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METHOD OF MAKING AND USING DICED SINGLE CRYSTAL IMPURITY SOURCE

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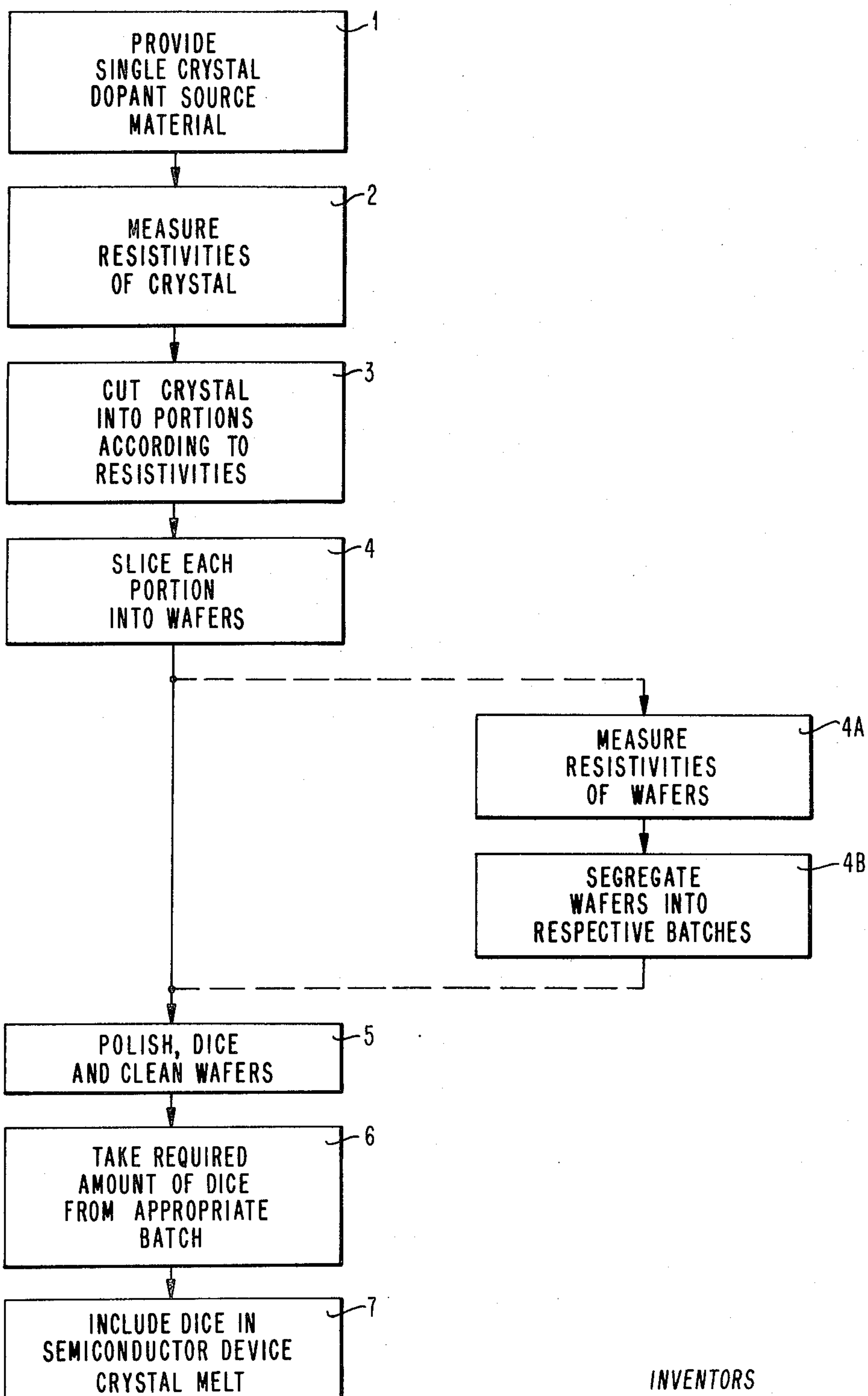


INVENTORS
MORRIS KAUFMANN
BERNARD R. SHULTZ

BY Robert J. Haase

ATTORNEY

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# METHOD OF MAKING AND USING DICED SINGLE CRYSTAL IMPURITY SOURCE

Morris Kaufmann, Los Angeles, Calif., and Bernard R. Shultz, Wappingers Falls, N.Y., assignors to International Business Machines Corporation, Armonk, N.Y.

