



Leibniz-Institut
für Festkörper- und
Werkstoffforschung
Dresden

Thin Film

Superconductors

Frederick Thomas
Sept. 26, 2012

Supervisor: Ruben Hühne

What is a Superconductor?

A Superconductor is a type of material that has **exactly zero** electrical resistance.

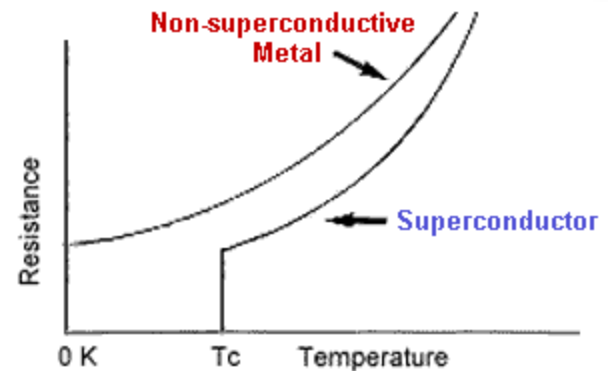
-Discovered on April 8, 1911 by Heike Onnes

There are two types of superconductors:

- Type 1
- Type 2

Also categorized by temperature

- High Temperature Superconductors (HTS)
- Low Temperature Superconductors

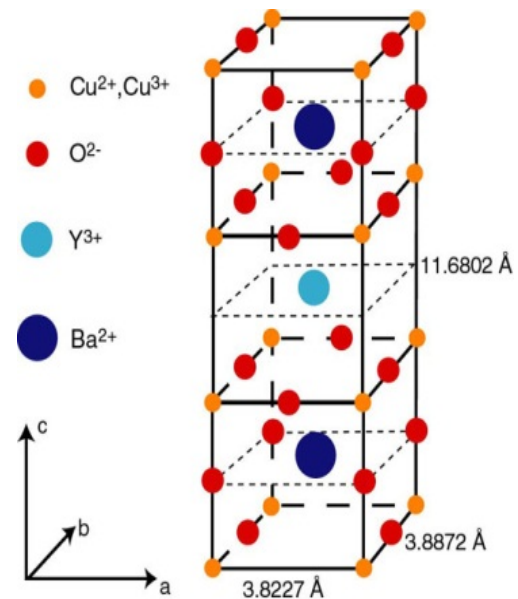


Yttrium Barium Copper Oxide ($\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$)

Discovered by Georg Bednorz and Karl Müller
in 1986 at IBM-Zurich

- Famous for being the first HTS
- Type 2 Superconductor

The upper critical field is 120 T for B perpendicular and 250 T for B parallel to the a-b planes.



Pulsed Laser Deposition

Pulsed laser deposition is a technique for creating thin films.

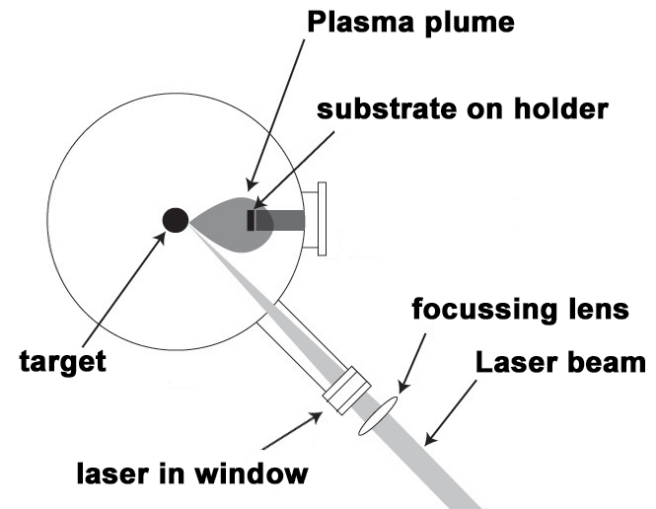
Configuration for a Standard Film:

-Substrate: Strontium Titanate (STO)

