FABRICATION AND VIBRATION ANALYSIS ON PIEZOELECTRIC MATERIAL

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Abstract

The analysis of commercially available piezoelectric coefficient monocrystalline materials such as PMN-PT (lead magnesium niobate - lead titanate) helps broaden the gate for silicon-integrated applications (PiezoMEMS) becoming more compatible with micro technology batch processes, further advances are expected in terms of miniaturization, optimization, functionality or integration with electronics. Subsequently, operating voltage will be lower and devices response time will improve dramatically. Fabrication of the piezoelectric materials has been performed and vibration analysis has been carried out.

Keywords: PMNPT material Stiffness, max amplitude , flux method

Introduction

As seen from the above chapter’s piezoelectric materials have wide applications and even can be used in our day to day life. But as such every technological invention has a flip side; even our crystal (piezoelectric) has a disadvantage or limitation to be precise.

As we know the piezoelectric materials convert the Mechanical vibrations into electricity, the piezoelectric material fails if the vibrations exceed a certain limit. In general, piezoelectric crystals are very sensitive and respond to even the slightest vibrations. When these vibrations are beyond a certain frequency our piezoelectric crystals will break or fails.

Fabrication

Addressing all the problems and failures discussed above, we have a solution to minimize those losses and failures. Though we cannot completely eliminate the problem of limiting to certain range of vibrations it can surely be minimised. i.e.: we can increase the frequency or amplitudes under which our piezoelectric material or crystal can be operated. For this purpose we need to increase the structural properties of the piezoelectric material or the crystal. This can be done by varying the compositions of different materials which are being used in the fabrication. Also utmost care must be taken while fabricating the crystal to minimise the faulty bonding and also the losses inside the crystal. By changing the compositions of the crystal the structural properties of the crystal would change giving a higher bonding strength between the atoms thereby increasing the strength of the piezoelectric material or the crystal.

Flux Method

Flux method is a method of crystal growth where the components of the desired substance are dissolved in a solvent (flux). The method is particularly suitable for crystals needing to be free from thermal strain and it takes place in crucible made of non-reactive metal like platinum, tantalum, niobium or other non-reactive elements.

We mixed the starting materials and placed it in the crucible. The crucible closed with a lid was heated up to soak temperature Ts at which, during 3 h, the dissolution took place. Next, the furnace was quickly cooled to the temperature T_1 and then slowly cooled to the temperature T_2 with a cooling rate from 0.7 to 2.51°C/h. At this temperature the excess solution was removed by decanting. The crucible with the grown crystals was then cooled to room temperature. It must be pointed out that the temperature of the beginning of crystallization process was not determined. By etching in hot water solution of acetic acid the remains of the solvent were removed as well as the crystals were softly separated from the crucible. The soak temperature and the other temperature T_1 and T_2 are based upon the crystal compositions we change. The cooling rate applied when bringing the temperature from T_1 and T_2 also depends upon the various percentages of the materials involved in the compositions. The values of T_1 and T_2 for 0.32% crystal are 1080°c and 910°c with a cooling rate of 2°c /h whereas the temperatures stand as 1070°c to 890°c for 0.21% crystal with a cooling rate of 1.7°c/h. One advantage of this method is that the crystals grown display natural facets so that they can be used for optical experiments without the need for further polishing. A disadvantage is that most flux method syntheses produce relatively small crystals

Figure: a) Crucible with the crystal at 910 °c

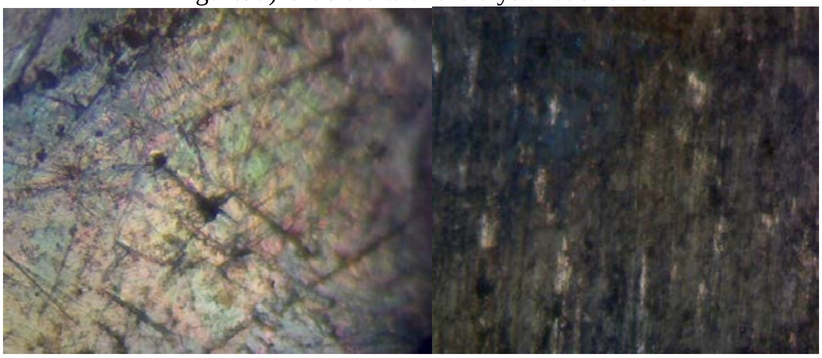

Figure: b) Structure of the crystal before and after finishing

Vibration Analysis

Support one end of a cantilever beam in the slot of fixed plate and clamp it by means of knob**.** Place the crystal on the other end of the cantilever beam. Give wiring to the crystal and connect it to a multimeter**.** Clamp an exciter assembly at any convenient position in the cantilever beam. Switch on the mains**.** Switch on the rotor switch**.** Change the required speed by operating the speed controller. Toggle switch to be in the top position (forced vibrations)**.** Allow system to freely vibrate under the set speed**.** Neglect the initial reading because due to some sensitive vibrations Observe the digital meter and note down the amplitude and frequency.

Repeat the experiment for varying speed and note down the reading.

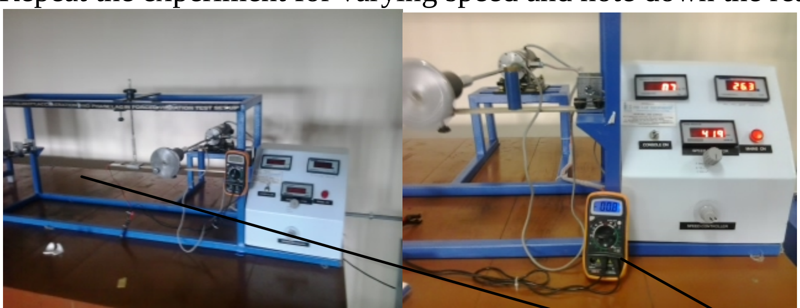

Figure: c) Experimental setup for Vibration analysis

Multimeter

Crystal

OBSERVATIONS:

FREQUENCY (MHz)	AMPLITUDE (mm)	VOLTAGE (x200mv)	RPM
3	10	0.1	196
4	16.6	0.7	250
6	18	0.8	361
8	24	0.9	420

TABLE: a) Observations of amplitude, voltage for PMN-PT 0.32%

Conclusion

From the table A we can infer the results done for vibration analysis on the spring mass damper setup. Voltage was generated was about 180milli volts at a deflection of 24mm at a speed of 420RPM and at an amplitude of 24 MHz. The same crystal with normal compositions was failed at 18 MHz i.e. the crystal broke into pieces. But, increasing the TITANIUM composition led to the increase in sustainability of the crystal.

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