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CONFORMAL COATING PROCESS TO IMPROVE PACKAGE RELIABILITY IN ADVERSE ENVIRONMENTS

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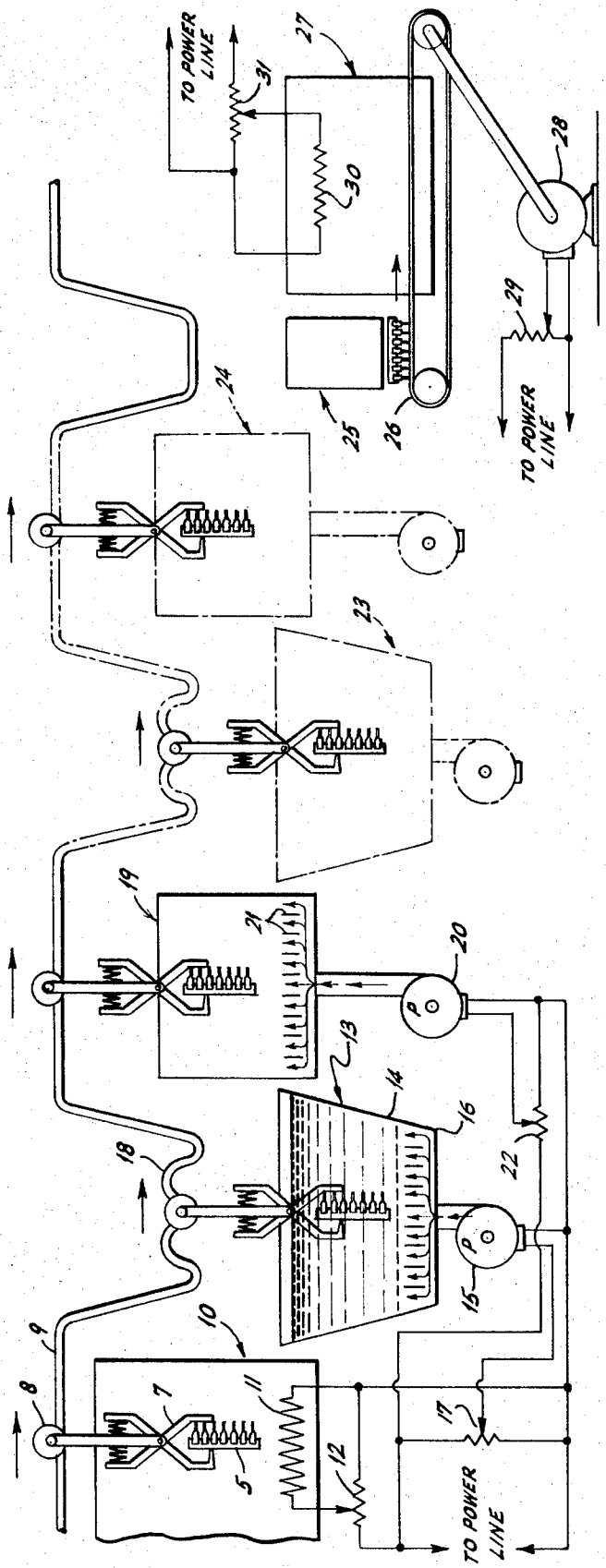


FIG. 3.

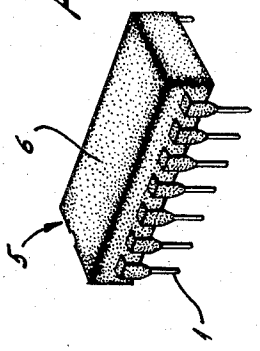


FIG. 2.

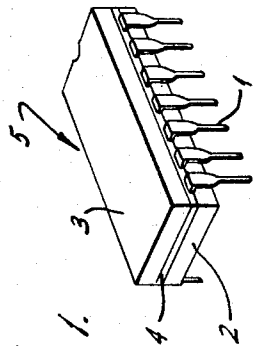


FIG. 1.

INVENTORS
STEPHEN M. SOBOTA JR.
ROBERT J. SCHEETZ
BY
Gail W. Woodward
AGENT

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CONFORMAL COATING PROCESS TO IMPROVE PACKAGE RELIABILITY IN ADVERSE ENVIRONMENTS

Robert J. Scheetz, Sellersville, and Stephen M. Sobota, Jr., Souderton, Pa., assignors to Philco-Ford Corporation, Philadelphia, Pa.

