

DEVELOPMENT AND PRODUCTION OF A DISCRETE – SOLID BODY FUSE

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ABSTRACT

Tateyama Kagaku Industry Co., Ltd. is located in the center along the Japan Sea and aiming for contribution to the world as well as our region.

Some of our product lines are passive components such as chip resistors, chip thermistors, assembled thermistors and electro static discharge protection elements supplying to automotive as well as consumer market in Japan and Europe.

In Space field, our product range is expanding from chip resistors to chip thermistors, assembled thermistors as well as discrete - solid body type fuses.

The new-release and EPPL listed discrete - solid body type fuses were developed by investigation of market supplying trend and customers' needs.

The fuse is formed by thick film printing and is able to work in the vacuum and high vibration and shock environments. This paper shows our company and products' introduction and explains the fuses.

TATEYAMA GROUP STRUCTURE

Our presentation will provide the company profile such as statistics, sites, products range in consumer field, segments and achievements in Europe.

As can be seen from Figure 1, Tateyama Kagaku Group has 11 companies and 1,300 employees with annual turnover EUR 300 million in 2011.

One of the 11 companies is Tateyama Kagaku Industry Co.,Ltd.

The group headquarter is in Toyama, Japan. Three domestic sales offices are in Tokyo, Osaka, and Nagoya.

Overseas sales office, factory and laboratory are located in Hong Kong, Thailand, Malaysia and Hungary respectively.

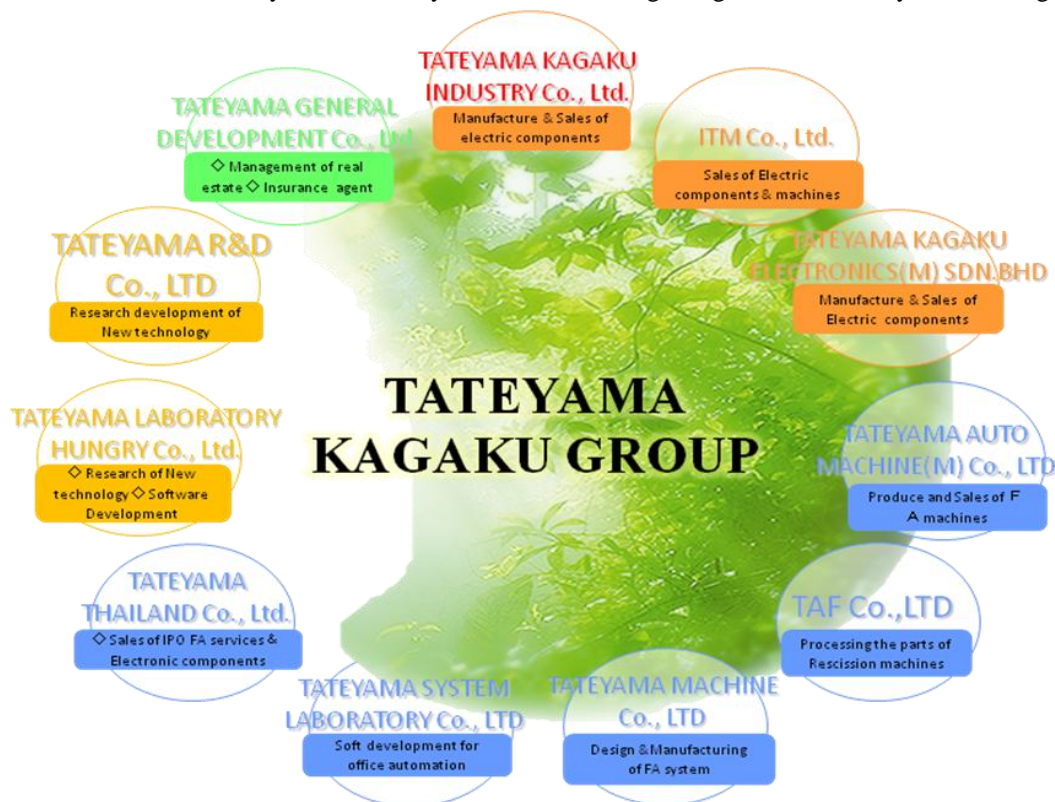


Fig. 1: Group Structure

Business contents:

Manufacture and sales of Electronic devices, Wireless devices, and Measuring devices and modules

Development and manufacture of FA system, and Manufacture of Precision mounting machines.

