Study on Performance of Silicon Ignitiors based on Energetic Chip of Porous Silicon

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Abstract: In order to study the igniton properties of the silicon ignitior, firing sensitivity test with output charge B-KNO3 were carried out, and the igniton properties was studied as well. The result indicates that the energetic chip can ignite B-KNO3 which burns sufficiently. The 50% firing voltage was 21.3V, standard deviation was 1.87, the 99.9% point was 27.1V.

Keywords: porous silicon, energetic chip, silicon ignitior, electrochemical etching.

1 Introduction

As the modern weaponry developed toward miniaturization, intelligent, integrated, traditional Pyrotechnics can not meet the requirements[1,2]. Silicon ignitiors are based on the concept of MEMS manufacturing. The porous silicon chips have micronano-scale precision and the microscale planar structure which greatly reduced the volume and the weight of initiator[3,4]. The performance of porous silicon energetic chip can be adjust by different concentration of NaClO4/methanol solution[5,6].

Aiming at the need of integration development of pyrotechnics, the design and manufacture of silicon ignitior were researched, which include the whole design, the manufacture of porous silicon sequence and its performance. The design principle of initiators based on MEMS will support the development of mocro arms initiation, ignition and work.

2 Experiment

2.1 Reagent and apparatus

HF acid,analytical, XI'an chemical Reagent factory; Ethanol, Sichuan xilong Chemical Co.;Bno3,Xi'an213; P-type silicon, crystal-100,Resistivity of 0.02～0.03Ω·cm, thickness: 300±15μm, Shanghai Junhe electronic materials Co.; platinum electrodes, pureity 99.95%, diameter 70mm, Shanghai dingfu metal materials Co.; NaClO4, analytical, Tianjin fucheng chemical Reagent factory; current loop, and width :35MHz, measuring range: :0~500A, rise time :10ms.

2.2 Experiment equipment

The schematic diagram of ignition test system shown in Figure 1, which is made up of oscilloscope, optical probes, current loop and switch. The fire sensitivity tests of porous silicon ignitors were carried out and the range of voltage is from 10V to 50V.

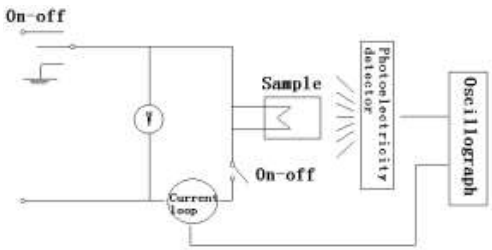
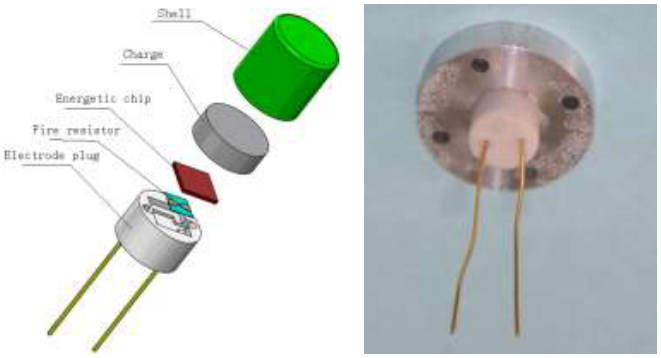


Fig.1. The test system of porous silicon energetic chip

2.3 Preparation of test sample

2.3.1 Design of porous silicon ignitor

Porous silicon ignitor was made of shell, output charge, energetic porous silicon chip, the energetic chip and electrode plug. The bridge film was produced through the process of sputtering, photolithography and wet etching. The micro energetic chip was made by in-situ charge method. The chip was stick to the groove in electrode plug. The sctech map showed in Figure 2.



(a)Structure of silicon ignitior (b)Sample of silicon ignitior

Fig.2. Structure and sample of silicon ignitior and Silicon ignitior

2.3.2 Design of charge

The charge was 74mg B/KNO3 pellet, whose charge size was Φ4.2mm×3.8mm and density was 1.4g/cm3.

