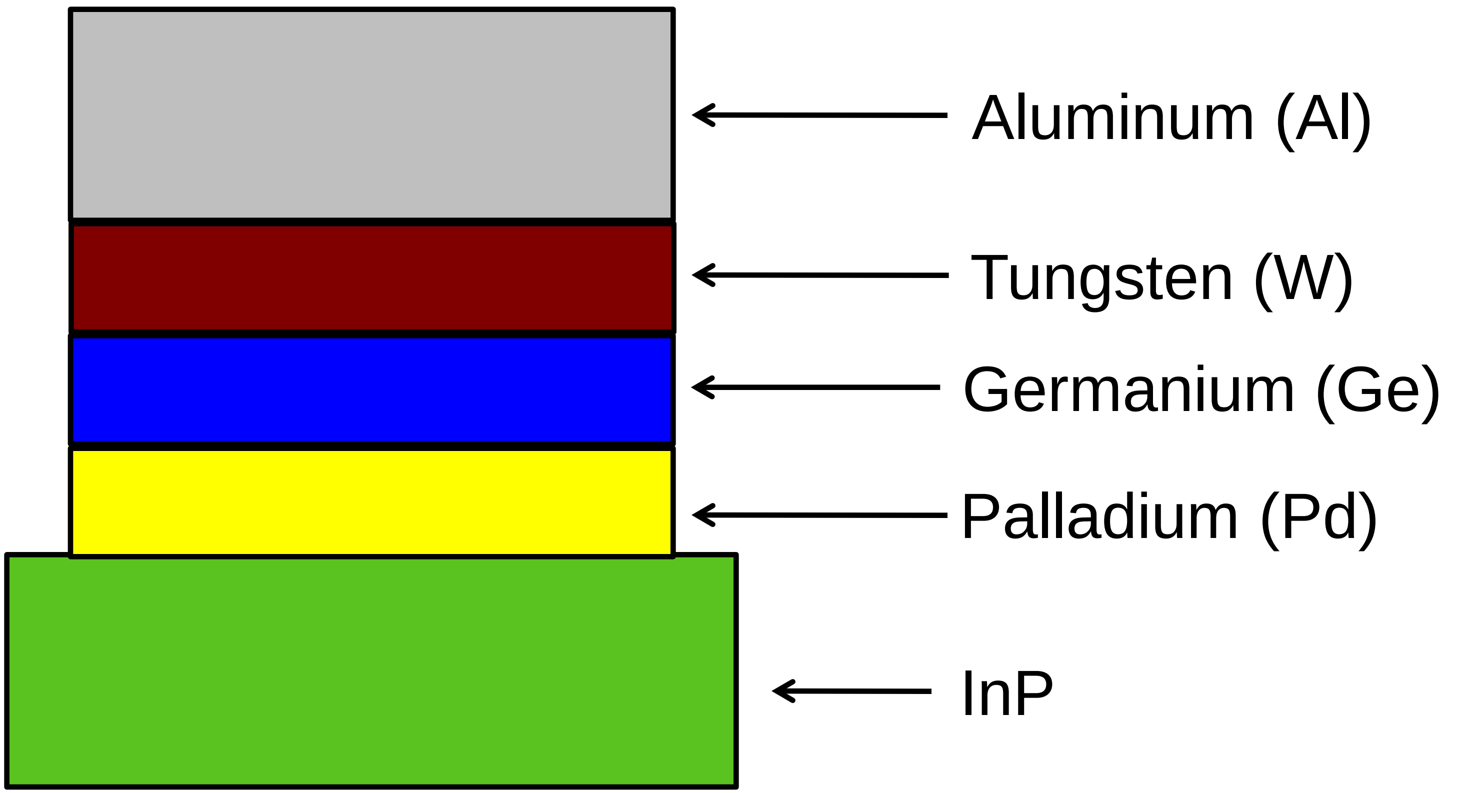
Anatomy of a metal contact



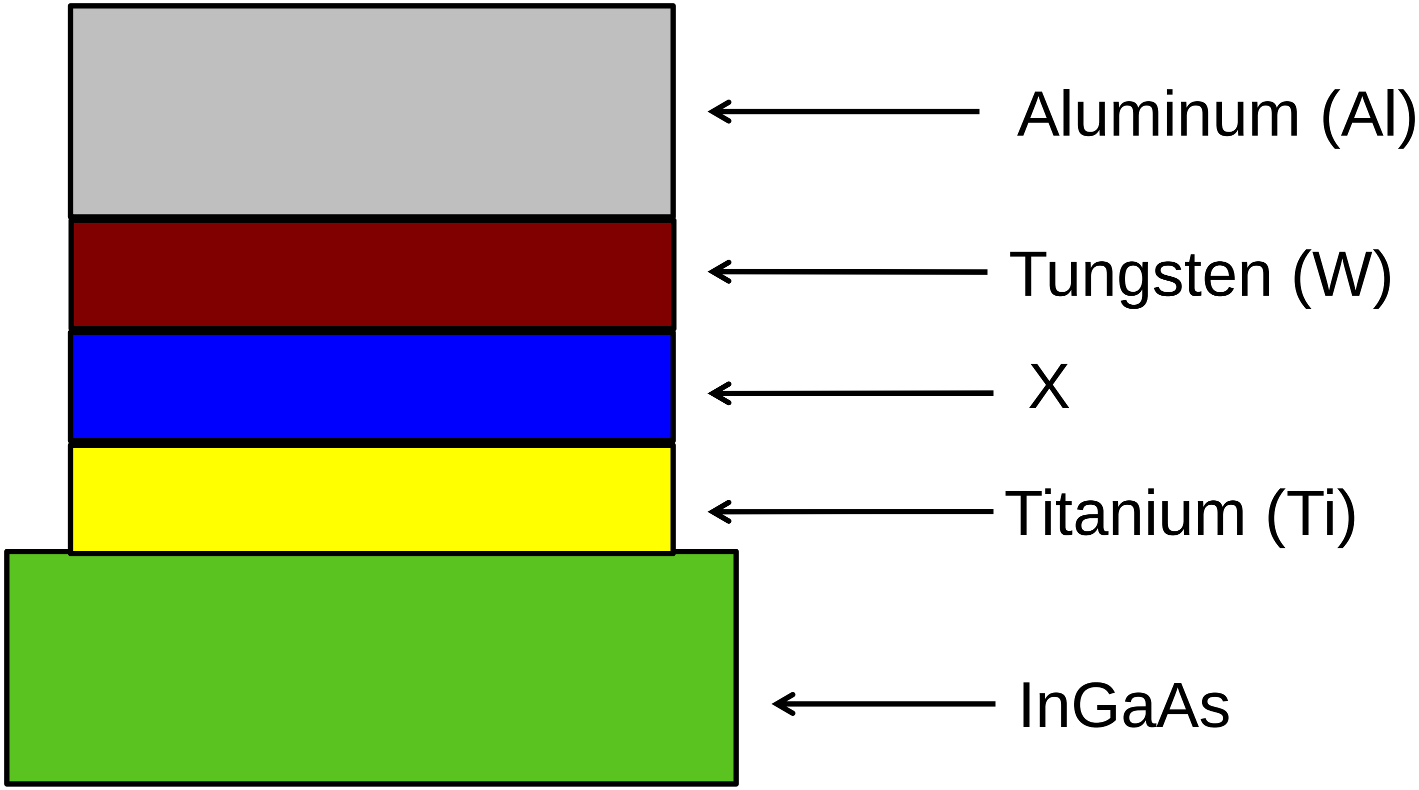
Anatomy of a metal contact

On Indium Phosphide (InP):



Anatomy of a metal contact

On Indium Gallium Arsenide (InGaAs):



