# An Innovative Fabrication Technique for Large-Scale Production of Tungsten Based Transition-Edge Sensors

**A. H. Abdelhameed**[a] · G. Angloher[a] · P. Bauer[a] · A. Bento[a] · E. Bertoldo[a] · L. Canonica[a] · N. Ferreiro Iachellini[a] · D. Fuchs[a] · D. Hauff[a] · M. Mancuso[a] · F. Petricca[a] · F. Pröbst[a] · J. Riesch[b] · J. Rothe[a]

[a]*Max-Planck-Institut für Physik, Föhringer Ring 6, München, D-80805, Germany*

[b]*Max-Planck-Institut für Plasmaphysik, 85748 Garching, Germany*

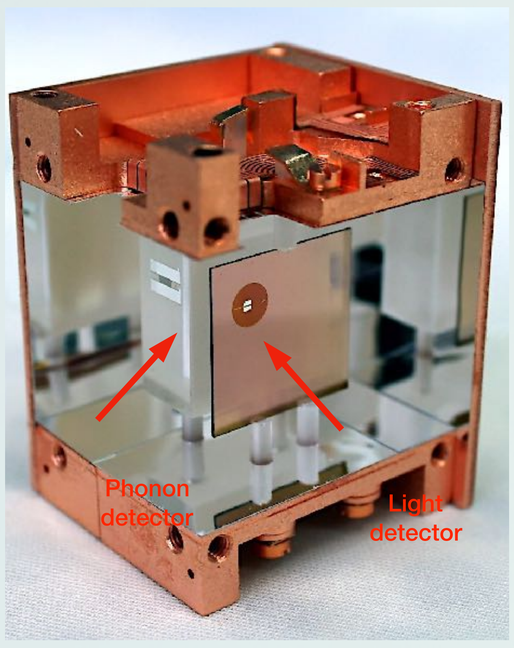
aab@mpp.mpg.de

## Abstract

To cope with the foreseen demand for tungsten based TESs in the current and future phases of the CRESST experiment, we investigated the possibility to implement a reliable, simple and reproducible fabrication method using sputtering. In this contribution we present the method under development for tungsten deposition using conventional magnetron sputtering with xenon as sputtering gas. TESs with transition temperature (Tc) down to 15.0 mK have been obtained with transition width smaller than 1.0 mK. We also give a first assessment on the reproducibility of the process and present the potential for tuning of the Tc.

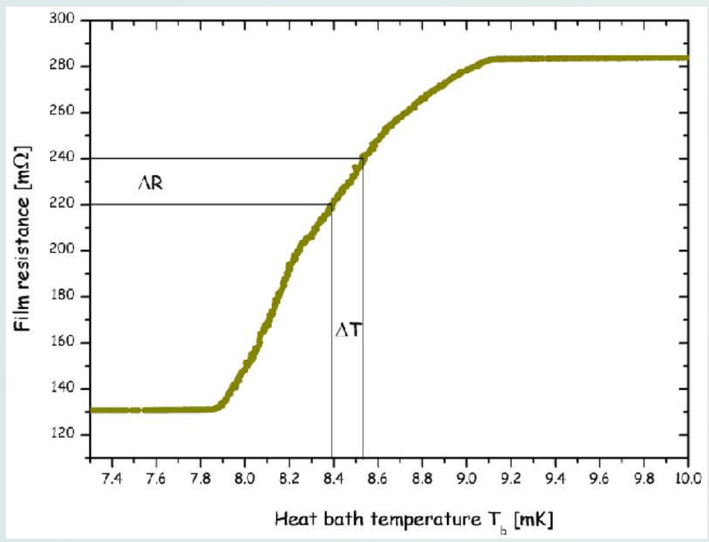
## CRESST experiment:

- CRESST is a direct dark matter detection experiment.
- The setup is located at LNGS.
- It uses cryogenic calorimeters at ~10 mK.
- Uses TES for light and phonon signal detection.