Computer software development

The statistics of Tateyama Kagaku Industry Co.,Ltd is shown where annual turnover is EUR100 million. In addition, the product range is shown, which are chip components and sensors together with its segments(See Figure 2.).



Fig. 2 : Products and Segments

SPACE BUSINESS IN TATEYAMA

According to the road map in Figure 3, as time goes on, we are expanding our product range. We started our business with chip resistors. Then, it is expanding to chip thermistors, leaded thermistors, leaded fuses and SMD fuses.

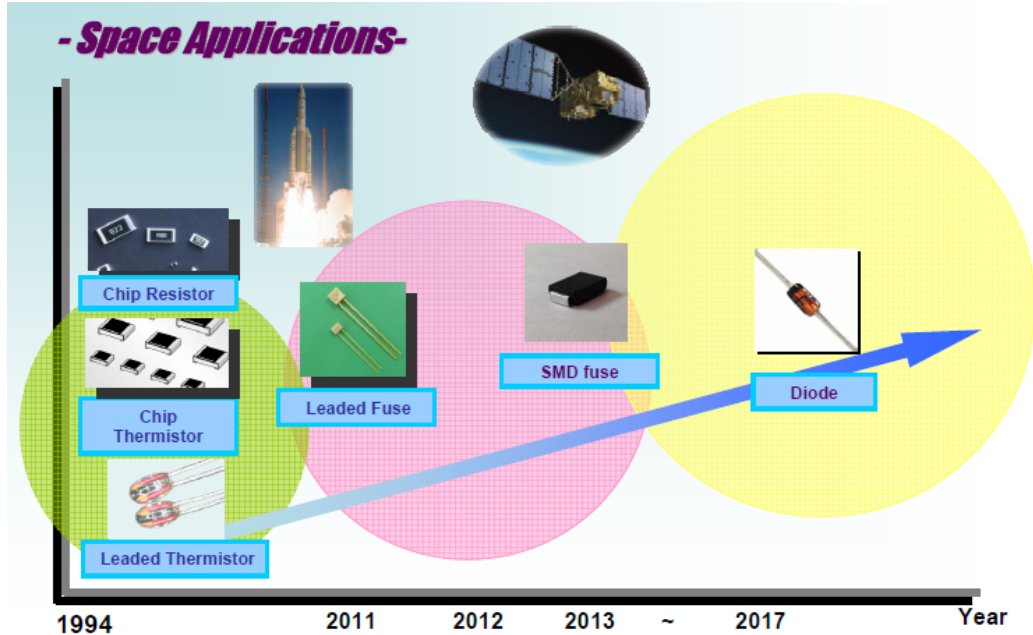


Fig. 3: Road map of Space business

Chip Resistors, Chip thermistors, Leaded thermistors and Leaded Fuses are on sale. SMD Fuses and Diodes are under development.

We explain some of the space products on sale.

Chip Resistors

We acquired JAXA qualification on chip resistors in 2007.

We have been supplying chip resistors to Japanese Space makers for more than a decade.

We have a glass coating that results in superior in stability and heat resistance and solder plating terminal that contains lead to avoid whisker.

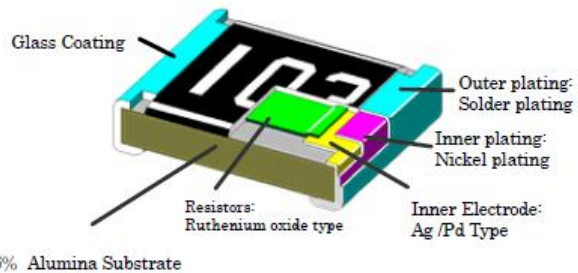


Fig. 4: Chip Resistors

Chip Thermistors

We acquired JAXA qualification on Chip thermistors in 2010. Chip thermistors also use Thick Film structure that has high mechanical strength and reliability due to thermistor film and glass coating on alumina substrate. This thermistors also use solder plating terminal that contains lead to avoid whisker.