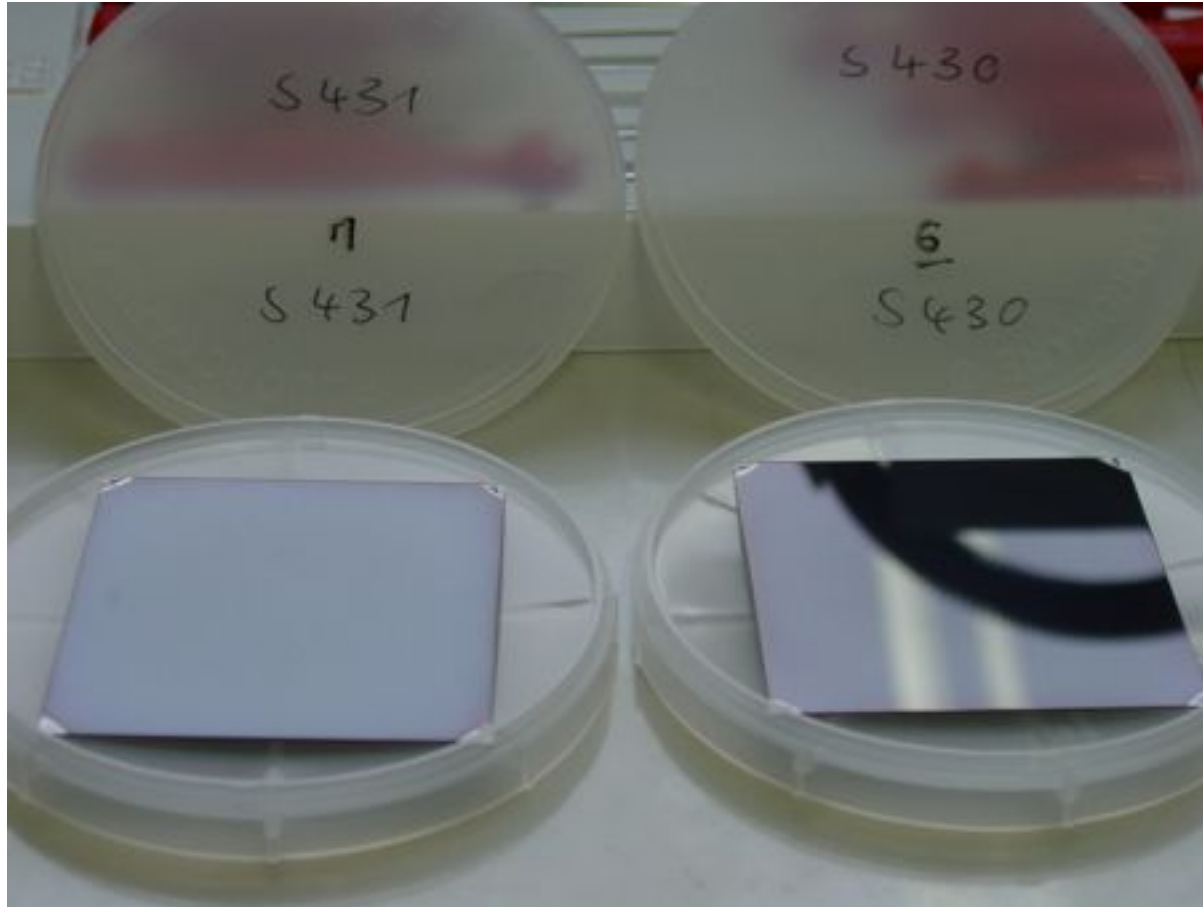
-Temperature: 825°C

-O₂ pressure: 0.4mbar for YBCO
0.225mbar for YBCO + BZO

-Laser: 2000 Pulses @ 5Hz with 123mJ



Result of a Deposition



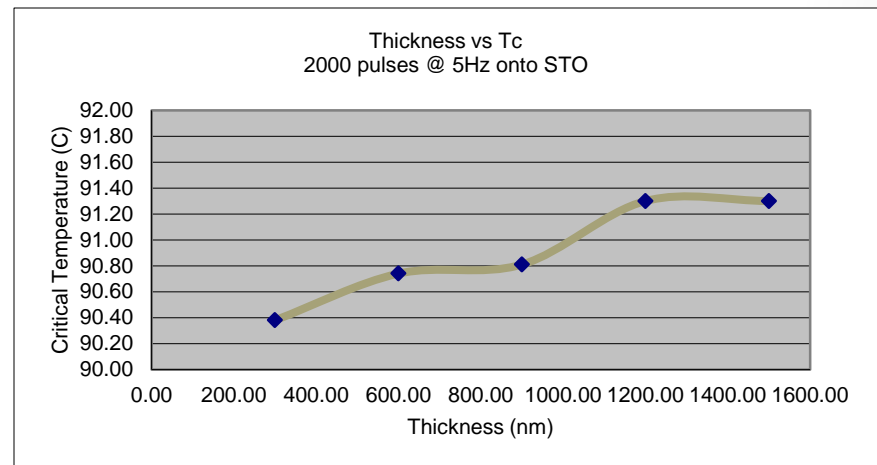
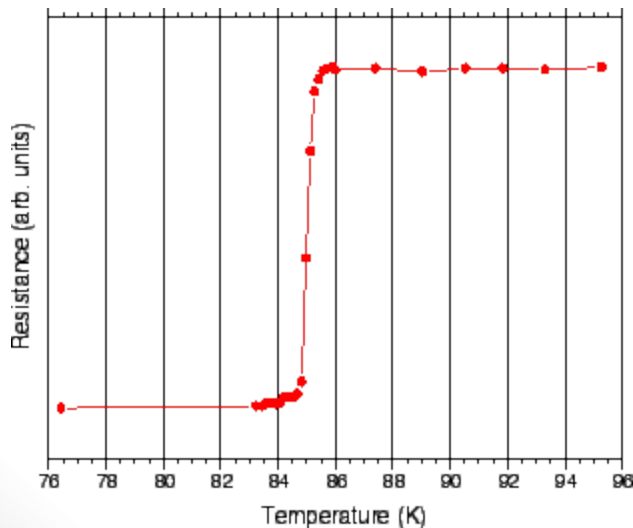
Determining the properties of a superconductor