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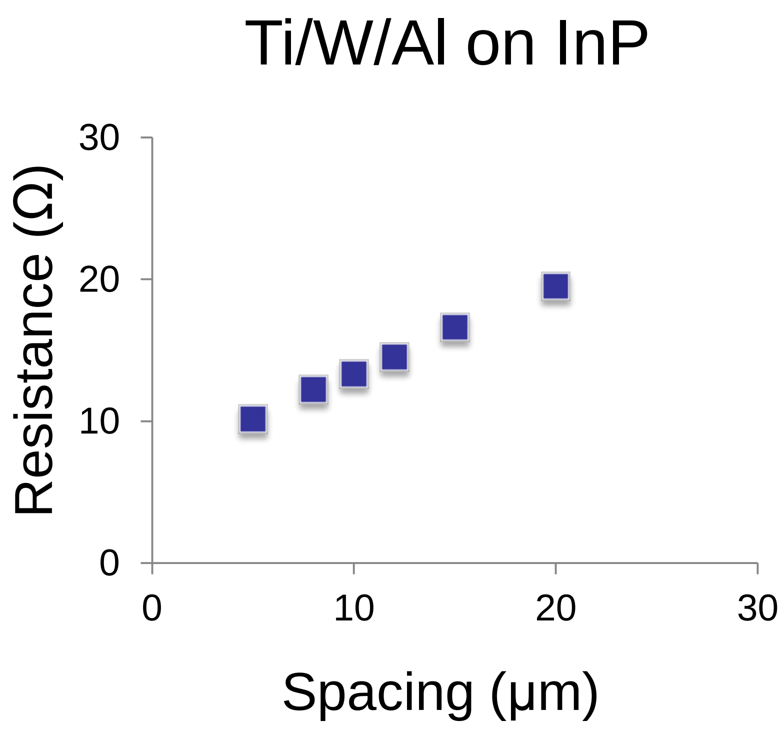
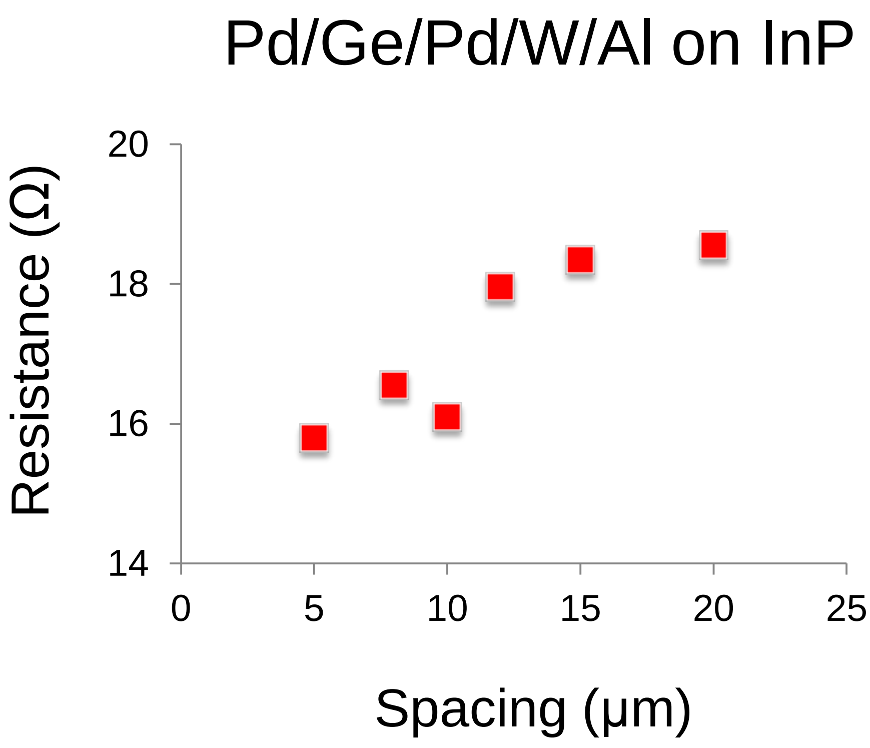
Non-annealed samples