DEVELOPMENT AND PRODUCTION OF A DISCRETE TYPE – SOLID BODY FUSE

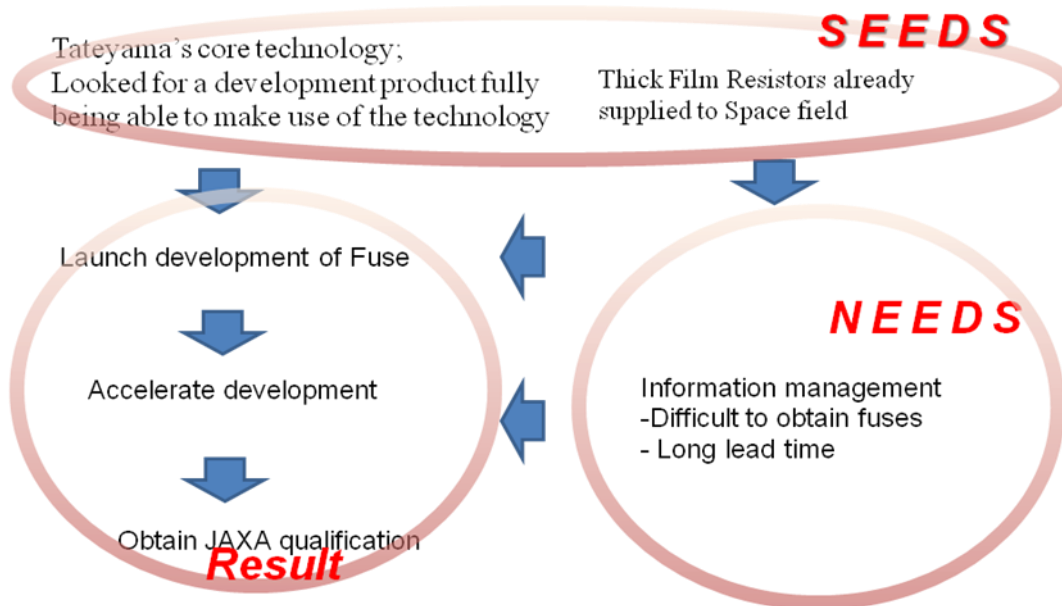
As can be seen from Figure 5, we started developing discrete - solid body fuses.

The requested function of fuses;

- When an application mounting fuses is operated correctly, the fuses shall not be open circuit (shall not be open circuit by current less than the rated current.).
- In case that abnormality happens in an application, the fuses in the application shall safely shut current down. In case of artificial satellites, failure is assumed by short circuit inside an application and in the failure, fuses make the application electrically detached from the satellite base. In Tateyama fuses, the specification when abnormality happens defines pre-arcing time for over-current that is 250%, 400% and 600% of rated current (See Table 1).
- The fuses shall not be reconnected after cutting current. The source of an artificial satellite is electricity stored in its battery. If current continues flowing in an application where abnormality (short circuit) happens, all electricity is used up and other applications operating correctly do not obtain electricity. As a result, in case of an artificial satellite, the whole of a satellite is finally down. It is an important function to keep stable electric insulation of fuses after firing. Tateyama fuses have a design to form stable insulation by reacting with the upper glass during clearing activity (See Figure 7).

Furthermore, what fuses are needed for space use is;

- They shall be resistance to vibration and shock caused by launching a rocket.
- In vacuum environments, fuses shall keep their specifications as they are defined. Fuse's clearing action is realized by balance between self-heating and radiation of heat. For example, in case of fuses for automotive use, a fuse element is formed in resin cavity and the structure of some of fuses is the one to expose their element to the air. In this case, by balance with heat conduction to the air, pre-arcing time is made up. However, in fuses with such structure, in vacuum environments, heat conduction and radiation of heat decrease and pre-arcing time becomes shorter than in the air. In addition, if electricity is turned on when elements are exposed to vacuum environments, it is assumed that by vapor pressure's becoming lower, a fuse element is sublimated to the gas and open.



Year	
1994	Supplying chip resistors for space use
2007	Chip resistors qualified by JAXA
2010	Chip thermistors qualified by JAXA

Expanding the product range

Fig. 5: Development background

As seeds, we have had our core technology, thick film technology that was able to be made full use of.
As market needs, trend and environment, it was difficult to obtain fuses and lead time was long.