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U.S. Cl. 117—212 8 Claims

ABSTRACT OF THE DISCLOSURE

A conformal insulating coating is applied to the hermetic package housing an electronic device using a process that eliminates the coating from the tips of the electrical connecting leads. The encapsulated device is heated and then immersed into a fluidized bed containing solid granules of unreacted coating material. The granules stick to the major portions of the package but the lead extremities, being cooler because of their low thermal mass and remoteness from the body of the package, cool to a temperature too low to permit the granules to stick. Upon firing, the adhering granules melt and coalesce permitting a chemical reaction to take place and complete the coating. The resultant coating improves the package hermeticity and greatly improves resistance to adverse ambient atmospheres. The coating is applied without the masking normally required to prevent its application to unwanted areas on the connecting leads.

BACKGROUND OF THE INVENTION

Electronic devices are commonly mounted inside hermetic enclosures to improve performance and extend life. This is particularly true of such devices as piezoelectric crystals and semiconductor elements where adverse ambients can quickly and drastically alter operating characteristics. The hermetic enclosures or packages must be of a nature that will not adversely affect the enclosed device device either during the closure process or during subsequent life. While many enclosures satisfy these conditions to a degree, the enclosure itself is subject to attack from adverse ambients and will degrade with time. Accordingly it has been common to further coat the encapsulated device with a material that protects the enclosure. Various natural and synthetic resins have been used with good success. The materials can be applied by dipping, spraying or other well known techniques, and these coatings have proven of great value. Not only do they protect the enclosure from adverse ambients, they improve the appearance of the finished product and, because they can be colored, provide a means of color coding the devices.

The major problem associated with protective coatings is in avoiding their application to those areas of the electrical connecting leads where contact must be made to operate the device. This is ordinarily accomplished by controlling the coating application as in selective dipping or by providing masking coatings prior to applying the protective coating. For example a waxy material can be applied, by dipping, to the electrical leads. In some cases this material will prevent the adherence of the protective coat and, in other cases, while not preventing adherence, permits easy removal after coating. In any event the masking material must be removed after the coating process is completed. Both the application and subsequent removal of masking material is troublesome and time consuming and requires considerable care in handling.

Alternately the coating can be applied to the entire device and then removed from those regions where it is not wanted. Mechanical removal such as abrading, wire brushing or grit blasting can be employed but the delicate leads on many devices make such approaches dubious. Chemical stripper means can be employed. The portions of the device where coating is not wanted are immersed into a suitable chemical bath and the coating loosened. A subsequent wiping operation removes the loosened coating. Such chemical treatment usually calls for a following rinse and drying operation. The chemical removal approach is troublesome because some of the coating resins are quite difficult to remove. They require several possibly extended immersions in powerful solvents and leave a messy residue to be wiped off.

In general while conformal coatings have solved several important problems in the encapsulation art, the problem of how to keep the coating off of areas where it is not desired has proven formidable.

SUMMARY OF THE INVENTION

In is an object of the invention to provide a conformal coating to encapsulating housings to improve resistance to adverse ambients while avoiding the coatings of areas where no coating is desired.

It is a further object to employed thermosetting resin coatings applied from a fluidized bed of solid granules.

It is a further object to provide coating localization by means of a simple thermal control.

These and other objects are accomplished by heating the encapsulation to a temperature that will cause the granules in a fluidized bed to stick thereto. The granules in the fluidized bed are selected to provide the required protection and can be applied at a temperature that will not harm the device inside the housing. In general, epoxies are preferred and the granules are made of resin and unreacted hardener. This material is inert at room temperatures but when heated will flow and react to produce a suitable coating.

The housing is heated to a temperature above that at which the granules will stick to it but low enough so that when the housing is immersed into the fluidized bed, the lead extremities will cool quickly to below the temperature at which the granules will stick. The housing is then removed from the fluidized bed and subjected to an air blast to remove any granules not firmly stuck thereto. The dipping can be repeated several times to build up the required coating thickness with intermediate air blasts to remove loose granules. The device is then passed through an oven to provide a heat cycle that melts the granules and flows them into a continuous, hole-free coating and at the same time reacts the resin and hardner to set the epoxy to the desired degree of cure.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows an uncoated package,

FIG. 2 shows the coated package in accordance with the invention, and

FIG. 3 shows the basic elements in a production line to practice the process of the invention.

