

## TABLETING PROCESS AND TABLETING MACHINE

This invention relates to a process for  
tableting a thermosetting resin molding material and a  
tableting machine to be used therefor, particularly to a  
process for tableting an epoxy resin molding material  
5 for encapsulating a semiconductor and to a tableting  
machine to be used for the process.

When semiconductors are encapsulated with an  
epoxy resin molding material or the like, a process has  
been carried out which comprises tableting the epoxy  
10 resin molding material to be used, preheating the  
resulting tablets by a high-frequency preheater or the  
like, encapsulating the semiconductors with the  
preheated tablets using a transfer molding press or the  
like and thereafter heat-curing the epoxy resin molding  
15 material to obtain a semiconductor device. When the  
epoxy resin molding material is tableted, a usual  
tableting machine is used and the tableting is carried  
out under normal pressure. In recent years, in other  
fields, for example, in tableting of medicine, a vacuum  
20 tableting machine has also been used. However, it has  
not yet been utilized for tableting epoxy resin molding  
materials.

As the vacuum tableting machine for medicine,  
there is disclosed a vacuum tableting machine for  
25 medicine which comprises a closed box in which the

tableting process occurs. The internal pressure of the box can be reduced by means of a vacuum pump (JP-B-7-32,960). This box is connected to a powder-storing hopper through an airtight valve and also to a tablet-receiving can through another airtight valve. However, this machine is aimed at effectively removing undesirable conditions in tableting such as capping, laminating and the like and does not change the composition of the material as it is merely exposed to the vacuum for a short time during the tableting process.

This invention has been made for solving molding problems such as void, blister, peeling, and cracks, which are easily caused during or after the transfer encapsulation of semiconductors with an epoxy resin molding material. The object of the invention is to provide a vacuum tableting process for forming tablets having excellent encapsulating properties, keeping the content of moisture and other volatile matters minimal without deteriorating the physical properties and the other various characteristics and also provide a tableting machine to be used for the above process.

According to this invention, there is provided a process for tableting an epoxy resin molding material, characterized by introducing the epoxy resin molding material into a first vacuum hopper, reducing internal pressure of the first vacuum hopper to remove moisture

and other volatile matters found in the epoxy resin molding material, transferring the epoxy resin molding material to a second vacuum hopper connected to the first vacuum hopper through an airtight valve, closing  
5 the airtight valve to allow the first and second vacuum hoppers to stand in closed state, introducing the epoxy resin molding material from the second vacuum hopper to a tableting section provided within a closed box kept in vacuum state while keeping the second vacuum hopper in  
10 vacuum state, and continuously tableting the epoxy resin molding material in the tableting section.

Moreover, according to this invention, there is provided a tablet of an epoxy resin molding material obtained by the above-mentioned tableting process and  
15 also provided a semiconductor device in which semiconductors are encapsulated with the above tablet.

Furthermore, according to this invention, there is provided a tableting machine having a tableting section provided in a closed box which can be kept in  
20 vacuum state, characterized in that a first vacuum hopper for removing moisture and other volatile matters found in an epoxy resin molding material is placed above the closed box and a second vacuum hopper is placed between the first vacuum hopper and the closed box and  
25 connected to the former through a first airtight valve and to the latter through a second airtight valve, the above second vacuum hopper being for introducing the epoxy resin molding material which has been allowed to

fall down therein from the first vacuum hopper through the first airtight valve and from which moisture and other volatile matters have been removed in the first vacuum hopper, into the tableting section through the  
5 second airtight valve while keeping the epoxy resin molding material in vacuum state.

In the accompanying drawing, Fig. 1 is a view for explaining the outline of a vacuum tableting machine which is an embodiment of this invention. In Fig. 1,  
10 the meanings of the reference numerals used are as follows:

- 1     Tableting section
- 2     Closed box
- 3     First vacuum hopper
- 15 4     Second vacuum hopper
- 5     First airtight valve
- 6     Second airtight valve
- 7     Airtight valve for introducing material
- 8     Airtight valve
- 20 9     Airtight valve
- 10    Airtight valve
- 11    Vacuum equipment

The tableting machine of this invention is explained in detail based on Fig. 1. Fig. 1 is an  
25 embodiment of this invention and this invention should not be construed to be limited thereto.