As a result of the combination of the above, we could launch development of fuses. We accelerated the development, obtained JAXA qualification and started supplying.

Difficulty

We faced a difficulty on production process design (See Figure 6). In spite of long life time of the product, the product quantity is small. Therefore, it is difficult to maintain production equipment in the future. However, by semi-automatic machines, it is successful to consist of a production line for small quantity.

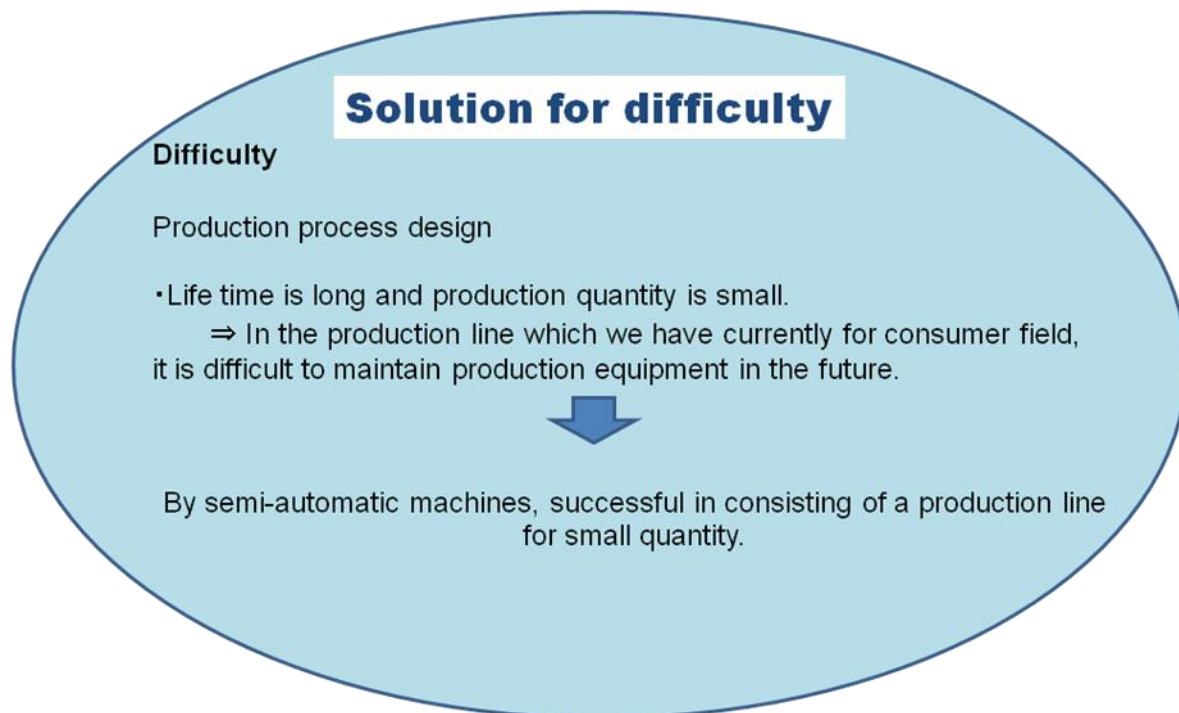


Fig. 6: Difficulty

Electrical feature of the fuse

We have current range from 1A to 15A under 72V and 1A to 5A under 126V.

Under 72V, pre-arcing time is 10ms to 300ms in Load current 250%, 1ms to 15ms in Load current 400% and 0.15ms to 3ms in Load current 600%.

Under 126V, pre-arcing time is 10ms to 300ms in Load current 250%, 0.75ms to 15ms in Load current 400%, and 0.1ms to 3ms in Load Current 600%(See Table 1).

Rating			Pre-arcing time (ms)			Operating temperature	Maximum breaking capacity (DC)	Style
Voltage (V)	Current (A)	Resistance Value Max (mΩ)	Load current 250%	Load current 400%	Load current 600%			
72	1.0	220	10.0 ~ 300	1.00 ~ 15.0	0.15 ~ 3.00	-55°C ~ +125°C	1,000A	J1
72	1.5	163						
72	2.0	75.0						
72	3.0	43.8						
72	5.0	22.5						
72	7.5	13.8						
72	10.0	10.7						
72	15.0	7.00						J2
126	1.0	270	10.0	0.75	0.10			
126	3.0	95.0	~	~	~			
126	5.0	40.0	300	15.0	3.00			

Table 1: Electrical feature of the fuse

Style



Type	Size (mm)					
	A	B	C	D (Min)	E	F
J1	7.0	5.4	3.5	40	4.0	0.60
J2	9.0	9.3	5.0	57	5.0	1.20

Table 2: Style

Structure

As our core technology is thick film one, the fuses also use thick film structure. We have upper glass layer on fuse element.