2.3.3 Preparation of porous silicon energetic chip

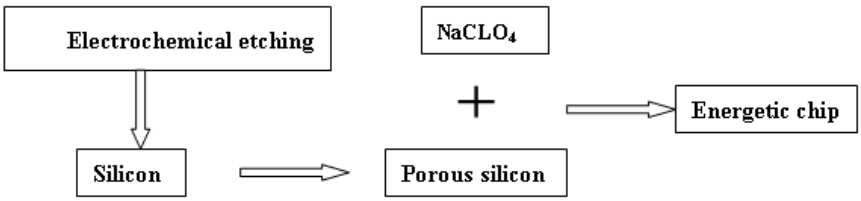


Fig.3 Preparation process of energetic chip

The principle of porous silicon energetic chip was showed in Figure 3. The silicon was prepared by electronchemical etching to form a sponge-like structure. The saturated solution of NaClO4 was added to the porous silicon to make the porous silicon energetic chip. The porous silicon was produced by electrochemical etching of silicon in HF/ethanol(HF/CH3CH2OH=1:1) electrolyte by five step constant current etching method.

Table 1. The parameter of Porous silicon Preparation

	Step 1	Step 2	Step 3	Step 4	Step 5
Current(A)	2.8	2.4	2.0	1.6	1.3
Etching time(min)	20	10	30	10	50

Placed porous silicon on the hot plate. Added saturated NaCLO3 to the porous silicon to made the porous silicon energetic chip. The temperature of hot plate controlled at 70°C~90°C and blowing hot air to the porous silicon 5~8second.Repeated dropping 3~5times. Carbinol volatilized, and oxidant aggregated in the porous silicon. The structural of porous silicon energetic chip shown in Figure 4.

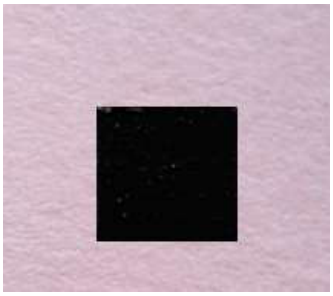


Fig.4. Image of porous silicon energetic chip

3 Results and discuss

The firing sensitivity was tested according to LangLie Method[7,8], firing current was less than 1.7A, firing voltage was less than 15V, ignition time was millisecond level, result can be seen from the table 2:

Table 2. Firing voltage of porous silicon energetic chip

number	sample siza	50% firing voltage	99.9%response point	standard deviation
1	12	21.3V	27.1 V	1.87
2	15	14.4V	20.8V	2.09
3	17	18.6V	17.9V	1.23

The firing sensitivity was tested according to LangLie Method, 50% firing voltage was less than 15V, test results wa shown in Figure 5. The image of porous silicon energetic chip after firing was shown in figure 6, BKNO3 effected completely shown in figure 6.

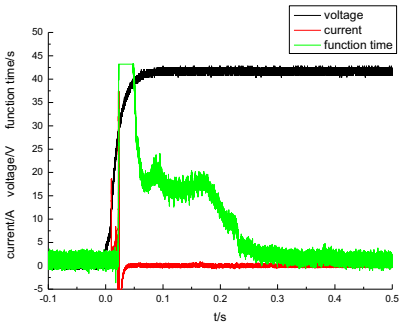


Fig.5. Curve of firing voltage、current and function time change

Fig.6. image of porous silicon energetic chip after firing of porous silicon energetic chip

4 Conclusion

Paper used electronchemical etching method to etched the silicon into a sponge-like structure.Added saturated solution of NaCLO3 to the porous silicon to made the porous silicon energetic chip. LangLie Method used to test the firing sensitivity of porous silicon energetic chip ignition, results indicated:

(1)Combined with the technics of MEMS, used electronchemical etching method to etched porous silicon energetic chip.Company with MEMS Ni/Cr-bridges and charge to facture the silicon ignitiors.

(2)The energetic chip can ignited B-KNO3 which burns sufficiently, text indicated porous silicon energetic chip can ignited charge and burning sufficiently.

(3)LangLie Method used to test the firing sensitivity of porous silicon energetic chip ignition, the 50% firing voltage 21.3V, standard deviation 1.87 the 99.9% point 27.1V.

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