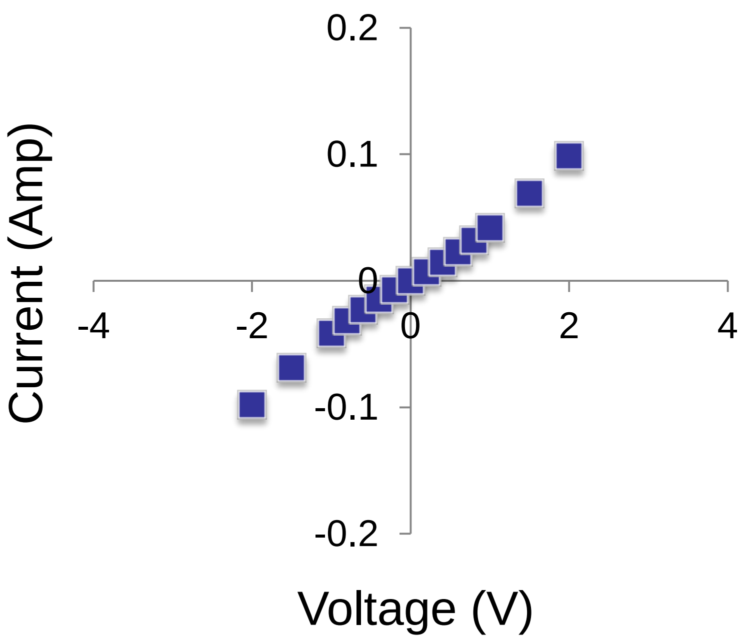


Some samples not even linear
→ non-linear = not *Ohmic*

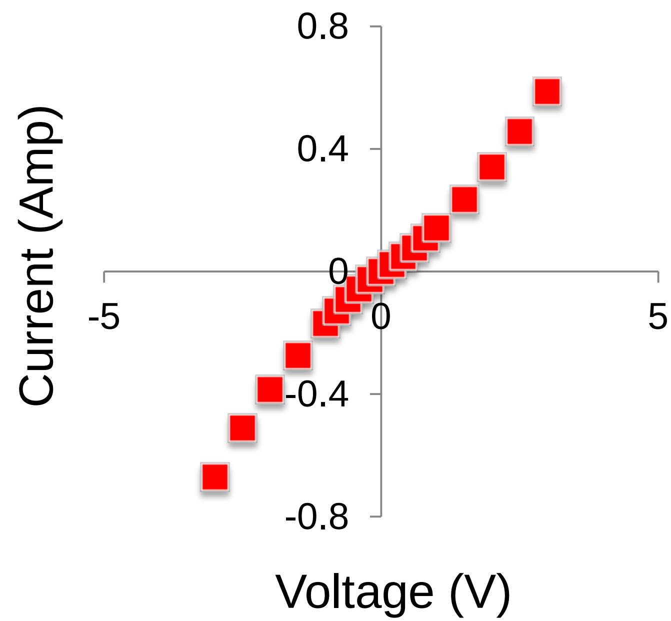
[Ohmic: V = iR]

Non-annealed samples

Ti/W/Al



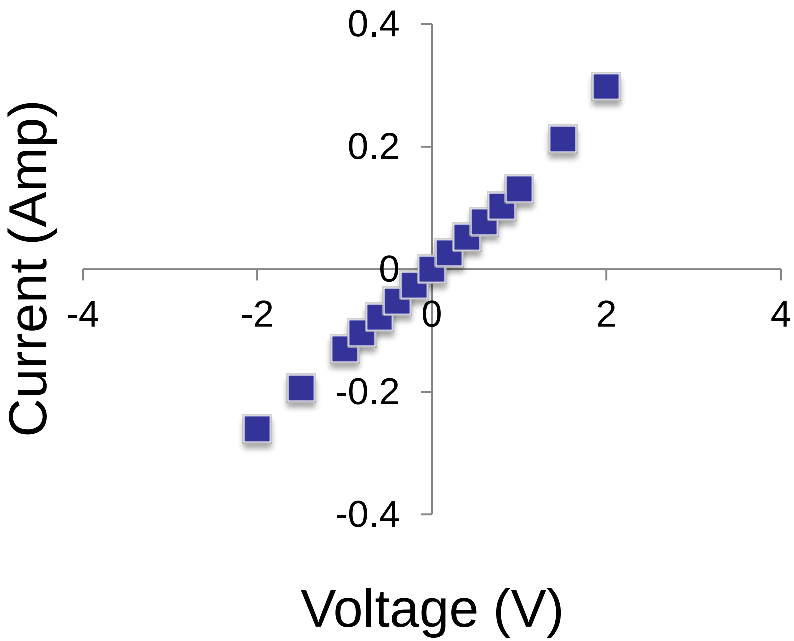
Pd/Ge/Pd/W/Al



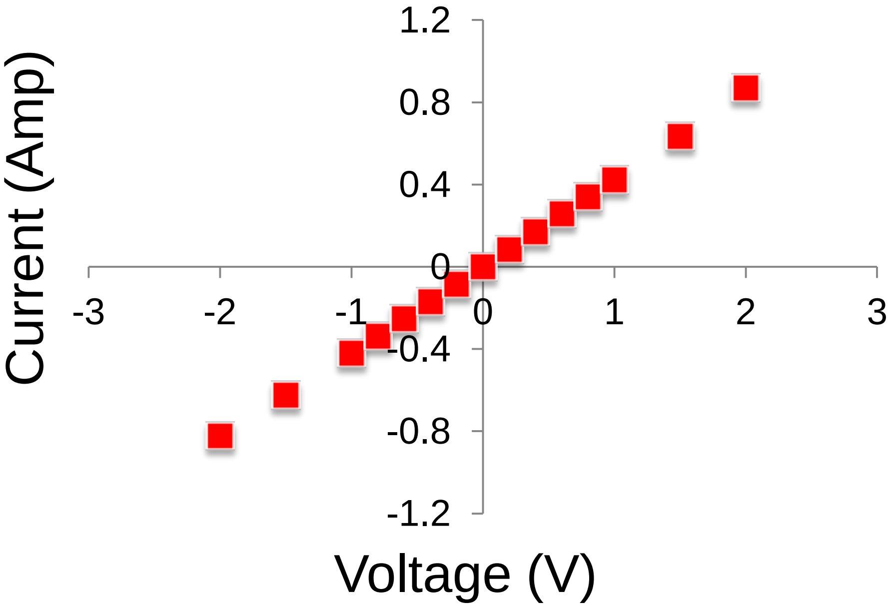
Ohmic: Linear relationship between voltage and current
(Contacts must be Ohmic)

