Status of the 3" x3 Demonstrator

27/03/2025 – BULLKID-DM Meeting – Online

Daniele Delicato for the BULLKID collaboration



Project goal





Setup of a first 3 wafer demonstrator

3 inch demonstrator:

- 3x 3inch wafers
- Identical lithography (60nm Al) with 60 KIDs per unit
- Total instrumented mass of 61.2g
- Three independent readout lines
- Passive shielding (PB + ??)



Current prototype of the 3 wafer demonstrator



Stack-01: 60nm Al

40 working pixels out of 60 Quality factor (median): 185k Coupling Q factor (median): 190k



Stack-02: 90nm Al

44 working pixels out of 60

Quality factor (median): 80k

Coupling Q factor (median): 140k

Status of the BULLKID 3" demonstrator*

*as our last update, 16/01/25

- **Thermalization** of the wafers via the copper structure
- **Electrical coupling** not compromised by proximity among wafers
- Energy threshold on par with earlier prototypes
- Scale readout and analysis to simultaneously measure multiple wafers
- Background in a shielded environment flat and lower than 10⁵ dru

From the CDR:

For the time

being we plan to repeat the measurement with a mild lead shield at Sapienza U. before the end of the year (the maximum amount of lead is limited to a few kg by the load that the current cryostat can sustain). This shield is expected to reduce the background by a factor close to 50, below 10^5 DRU.

Flat background $< 10^5$ dru demonstrated

- Above ground
- Passive internal and external Pb shields

To probe background < 650 eV

- Lower threshold
- More active pixels
- Overall better samples are needed

Conclusions last meeting: produce more uniform arrays



Fabrication status of additional stack elements: STACK-04



Stack-04: 60nm Al

57 working pixels out of 60 **Quality factor (median): 88k** Coupling Q factor (median): 100k



Preliminary test in GRENOBLE

Concerto2-83 @ 130mK; Qi > 1M

Single wafer configuration

Fabrication status of additional stack elements: STACK-04



Stack-04: 60nm Al

57 working pixels out of 60

Quality factor (median): 120k

Coupling Q factor (median): 130k

Bonding across the line removed artifacts



Preliminary test in ROME + bondings P165 @ 30mK; Qi > 5M Single wafer configuration

Increased Decay Time



More pixels, more possible clusters



Fabrication status of additional stack elements: STACK-05

The first AITiAI BULLKID !



Increase in α (x4!) Smaller gain from Δ_0 #4 lithography successful (on spare forkless wafer)



Status of the BULLKID 3" demonstrator: next steps

STACK-04:

- Calibration (LED and Americium)
- Shielded background run (< 10^5 dru)

STACK-05:

• Test AlTiAl performance and noise

Other:

- Multi wafer coincidences
- Production of more wafers !



Status of the BULLKID 3" demonstrator: next steps

STACK-04:

- Calibration (LED and Americium
- Shielded background run (~ 105 dru)

STACK-

Thanks for your attention!

Other:

Test Al

- Multi wafer coincidences
- Production of more wafers ?

Optimization of the KID responsivity



Optimization of the KID responsivity: α – AlTiAl trilayer

Al 14 nm / Ti 33 nm / Al 30 nm $T_c = (835 \pm 5) \text{ mK}; \Delta_0 = 1.266 \cdot 10^{-4} eV$

$$\Delta(T_{\text{low}}) \approx \Delta_0 \cdot e^{-\sqrt{2\pi k_B T / \Delta_0} \cdot e^{-\Delta_0 / k_B T}}$$



$$\frac{\delta f}{f_0} = -\frac{\alpha}{2} S_2(\omega, T) \frac{\delta n_{qp}}{2N_0 \Delta}$$

Fit for α with Δ_0 fixed: • $\alpha = 24\%$ (Cardani2018 reports $\alpha = 17\%$ and $T_c = 805$ mK) Optimization of the KID responsivity: α – AlTiAl trilayer



Fabrication status of two additional stack elements: STACK-03



Stack-03: 60nm

55 working pixels out of 60 Quality factor (median): 90k Coupling Q factor (median): 110k

Preliminary test in Grenoble Concerto2-60 @ 130mK Single wafer configuration

Limited discrimination power, KID-11



Background of stable cluster, KID-11



Background shielded vs unshielded STACK-01

