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Development and production of low background and high energy resolution Micromegas detectors using the thermal bonding method for the PandaX-III experiment

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High pressure xenon time projection chamber (TPC) is an important detector technology to search neutrino-less double beta decays. The neutrino-less double beta decay search experiment of PandaX-III at the China Jinping Underground Laboratory uses a 10 bar 136Xe TPC with a readout plane consisting of 52 200×200 mm Micromegas detectors for high granularity, good energy resolution and a radio-purity background. In this report, we present the R&D work for the PandaX-III Micromegas detectors. The Micromegas detectors were fabricated using the thermal bonding method developed at USTC. The thermal bonding Micromegas detectors were designed and manufactured in an optimized way to form spark-resistant and dead-channel-free readout modules for the PandaX-III TPC while maintaining the radio-purity as good as the Micro-bulk Micromegas detectors. The thermal bonding Micromegas detectors were operated in a gas mixture of argon and isobutane (2.5%-3.5%) with pressure from 1 to 10 bar and characterized in detail with X-rays. Excellent performance including high gas gain of >104, good energy resolution of <20% (FWHM @5.9keV) at 1 bar, and long-term stability for 10 bar operation in a test of >10 days was demonstrated. These results have validated the thermal bonding Micromegas detector as a promising readout solution for the PandaX-III TPC. A fabrication process optimized for mass production of the Micromegas detectors was developed, and more than 52micromegas-detectors had been produced. Electron transparency, gas gain and non- uniformity of these detectors were tested with flowing gas at 1 bar and showed similarly. stability at gains of >2000 at 10 bar was also demonstrated for more than 24 hours. A PandaX- III TPC prototype containing approximately 140 kg of 136Xe was constructed and instrumented with the Micromegas detectors, and is currently being tested.

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