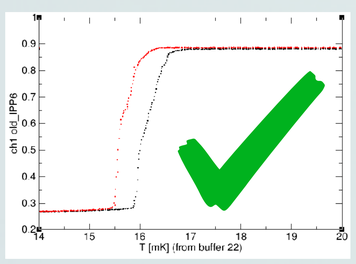

## What is a TES?

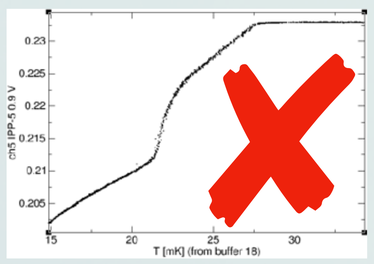
- TES is a thermal sensor that is operated in the transition from normal to superconducting state.
- A small change in temperature results in a measurable resistance change.
- Tungsten films for TES (~200 nm) are being produced in-house using e-beam evaporation.




## A good TES should have:

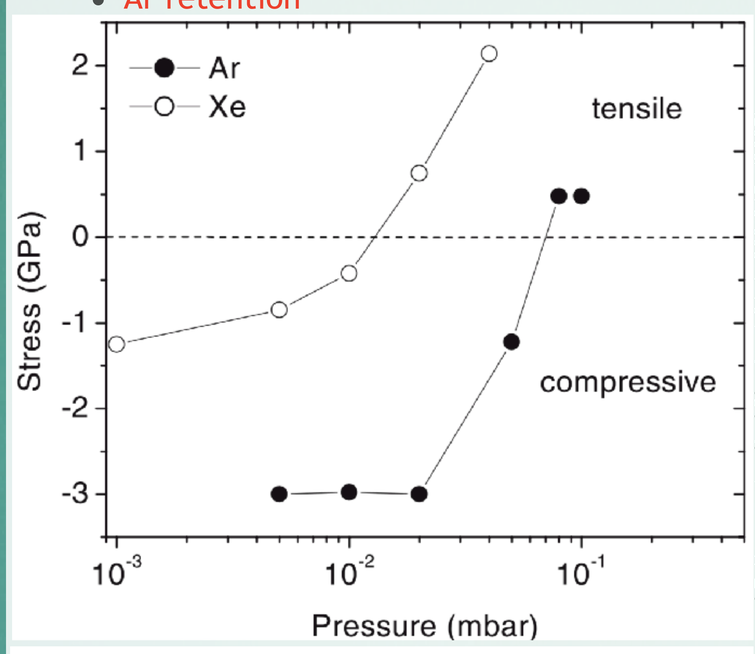
- Featureless transition
- Tc ~ 15 mK
- ΔTc ~ 1mK

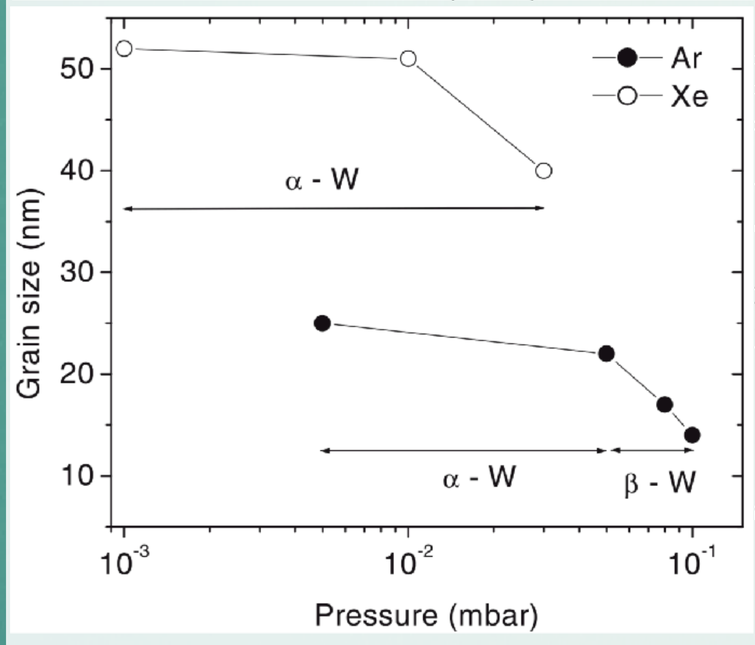



## Why sputtering with Xe not Ar?

- We propose using xenon as sputtering gas for producing W-TES
- TESs sputtered with Ar were not suitable.
- Some film properties can shift the transition temperature.
  - Phase (α-W Tc ~15 mK, β-W <4 K)
  - Impurities (e.g. ferromagnetic)
  - Stress
  - Ar retention




Figures were reprinted from: Bouziane, K., M. Mamor, and F. Meyer., *Applied Physics A* 81.1, 209-215, (2005).