The tableting section 1 is provided in the closed box 2 and this closed box 2 is connected to the

vacuum equipment 11 through the airtight valve 10. The closed box 2 is so constructed that the interior thereof can be kept in vacuum state by the vacuum equipment 11. Above the closed box 2, the second vacuum hopper 4 is placed and connected to the closed box 2 through the second airtight valve 6. This second vacuum hopper 4 is also connected to the vacuum equipment 11 through the airtight valve 9 and is constructed so that the interior thereof can be kept in vacuum state by the vacuum equipment 11. Above the second vacuum hopper 4, the first vacuum hopper 3 is placed and connected to the second vacuum hopper 4 through the first airtight valve 5. This first vacuum hopper 3 is also connected to the vacuum equipment 11 through the airtight valve 8 and is constructed so that the interior thereof can be kept in vacuum state by the vacuum equipment 11. The first vacuum hopper 3 is equipped on its top with the airtight valve 7 for introducing an epoxy resin molding material. All the above components of the vacuum tableting machine are made of vacuum-resistant material of construction.

The tableting process of this invention is explained in detail based on the form of use of the tableting machine of this invention shown in Fig. 1.

The airtight valve 8 and the first airtight valve 5 are closed, and the airtight valve 7 for introducing an epoxy resin molding material is opened. After the introduction of the material, the airtight valve 7 is closed. The airtight valve 8 is then opened

and the vacuum equipment 11 is actuated to reduce the internal pressure of the first vacuum hopper 3 to vacuum state. In this case, the degree of vacuum in the first vacuum hopper 3 is adjusted to 80 Torr or less, preferably 30 Torr or less so that the amount of moisture and other volatile matters found in the epoxy resin molding material is reduced to not more than 0.05% by weight. It is preferable to subject the epoxy resin molding material to vacuum state for at least 30 minutes. In addition, more preferable results are obtainable by installing a stirring mechanism for stirring the molding material in each of the first and second vacuum hoppers. In particular, when a stirring mechanism is installed in the first vacuum hopper, the time for keeping the first vacuum hopper in vacuum state can be shortened, and thus a greater effect is achieved.

Subsequently, the second airtight valve 6 connected to the second vacuum hopper 4 is closed, the airtight valve 9 is opened, and the degree of vacuum in the second vacuum hopper 4 is adjusted to 80 Torr or less, preferably 30 Torr or less by actuating the vacuum equipment 11, after which the airtight valves 9 and 8 are closed. The first airtight valve 5 is then opened leaving the airtight valve 7 for introducing the molding material open, and the epoxy resin molding material in the first vacuum hopper 3 is transferred down to the second vacuum hopper 4. After the transfer, the first airtight valve 5 is closed, the airtight valve 9 is

opened, and the vacuum equipment 11 is actuated to keep the interior of the second vacuum hopper 4 in vacuum state. Thereafter, the second airtight valve 6 is opened, and the epoxy resin molding material in the  
5 second vacuum hopper is transferred to the tableting section 1 which has already been kept in vacuum state by opening the airtight valve 10 and actuating the vacuum equipment 11, upon which tableting process begins in the tableting section 1 and tablets are produced. While the  
10 tablets are being produced, fresh epoxy resin molding material is continuously introduced into the first vacuum hopper 3, and the above-mentioned operations are repeated. Thus, the tableting process is continuous.

The first airtight valve 5 is connected to the  
15 bottom of the first vacuum hopper 3 serving as a material-feeding hopper. This valve 5 acts as a molding material-exhaust port of the first vacuum hopper 3, and as a molding material-receiving port of the second vacuum hopper 4. Similarly, the second airtight valve 6  
20 is connected to the bottom of the second vacuum hopper 4 serving as a hopper for feeding the molding material directly to the tableting section 1. This valve 6 acts as a molding material-exhaust port of the second vacuum hopper 4 and serves as a molding material-receiving port  
25 of the tableting section 1.

The degree of vacuum in the tableting section 1 is kept at 80 Torr or less, preferably 30 Torr or less.

According to this invention, the amount of moisture and other volatile matters found in tablets of an epoxy resin molding material for encapsulating a semiconductor can be controlled to a very low level.

5 Hence, this invention is very effective to prevent voids, blisters, peeling and cracks from occurring in a high grade semiconductor device in which more highly integrated semiconductors are encapsulated.

#### Example

10 Using a mixer, 4.2 parts by weight of an epoxy resin, 4.3 parts by weight of a phenol resin, 0.2 part by weight of a curing accelerator, 86.0 parts by weight of silica powder, 0.5 part by weight of a silane coupling agent, 1.0 part by weight of antimony trioxide,  
15 1.0 part by weight of a brominated epoxy resin, 0.5 part by weight of carnauba wax and 0.3 part by weight of carbon black were mixed at room temperature. The resulting mixture was kneaded at 100°C using a twin roll mill, cooled and then pulverized to obtain a molding  
20 material. This epoxy resin molding material was tableted using;

- (a) a usual tableting machine (referred to hereinafter as the usual tableting machine),
- (b) a vacuum tableting machine in which only the  
25 tableting section is kept in vacuum state (referred to hereinafter as the mere vacuum tableting machine) and
- (c) the vacuum tableting machine of this invention (referred to hereinafter as the present vacuum tableting

machine).

