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Development of the micro pixel chamber based on MEMS technology

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- (1) The u-PIC (micro pixel chamber) is our original gaseous two-dimensional imaging detector made by PCB (Printed Circuit Board) technology. The pixel Cu electrodes of u-PIC with a pitch of 400 μm are placed on a polyimide substrate. At present u-PICs are used as the TPC of the Electron Tracking Compton Camera (ETCC) which is being developed for MeV gamma-ray astronomy. In order to improve the accuracy of electron tracking, a position resolution of electron less than 100 μm and the uniformity of the gain less than one percent are requested. However, for the present u-PIC, the accuracy of the pixel structure and its pitch are strongly limited from the limitation of the PCB technology. For that reason, we require new technology that can manufacture a fine pixel structure with an μm accuracy. And we found MEMS (Micro Electro Mechanical System) technology that may be satisfied with it. To study this MEMS u-PIC, a small (5 mm x 10mm) MEMS u-PIC has been developed, and the fundamental feature of it as a MPGD has been measured.
- (2) MEMS u-PIC consists of Cu electrodes and Si substrate, SiO₂ wafer, polyimide wafer with a columnar cavity. For improvement of insulation, there are SiO₂ and polyimide wafer between the cathode electrode and substrate. We made 4 types of prototype MEMS u-PIC in order to study the behaviors of MEMS u-PIC. Parameters for them are thickness of SiO₂ wafer, diameter of polyimide cavity and manufacturing process. We investigated characteristics of them with X-ray source (Fe-55, 5.9 keV) and gas of 1 atm, Ar/C₂H₆ (90%/10%).
- (3) In this work, all of 4 types MEMS u-PIC sent out signal from both anode and cathode. By the experiment, we obtained the gain of 700–1800 with MEMS u-PICs when anode voltage is 500 V. In comparison with PCB u-PIC, the gain of MEMS u-PIC is smaller than that of present u-PIC. However, our simulation gas avalanche using Garfield++ suggests that a gain of MEMS u-PIC is twice higher than the gain of present u-PIC. In addition, MEMS u-PIC with SiO₂ 1 μm has a lower gain and a bigger leak current than MEMS u-PIC with SiO₂ 10 μm .
- (4) Most of MPGDs are made by PCB technology. But the processing accuracy of PCB technology is about 10 μm while that of MEMS technology is about 1 μm . Because processing accuracy make energy resolution higher, we expect MPGDs based on MEMS to open the new way. This work research MPGD based on MEMS and shows the characteristics.
- (5) We think deterioration of MEMS u-PIC gain against simulation data is caused by Si working as semiconductor near anode. Thus we guess that the thicker SiO₂ wafer become, the higher u-PIC gain become. Additionally MEMS u-PIC have more robustness against the discharge and higher gain than that with thin SiO₂ wafer. MEMS enable us to make SiO₂ wafer thicker than current prototype, therefore we make the next MEMS u-PIC with 20 μm or thicker SiO₂ wafer. Considering this work, we develop the next MEMS u-PIC and study characteristics of MEMS u-PIC in more detail.

Primary author: Mr TAKEMURA, Taito (Kyoto Univ.)

Co-authors: Dr TAKADA, Atsushi (Kyoto Univ.); Dr TOMONO, Dai (Kyoto Univ.); Dr KUBO, Hidetoshi (Kyoto Univ.); Mr YOSHIKAWA, Kei (Kyoto Univ.); Dr MIUCHI, Kentaro (Kobe Univ.); Mr OTA, Kohei (Dai Nippon Printing Co., Ltd.); Mr ODA, Makoto (Kyoto Univ.); Mr IWAKI, Satoru (Kyoto Univ.); Dr SONODA, Shinya (Kyoto Univ.); Mr MIYAMOTO, Shohei (Kyoto Univ.); Mr KOMURA, Shotaro (Kyoto Univ.); Mr SAWANO, Tatsuya (Kanazawa Univ.); Mr KISHIMOTO, Tetsuro (Kyoto Univ.); Dr MIZUMOTO, Tetsuya (Kyoto Univ.); Mr

MOTOMURA, Tomohisa (Dai Nippon Printing Co., Ltd.); Prof. TANIMORI, Toru (Department of Physics, Kyoto University); Mr MATSUOKA, Yoshihiro (Kyoto Univ.); Dr MIZUMURA, Yoshitaka (Kyoto Univ.); Mr NAKAMASU, Yuma (Kyoto Univ.)

Presenter: Mr TAKEMURA, Taito (Kyoto Univ.)

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