(top) variation of stress with pressure of both argon (filled circles) and xenon (open circles) for W films sputter deposited at a power of 100 Watts. (bottom) average grain size versus working gas pressure for about 500 nm thick films sputtered in argon and xenon.

## Why is sputtering the way to go?

- For the next CRESST upgrade, a few hundreds of TESs are foreseen.
- Making them with evaporation is difficult.

| | Evaporation | Sputtering |
|---|---|---|
| Time per run | ~ a week | A few mins |
| Heating | ~ 600 °C | No heating |
| Throughput | 1 - 4 / week | > 100 / day |

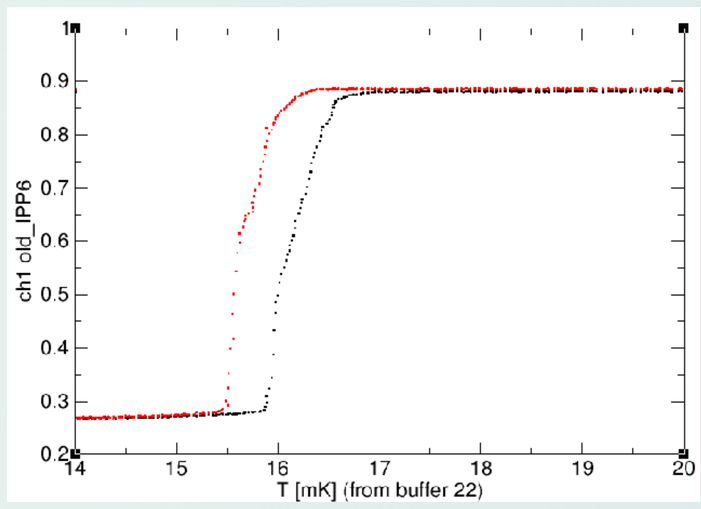
## Fabrication process:

- Substrates are Si with ~30 nm $SiO_2$.
- 200 nm W layer was deposited in a commercial device at IPP

| | | |
|---|---|---|
| Pressure | 0.6 | Pa |
| Gas flow | 9 | sccm |
| Power | 300 | W DC |
| Current | 0.52 | A |
| Rate | 40 | nm/min |

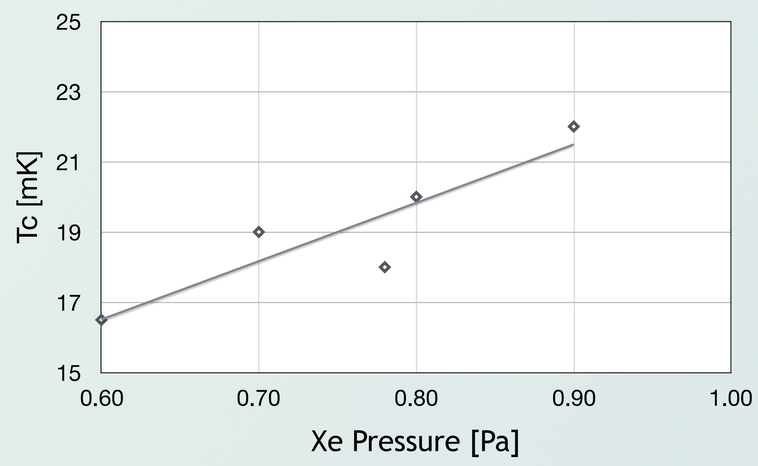
## Comparison of two TES on the same substrate:

- The transition shape is very similar
- Measured Tc ~16 mK
- ΔTc ~ 0.4 mK




## Tuning of Tc by pressure:

- A few runs to study the effect of pressure on Tc.
- A correlation of Tc with pressure can be seen.




## Summary & outlook:

- Sputtering W films for TES fabrication with xenon gas showed that TES with *Tc* down to 15 mK with transition width smaller than 1 mK is achievable. Tuning of *Tc* may be possible.
- So far the films were grown on Si substrates however the next step is to study deposited W films on different substrates.
- Another production campaign at IPP is planned to study the reproducibility.