A semiconductor device (package) which is apt to cause voids was encapsulated with the tableted sample obtained, after which the encapsulated semiconductor device (package) was subjected to evaluation. Incidentally, the epoxy resin molding material used in the present vacuum tableting machine was obtained by treating the above molding material at a degree of vacuum of 35 Torr for one hour in the first vacuum hopper. This material had a moisture content of 0.03% by weight and a total content of methanol and ethanol of 3 ppm. In this connection, the moisture content was determined by precisely weighing about 5 g of the epoxy resin molding material pulverized to particles having the largest diameter of 2 mm or less, placing the same in a phosphorus pentoxide-containing pressure-resistant closed vessel, allowing it to stand at a degree of vacuum of 600 mmHg for 24 hours and then measuring the weight to determine weight change. The total content of methanol and ethanol was determined by gas chromatography.

Specifically, in each case, the epoxy resin molding material was tableted to obtain tablets each having a diameter of 9.8 mm and a weight of 2.9 g. The tableted sample was used to encapsulate a dummy lead frame into a 100 pQFP having a size of 20 mm x 20 mm x 2.7 mm (thickness) for testing under the conditions of 175°C, 40 kg/cm<sup>2</sup>, a transfer time of 4 seconds and a

curing time of 90 seconds using a low pressure transfer molding machine with a one pot-one cavity system. The surface of the package formed was observed with a microscope to determine the number of external voids and the size of the voids in each case. The data obtained were compared as shown below.

In the process of this invention, as compared with the conventional processes, the number of voids caused was 1/7 or less and the size of the void caused was the smallest.

(1) Comparison of the number of voids caused in the conventional process using the usual tableting machine with that in the process of this invention using the present vacuum tableting machine

Number of samples: 48 in each case

Preheating time: After allowing the tablets to stand for 15 seconds from the introduction thereof, clamping was started.

| Void size (mils)                  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11-20 | Total |
|-----------------------------------|---|---|---|---|---|---|---|---|---|----|-------|-------|
| Usual tableting machine:          |   |   |   |   | 1 | 2 | 2 |   |   | 1  | 1     | 7/48  |
| Present vacuum tableting machine: |   |   |   |   | 1 |   |   |   |   |    |       | 1/48  |

(2) Comparison of the number of voids caused in the conventional process using the usual tableting machine, that in the mere vacuum tableting process using the mere vacuum tableting machine and that in the process of this invention using the present vacuum tableting machine:

**Number of samples: 24 in each case**

Preheating time: After allowing the tablets to stand for 12 seconds from the introduction thereof, clamping was started.

[illegible]



WHAT IS CLAIMED IS:

1. A process for tableting an epoxy resin molding material, characterized by introducing the epoxy resin molding material into a first vacuum hopper, reducing internal pressure of the first vacuum hopper to remove moisture and other volatile matters found in the epoxy resin molding material, transferring the epoxy resin molding material to a second vacuum hopper connected to the first vacuum hopper through an airtight valve, closing the airtight valve to allow the first and second vacuum hoppers to stand in closed state, introducing the epoxy resin molding material from the second vacuum hopper into a tableting section provided within a closed box kept in vacuum state while keeping the second vacuum hopper in vacuum state, and continuously tableting the epoxy resin molding material in the tableting section.
2. The tableting process according to Claim 1, wherein the internal pressure of the first vacuum hopper is reduced so that the amount of moisture and other volatile matters found in the epoxy resin molding material is not more than 0.05% by weight.
3. A tablet of an epoxy resin molding material obtained by the tableting process according to Claim 1.
4. A semiconductor device in which semiconductors are encapsulated with the tablet according to Claim 3.
5. A tableting machine having a tableting section provided in a closed box which can be kept in vacuum state, characterized in that a first vacuum hopper for



removing moisture and other volatile matters found in an epoxy resin molding material is placed above the closed box and a second vacuum hopper is placed between the first vacuum hopper and the closed box and connected to the former through a first airtight valve and to the latter through a second airtight valve, the above second vacuum hopper being for introducing the epoxy resin molding material which has been allowed to fall down therein from the first vacuum hopper through the first airtight valve and from which moisture and other volatile matters have been removed in the first vacuum hopper, into the tableting section through the second airtight valve while keeping the epoxy resin molding material in vacuum state.