Four main types of measurements:

- Critical Temperature measurement
- Critical Current measurement, with or without field
- Scanning Electron Microscope (SEM)
- X-ray Diffraction (XRD)

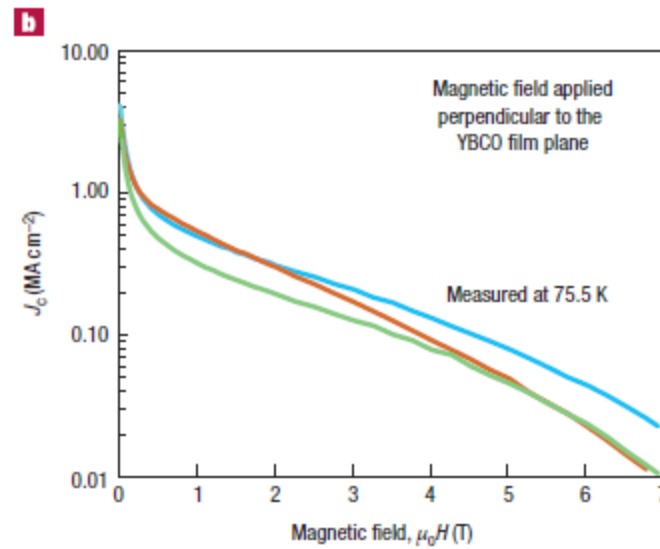
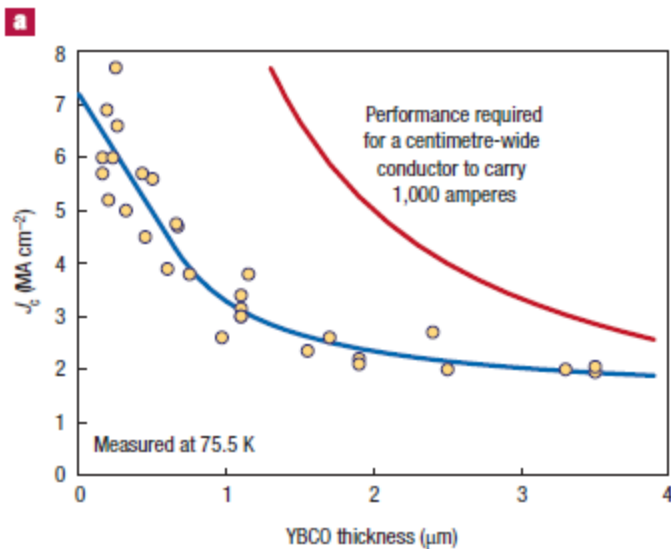
Critical Temperature (T_c)

- The critical temperature is the temperature that a superconductor becomes superconducting
- For HTS, $T_c > 77\text{K}$ (Boiling point of liquid nitrogen)
- Dependent on the laser frequency, number of pulses (thickness), temperature and oxygen pressure during deposition.



Critical Current Density (J_c)

- The maximum current that a wire can carry with zero resistance is known as its **critical current**.
- Measured by a program called Cyroscan
- Usually between 2-5 MA/cm²



