A BOLOMETRIC RECEIVER FOR THE LLAMA-QUBIC PROJECT

HIRSAP Annual Meeting - November 2023

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Detection and Readout system for QUBIC Next Gen





My thesis work is focused in the design and fabrication of the **MMB Detector Array**.

PROPOSED MULTIBAND BOLOMETRIC DETECTOR SYSTEM

Antenna-coupled bolometer





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THE MAGNETIC MICROBOLOMETER (MMB)

Simulation results of the paramagnetic sensor





Wet etching of Silicon using KOH solution

KOH and TMAH attack Silicon anisotropically following crystallographic planes and has large selectivity with dielectric materials





Sample holder and testing of KOH release



The sample is immersed in a KOH solution with 35% concentration in a water bath heated at $80^\circ\rm C$, for a couple of hours.





Dry etching of Silicon using Xenon Difluoride (XeF₂)

XeF₂ gas reacts with solid Silicon by the following expression:

 $2XeF_2 + Si \rightarrow SiF_4 + 2Xe + E_t$



The Linde Group, XeF₂ datasheet

Etching is isotropic and can be used to etch underneath our detectors.



Controlled pulse-etching with xenon difluoride, Chu et. al DOI:10.1109/SENSOR.1997.613739

Design and fabrication of our own XeF₂ processing machine

CAD design of the complete system



Special thanks to Eng. Pablo Strazzeri and Carlos Varela for mechanical drawings and fruitful discussions.



Special thanks to German, Andres Pantarotto and Carlos Piñero for machining the parts.



Design and fabrication of our own XeF₂ processing machine



Special thanks to Eng. Lucía Sucunza for software and firmware development.





















5.3) XeF_2 pulses 6) Photorresist removal O₂ Plasma Ashing







XeF₂ Front-Side release - First successful results!!



SUMMARY AND FUTURE WORK

Summary:

- Design of the multiband pixel is defined.
- Wet etching release techniques were investigated and tried out.
- A dry etching technique for the release of the bolometer islands has been developed and showing promising results.
- H structures were succesfully released by the front-etch release technique, with leftover v-shaped silicon underneath

Future Tasks:

- Optimization of the XeF₂ dry etching process using front-side and back-side etching.
- Stress characterization of dielectric films in conjunction with the fabricated devices.
- First suspended MMB prototypes will be fabricated. Device fabrication is planned to be done in Germany at IMS and membrane release in Argentina at CNEA DMNT
- Working pixels should be produced for testing with the QUBIC Technical Demonstrator Instrument by November 2024.

Courses and Lectures:

- Introduction to the Finite Element Method (UNSAM 2020)
- School for Nanoscience and Nanotechnology (CNEA 2021)
- Python programming (UNSAM 2021)
- Thin Films, Technology, Physics and Applications (KIT WiSe21/22)
- Single-photon Detectors (KIT WiSe21/22)
- Cosmology (ITeDA 2022)
- School for Nanoscience and Nanotechnology (CNEA 2023)

KSETA Courses:

- Statistical Methods in Data Analysis (March, 2021)
- Observational Cosmology (March, 2021)
- Introduction to Quantum Physics (October, 2021)
- Introduction to Quantum Cryogenic Detectors (October, 2021)
- Monte-Carlo Simulations (Feb, 2022)
- Introduction to general relativity for experimentalists (Feb, 2022)
- FPGA programming / signal processing (Feb, 2022)

PUBLICATIONS

Suitability of magnetic microbolometers based on paramagnetic temperature sensors for CMB polarization measurements - accepted for publication on January 2023, published February 2023 available at SPIE - JATIS (or arXiv...).



https://www.connectedpapers.com/.

This article is the first to offer a link between the CMB and the MMC communities.

microbolometer (MMB) that is based on a paramagnetic temperature sensor. It is an adaption of state-of-the art metallic magnetic calorimeters (MMCs) that are meanwhile a key technology for high resolution α , β , γ , and x-ray spectroscova swell as the study of neutrino mass. The effort to adard MMCs for CMB surveys is

PUBLICATIONS

Antenna Coupled Magnetic Microbolometers for CMB Polarization Surveys - Poster presentation at 20th International Conference on Low Temperature Detectors (LTD20), Daejeon, South Corea, July 2023.







Our work was positively recognized by the LTD community and received two best poster awards within our group.

Proceedings are currently under review for the LTD Special issue, Journal of Low Temperature Physics.



Thank you very much! Questions??

Sinuous Antenna - A Log-Periodic Planar Antenna

Frequency Range: $80GHz \rightarrow 300GHz$!!!





Key points:

- Impedance Matching to the transmision line in the entire bandwidth.
- Radiation Lobe matching to the telescope optics.
- Size: $\approx 3mm$ in diameter.

Spiral Antenna - Yet another Log-Periodic Planar Antenna

Frequency Range: $80GHz \rightarrow 300GHz$!!!





Key points:

- Impedance Matching to the transmision line in the entire bandwidth.
- Radiation Lobe matching to the telescope optics.
- Size: $\approx 3mm$ in diameter.

And it is polarization sensitive!

• Each pair of opposing arms act as independent polarized antennas.



BAND-DEFINING FILTER DESIGN







Key points:

- Lumped element design was chosen.
- 3rd order Chevyshev passband filters were designed
- Electromagnetic Simulations were performed to optimize dimensions and geometries.



Persistent Current Injection Scheme







ANTENNA IMPEDANCE AND RADIATION PLOTS WITH HIGH-K LENSLETS.



Impedance Matching

Impedance matching is performed by a microstrip line which is gradually weidend to follow a Dolph-Chevyshev impedance profile while travelling thorugh the antenna's arms.