DESCRIPTION OF THE INVENTION

FIG. 1 shows a popular hermetic package used extensively for the integrated semiconductor microcircuit art. It is referred to as cerdip after ceramic-dual-inline-package. An array of metal leads **1**, is glass sealed to ceramic base **2**. Seven leads per side are shown making a 14-lead cerdip package **5**. Typically the face of such a package measures about 7 x 20 mm. but many different sizes and lead arrays are available. The semiconductor device (not shown) is ordinarily glassed to the ceramic base **2** and suitable connections made to the leads. Ceramic cover plate **3** is then sealed by glass layer **4** to complete the package. The glassing is usually accomplished with a relatively low temperature maturing devitrifying glass frit.

Once completed such a package is rugged and has excellent hermetic properties.

One problem that has arisen in connection with the cerdip is associated with severe evironments, particularly high humidity and high temperature ambients. With the device operating, that is with voltages applied to the electrodes, surface leakage develops. Typically lead oxide is used as one of the sealing glass components to promote or catalyze devitrification. Leakage currents reduce the lead oxide to metallic lead which, after sufficient build-up, tends to short circuit the semiconductor device. While cleaning will restore normal operation the action can occur again and ultimately the hermetic integrity of the package will be impaired.

Where such hostile environments are encountered, a conformal coating, such as the one shown as **6** in FIG. 2, is very effective. All surfaces except those required for electrical contact are covered with an insulating coating that obviates the above mentioned electrolysis.

It has been found that epoxy resins provide suitable coatings. Such resins are good electrical insulators and will adequately resist the environments that ordinarily destroy device operation in a short length of time. One suitable resin is Scotchcast manufactured by the 3M Company. This resin is supplied in granular form suitable for application from a fluidized bed. The grains are about 100 microns in diameter and composed of epoxy resin and unreacted hardener in suitable proportions. Such grains are stable at room temperature for at least six months, but at 160 degrees C will cure to a suitable coating in about 20 minutes.

One method of practicing the invention uses a conveyor process as shown in FIG. 3. Device **5** is mounted in spring loaded clamp **7** which, by means of roller **8**, is propelled along conveyor track **9** by means not shown. The rate of motion along the track governs the duration of treatment in the various stations.

Station **10** is an oven heated by means of heater **11** when a suitable source of electrical power is applied by way of control **12**, which may be used to adjust oven temperature. The temperature of oven **10** is adjusted so that as package **5** traverses the oven it will be heated to a temperature that will be more fully detailed hereinafter.

After leaving oven **10** the part traverses the track **9** where it descends into station **13**, a fluidized bed coating-chamber. Container **14** has a foraminous bottom with holes small enough to prevent passage of granules contained therein. Container **14** is loaded with epoxy resin granules that will coat the device **5**. The resin granules, as were described above, are loaded into chamber **14** and pump **15** forces air (or inert gas) up through baffle chamber **16** which distributes the air flow up through the granular charge. The passage of air sets the granules in motion and in effect fluidizes the bed. Control **17** adjusts the output of pump **15** to secure the desired degree of fluidization. Thus even though the bed is composed of solids its behavior is that of a fluid. Sufficient air is passed to fluidize the bed but not enough to blow the granules out of the chamber. A similar effect can be secured by placing the granules in a container that is mechanically agitated, for example by placing it on a shaker table. In either case the effect is to cause the granules to come into intimate and complete contact with any object immersed therein, much the same as would occur if the bed were in fact a fluid.

As the hot device **5** is immersed, the epoxy granules will stick to the exposed surfaces due to point-of-contact surface melting. The device is agitated while in the bath by means of the undulating portion **18** of track **9**. This imparts a vertical motion that could be obtained alternatively by making track section **18** straight and including an agitating device in the suspension system for clamp **7**.

The temperature of device **5** as it enters the fluidized bed will in large measure control the coating process. The coating depends upon the nature of the resin as well as grain size, but once the resin is selected and a grain size established to provide suitable fluidizing, the only variable is temperature. When using the resin and grain size specified above, 14-lead cerdip packages as mentioned above were found to be coated as shown in FIG. 2 when their temperature just prior to entry into the fluidized bed was about 160° C. The exact temperature can easily be determined on an empirical basis. It is adjusted by way of control **12** which varies the power applied to heater **11** until the coating extends to the optimum length along the package lead. Raising temperature will cause the coating to extend further along the lead, whereas lowering the temperature will cause the coating line to recede back toward the body. If the temperature is much too low the body coating will become spotty.