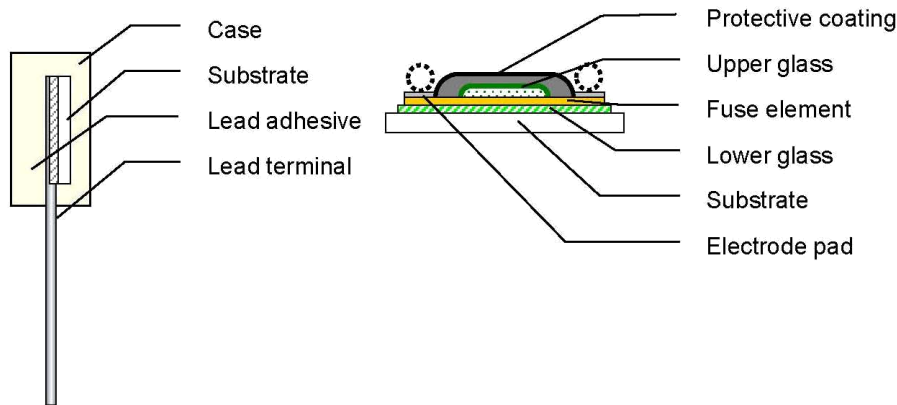


Fig. 7: Structure

Characteristic of Tateyama fuses

- *Upper glass layer*; It is formed by inorganic material upon an element. The purpose of this layer is to shut current down safely and to keep stable electric insulation after firing. Temperature of a fuse element becomes higher by self-heating caused by over-current and when a fuse element reaches a melting point, melting starts, which results in a fuse's clearing operation. In this operation, when an element (conductive material) is physically cut apart by melting, arc happens. By this arc, an element is heated further, changed to gas, and rapidly increases cubic volume. The function of upper glass layer is to absorb shock made by cubic volume's increasing. In addition, the function of this upper glass is to keep electric insulation after firing.
- *Electric Insulation after firing* : An element vaporized during a clearing operation diffuses inside upper glass. When an element is diffused, upper glass is also melted by the heat and reacting with an element material. As a result, a melting product consisting of an element material and glass is formed and superior electric insulation is shown. A cross-section picture is shown below which is after firing. Upper glass changes to red color by reacting to an element which is gold.

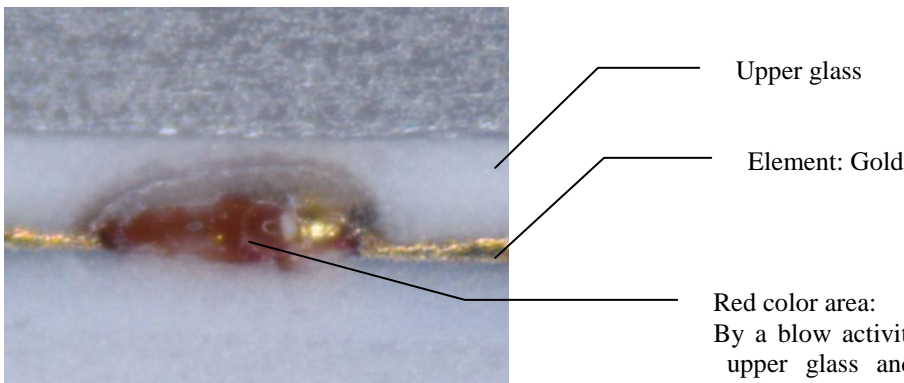


Fig. 8: After firing

CONCLUSION:

As Tateyama Kagaku Group's slogan is "Quality is our life blood". The field which requests us high quality and severe quality control is the one where we can pursue the way of living.

As contributing ourselves to the space field, we shall develop as many products as possible such as SMD fuse which we can supply to space field with a combination of customer needs and seeds.