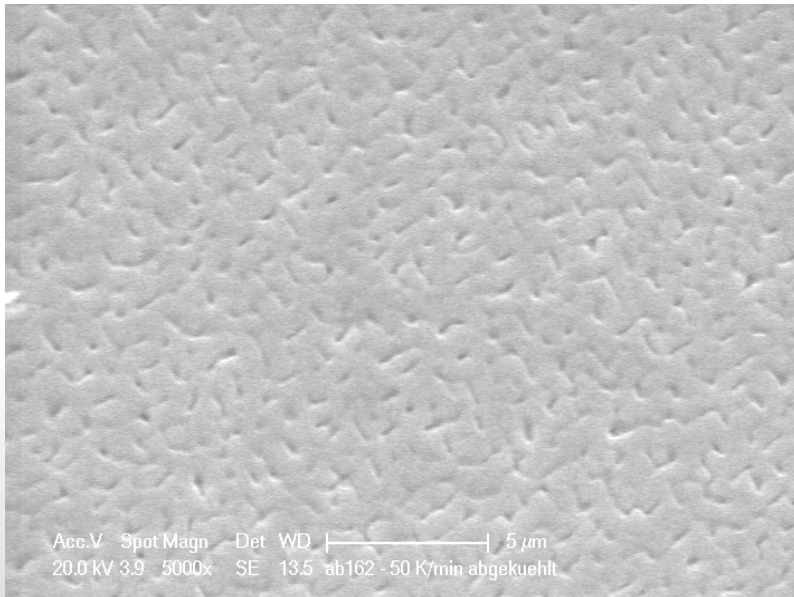
Scanning Electron Microscope (SEM)

Used to get a picture of the surface of the superconductor, in order to see if there are any defects in the sample and what type of defects

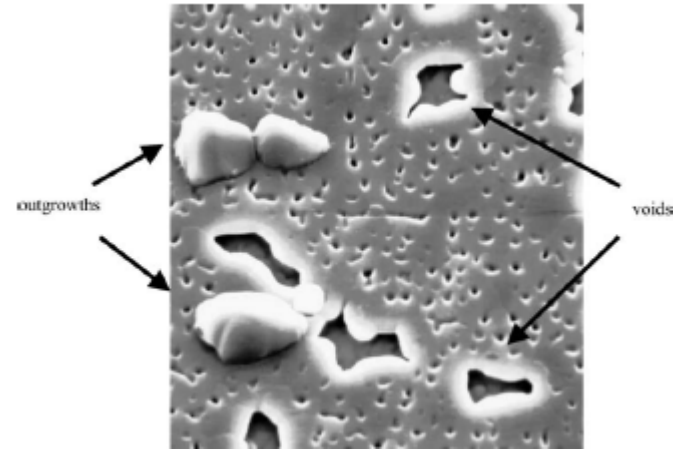
The thicker the YBCO layer, the more defects will show up

Goal: Minimize the defects

Good:



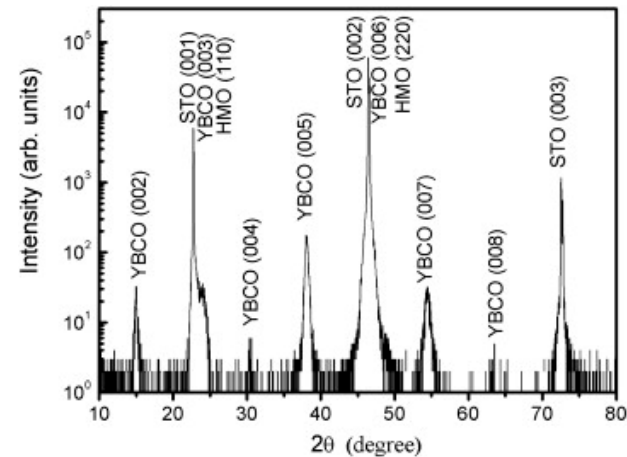
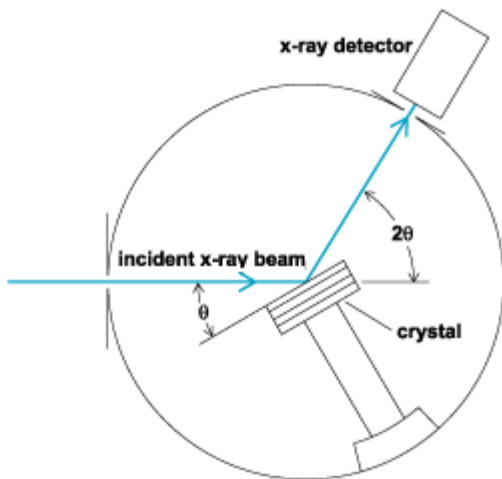
Bad:



X-Ray Diffraction (XRD)

Used to determine the crystal structure and physical properties of the thin film.

Application of Bragg's Law: $n\lambda = 2d\sin(\theta)$



Applications

Supratrans – A company using superconductivity for trains

-Superconducting Motors

-Fault-Current Limiters for power grids

-Superconducting Transmission Lines



References

- <http://www.superconductors.org/>
- <http://www.ifw-dresden.de/>
- http://en.wikipedia.org/wiki/Yttrium_barium_copper_oxide
- http://en.wikipedia.org/wiki/High-temperature_superconductivity
- <http://www.supratrans.de/>