Comparison of different Mo/Au TES designs for radiation detectors

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Abstract

We report progress on the development of TES X-ray detectors based on Mo/Au bilayers in Spain, within the framework of the initiative to develop a European backup for the detector of the X-IFU Instrument of Athena. Mo/Au TES are fabricated on Si$_3$N$_4$ membranes in Ultra High Vacuum conditions through a two-step process, using sputtering and electron-beam deposition, followed by dry etching photolithography. Superconducting Nb wiring is used. Central blocks or mushrooms of electrodeposited Bi are used as absorbers. Advanced dark characterization is performed through I-V curves, complex impedance and noise measurements. TES with two different designs have been characterized for several bath temperatures and bias points. This has allowed extraction of the basic parameters of our devices, examination of their standard behaviour, and evaluation of their prospects.

Parameters and performances of Mo/Au TES

- TES fabricated on low stress Si$_3$N$_4$ membranes (0.5µm and 1µm thick)
- Mo/Au bilayers (55/340 nm) deposited at room temperature. Tc = 100mK
- RF UHV sputtering of Mo + in situ DC sputtering of 15nm Au + ex situ Au deposition by ebeam
- Nb wiring
- Sensor fabricated by dry etching:
  - Electrodeposited Bi 4-6µm thick Central block or mushroom Ti/Au (5/100 nm) seed layer

Experimental data from Mo/Au TES

- Robust, coherent behaviour of the devices
  - R$_s$ = 10-30 MΩ
  - G scales with radiative area. 115 pW/K (X-IFU LPA2) achieved for 0.5 µm membranes and TES sizes close to 100 µm
  - Heat capacity C in agreement with calculated values, scales with TES volume
  - τ, small because of the low C (either no absorber or Bi absorber)
  - φ and β comparable to reported values for other TES
  - Rather low excess noise parameter, M$_{\text{excess}}$ = 1.2
  - No performances differences between TES with and without banks
  - Promising baseline resolutions Δ$\text{ref}$/1.2 eV

- Johnson excess noise M$_{\text{excess}}$ is estimated in the standard way by adding a term (1+MP) to the model.
- Excess noise remains at low frequencies which is characterized with a phonon-like M$_{\text{excess}}$ = 0.5-1 factor in a similar fashion.
- This M$_{\text{excess}}$ is likely related to ITTF, which is not taken into account in the 1 block (1B) thermal model considered here.