Annealed at 350°C, 30 sec

Ti/W/Al

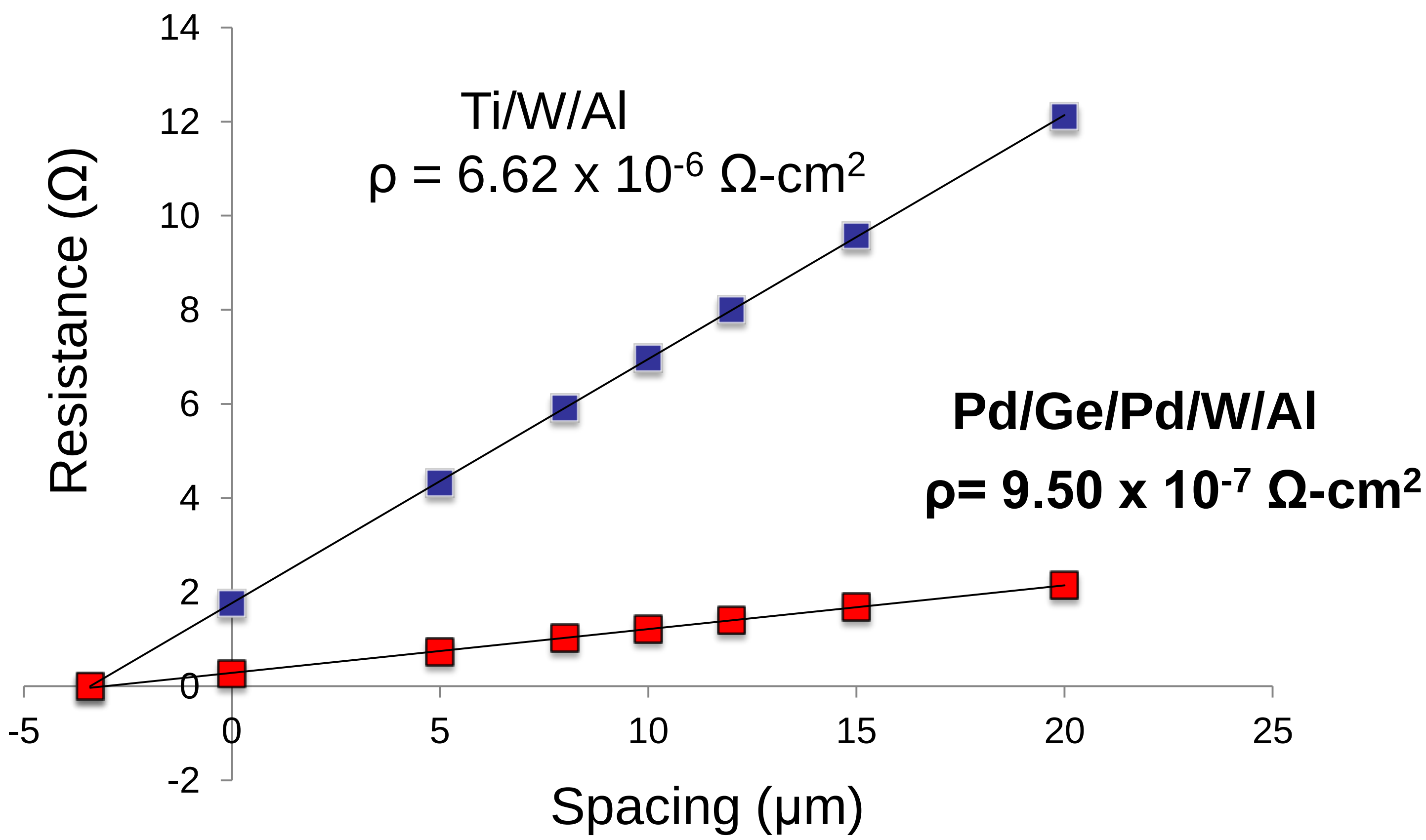


Pd/Ge/Pd/W/Al



After annealing, both samples are Ohmic

Which contact has lowest resistance?



Looking ahead…

- Two possible semiconductors: InP and InGaAs
- Find contact that will work equally well on both
  - Simplifies manufacturing

InP → lots of Germanium

InGaAs→ less Germanium