After coating, device **5** is passed along track **9** to station **19**, which contains an air blower. Pump **20** and baffles **21** direct an air blast at device **5** to remove coating particles that have not actually stuck to the surface. Control **22** adjusts the magnitude of the air blast.

Upon leaving station **19** the still hot device is coated but the coating is probably too thin. Accordingly, as shown in dotted outline, a second fluidized bed treatment is applied at **23** and a second excess granule removal treatment is applied at **24**. Two dipping operations are shown but any number could be employed to build up the desired coating thickness, in which case the dotted portion would be repeated for as many times as required. It is not ordinarily necessary to reheat device **5** because the original heating in oven **10** ordinarily provides enough heat for several successive dips. However, if desired, additional heaters could be employed between any of the air blast stations and the succeeding dipping station.

After the final removal of excess granules, device **5** is unloaded from the clamp **7** at station **25** onto conveyor **26**, preferably with the leads resting on the conveyor as shown, and passed through oven **27**. The conveyor is powered by motor **28** with speed being controlled by control **29**. The oven is heated by heater **30** to a suitable temperature as set by control **31**. As shown in the above resin example, a suitable oven temperature is 160° C. Motor **28** is operated by setting control **29** so that the oven is traversed in about 20 minutes. This melts the resin granules and causes the hardener to react with the resin. The granules coalesce and flow into a continuous smooth coating which then sets to form a hard but resilient inert insulating coating that will protect the housing from a wide variety of adverse ambients over extended periods even at elevated temperatures.

While the preferred embodiment shows a cerdip housed semiconductor device, other housings could be so treated with benefit. For example conventional glass-and-metal housings could be so coated and such diverse items as quartz crystals or electrical relays could be housed therein. Furthermore the coating could be other than epoxy. Other thermosetting resins such as phenolics could be used as well as the thermoplastic resins such as polyethylene and others. The resins could in addition include colorants and/or fillers to modify thermal or other physical properties. It is intended that the scope of the invention be limited only by the following claims.

We claim:

1. A process for applying a coating to an encapsulating housing having a body portion and having electrical contact portions of substantially lower thermal mass than said body portion comprising:

(a) heating said housing to a predetermined first temperature,

(b) immersing said heated housing into a fluidized bed composed of granules of coating material, said granules having the property of being adherent to a hot surface,

(c) causing said granules to adhere to said body portion while not adhering to said contact portions by

selecting said first temperature to be sufficiently high to effect said adherence but sufficiently low that the cooling of said low-thermal-mass contact portions by said fluidized bed precludes adherence of said granules to said contact portions,

(d) subjecting said heated housing, subsequent to said immersion, to the action of an excess coating removal operation, and

(e) heating said housing along with such of said granules that adhere as a result of said immersing and subjecting steps to a second temperature sufficient to cause said granules to flow and coat said housing.

2. The process of claim **1** wherein the heating of clause (e) is continued for a period of time sufficient to convert said granules to a stable form.

3. The process of claim **1** wherein the steps of clauses (b), (c) and (d) are repeated at least once.

4. The process of claim **1** wherein said granules comprise epoxy resin and unreacted hardener and said second temperature is selected to react said hardener and cure said epoxy.

5. The process of claim **1** wherein said excess coating removal operation comprises an air blast of sufficient force to remove nonadherent particles.

6. The process for coating an electrical device housing having a body portion and an electrical lead portion of lower thermal mass than said body portion, including said housing and immersing said housing in a fluidized bed containing granules of coating material in solid form, said heating being to a temperature selected to cause said granules to stick to said body upon contact and to avoid the sticking of said granules to said electrical lead portion of lower thermal mass than said body, agitating said body subsequent to the immersion step with sufficient force to remove non-adherent granules, repeating the immersion and agitation steps a sufficient number of times to produce a desired coating thickness, and heating at a final temperature selected to melt and flow said granules into a continuous coating.

7. The process of claim **6** wherein the agitation step is performed with a fluid blast.

8. The process of claim **6** wherein said heating at said final temperature is continued for a sufficient length of time to convert said granules to the chemical form of the desired coating.

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EDWARD G. WHITBY, Primary Examiner

U.S. Cl. X.R.

117—218, 21, 64, 161.2 B, Dig. 6; 118—406, Dig. 5

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,756,852 Dated September 4, 1973

Inventor(s) Robert J. Scheetz and Stephen M. Sobota , Jr.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, line 27, the third line of claim 6, after "including" insert --heating--.

Signed and sealed this 19th day of March 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents