16th International Workshop on Low Temperature Detectors
20 | 24 July 2015

Development of MMC-based photon and phonon detectors for rare event searches

Main author:

GASTALDO Loredana

Co-authors:

Enss Christian, Kirchhoff Institute for Physics, Heidelberg University, Germany

Enss Christian, Kirchhoff Institute for Physics, Heidelberg University, Heidelberg, Germany

Fleischmann Andreas, Kirchhoff Institute for Physics, Heidelberg University, Germany

Fleischmann Fleischmann, Kirchhoff Institute for Physics, Heidelberg University, Heidelberg, Germany

GASTALDO Loredana, Kirchhoff Institute for Physics, Heidelberg University

Gastaldo Loredana, Kirchhoff Institute for Physics, Heidelberg University, Heidelberg, Germany

Gray David, Commissariat a l'Energie Atomique, Saclay, France

Gray David, Commissariat à l'Energie Atomique, Saclay, France

Hassel Clemens, Kirchhoff Institute for Physics, Heidelberg University, Germany

Hassel Clemens, Kirchhoff Institute for Physics, Heidelberg University, Heidelberg, Germany

Hendricks Sebastian, Kirchhoff Institute for Physics, Heidelberg University, Germany

Hendricks Sebastian, Kirchhoff Institute for Physics, Heidelberg University, Heidelberg, Germany

Hengstler Daniel, Kirchhoff Institute for Physics, Heidelberg University, Germany

Kempf Sebastian, Kirchhoff Institute for Physics, Heidelberg University, Germany

Kempf Sebastian, Kirchhoff Institute for Physics, Heidelberg University, Heidelberg, Germany

Kim Yong-Hamb, CUP Center for Underground Physics, Daejeon, KOREA

Kim Yong-Hamb , Korean Research Institute of Standards and Science, Daejeon, Rep. of Korea

Loidl Martin, Commissariat a l'Energie Atomique, Saclay, France

Loidl Martin, Commissariat à l'Energie Atomique, Saclay, France

Möhl Gilles, Kirchhoff Institute for Physics, Heidelberg University, Germany

Navick Xavier-Francois, Commissariat a l'Energie Atomique, Saclay, France

Navick Xavier-Francois , Commissariat à l'Energie Atomique, Saclay, France

Rodrigues Matias, Commissariat a l'Energie Atomique, Saclay, France

Rodrigues Matias, Commissariat à l'Energie Atomique, Saclay, France

Wegner Mathias, Kirchhoff Institute for Physics, Heidelberg University, Germany

Wegner Mathias, Kirchhoff Institute for Physics, Heidelberg University, Heidelberg, Germany

Yoon Won-Sik, CUP Center for Underground Physics, Daejeon, KOREA

Yoon Won-Sik , Korean Research Institute of Standards and Science, Daejeon, Rep. of Korea

The use of scintillating crystals in cryogenic experiments searching for neutrinoless double beta decay and for direct interaction of dark matter particles allows for an efficient background reduction thanks to particle discrimination. We develop phonon and photon detectors based on metallic magnetic calorimeters (MMCs) to perform the simultaneous measurement of heat and light generated upon the interaction of a particle in a scintillating crystal.

Our P1 photon detectors are presently structured onto 2" germanium and silicon wafers with a thickness of 350 µm. The photon absorber is a circular island with 1" diameter in the center that is defined by three concentric slits through the wafer such that only three small bridges of about 1 mm are left over to connect the island to the rest of the wafer. The bridges are dimensioned for obtaining pulse decay times of the order of a few milliseconds. The MMC design is based on the sandwich geometry and for the first time uses the segmentation of the sensor along a 2-turn spiral stripline. The number of sensor segments is 58, each equipped with an Au phonon collector and arranged so that they homogeneously cover the 1" surface. This sensor geometry allows for a fast risetime of the thermal signal. First measurements have already shown risetimes as short as 10 µs. This detector design should also allow for a very good energy resolution of below 10 eV FWHM.

We are presently developing a combined design, P2, where the photon detector, based on the P1 concept, and the phonon detector are realized on the same wafer. The phonon detector consists of three MMC double meander pixels placed outside of the sensitive volume for the photon detector. Each of the three pixels is equipped with a gold cone which serves as thermal contact and mechanical support for the scintillating crystal which will be positioned on top of them. The idea to use only these three cones for supporting the crystal is to minimize the necessary structural material and thus to minimize possible background originating from that. The ultimative performance of the phonon detectors will mainly depend on the thermodynamical properties of the scintillating crystals. Estimations for the achievable energy resolution and risetime in realistic systems are 200 eV FWHM and 100 µs respectively.

We present the design considerations, fabrication issues and preliminary tests for these detectors. The expected performance makes the P1 and P2 designs suitable to be used in the AMoRE and LUMINEU projects as well as in future dark matter searches.