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## ABSTRACT OF THE DISCLOSURE

A method for producing homogenous dilute dopant material for use in growing semiconductor device crystals of desired resistivity from a melt which includes the dilute dopant material. The method comprises providing the dilute dopant material in single crystal alloy form, measuring the resistivity of the crystal along its length, cutting a portion of the crystal having resistivities within a desired range, slicing said portion, polishing, dicing and cleaning the slices, and weighing out the required amount of diced dopant material as needed for the growth of a semiconductor device crystal of desired resistivity from a melt which includes the diced dopant material.

## BACKGROUND OF THE INVENTION

As is well known, the growth of semiconductor material of desired resistivity is accomplished by first providing the semiconductor material in a very pure form and then adding accurately determined amounts of an appropriate impurity to achieve the desired resistivity. The accuracy with which the wanted resistivity value is obtained, of course, is dependent upon the precision achieved in the introduction of the dopant material. Especially in the case where high resistivity single-crystal material is required, where relatively small amounts of impurity material are to be introduced, prior art methods of preparing the impurity material and for introducing the impurity material into the host semiconductor crystal do not produce acceptably uniform end results on the manufacturing floor.

Impurity source material traditionally is produced in powdered form which is weighed out in appropriate amounts according to the desired resistivity of the host crystal to be grown from a melt of highly purified semiconductor material and powdered impurity source material. It has been found, however, that the powdered source material comprises particles of relatively large and variable surface area having both absorbant and adsorbant properties which render them extremely susceptable to moisture and other contamination. The extremely small quantities of the powdered impurity material required for the growth of high resistivity semiconductor material particularly aggravates the problem of precisely ascertaining the correct amount of powder to achieve reproducible resistivity values in the end product host crystal.

## SUMMARY OF THE INVENTION

The method of the present invention produces homogeneous dilute impurity source material in diced form of uniform size which does not attract moisture and other contamination which can be etch cleaned as necessary, and which is very convenient to weigh out in appropriate amounts to achieve precisely determined resistivities of the semiconductor device crystal to be grown from a melt including the impurity material. The impurity material is first grown as a single crystal alloy, characterized for resistivity and cut into portions having resistivities within respective range. At least one of the portions is sliced into wafers, polished, diced and cleaned. An amount of diced impurity material required for the growth of a given



resistivity semiconductor device crystal is weighed out and included in the melt from which the device crystal is grown.

## BRIEF DESCRIPTION OF THE DRAWING

The single figure is a flow diagram of a preferred embodiment of the method of the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

In step 1 of the drawing, dilute dopant source material is provided in single crystal form. Such single crystals may be procured from commercial vendors or may be grown by the user in accordance with well known crystal growth methods. The single crystal dopant source is prepared for the resistivity measurement of step 2 by grinding to yield a crystal of uniform diameter. Resistivity measuring probes are brought into contact with the crystal surface parallel to the crystal axis to determine the resistivity of the crystal as a function of position along the length of crystal. The crystal then is cut transversely with respect to its longitudinal axis into portions in accordance with the measured resistivities. Each crystal portion is characterized by resistivity values within a predetermined range of values. Depending upon the requirements of the user, one or more of the portions are subjected to further processing in accordance with the present invention.

Each portion of interest to the user is separately subjected to the additional steps 4–7. In step 4, each portion is sliced into wafers. The wafers are polished, diced and cleaned in step 5 in accordance with well known techniques or, optionally, they are first treated by steps 4A and 4B. Steps 4A and 4B provide for the further characterization of the wafers by measuring the resistivities of the wafers (step 4A) and then segregating the wafers into respective batches (step 4B) in accordance with their measured resistivities. The wafer resistivity measurement and wafer segregation may be required where very tight resistivity control is required of the dopant source which cannot be reproducibly achieved solely by the bulk resistivity measurement of step 2. In any event, either the batch of wafers yielded directly from step 4 or one of the wafer batches yielded from step 4B is polished, diced and cleaned in step 5. Each of the additional wafer batches resulting from step 4B is separately processed in the same manner.

It has been found that conventional polishing, dicing and cleaning operations inherently provide a certain amount of dice mixing and intermingling which is adequate for many applications of the present invention. In special cases where more thorough (random) mixing of the dice is required, a separate dice mixing step may be added to the present invention directly following step 5. In step 6, the required amount of dice is taken from the mixture of dice of an appropriate batch (from step 4 or from step 4B) and is included (step 7) in the melt from which the ultimately desired semiconductor device crystal is grown. As is well known, the amount of dilute dopant dice taken in step 6 is determined in accordance with the impurity concentration required in the semiconductor device crystal.

The precision with which the required impurity concentration is achieved depends, of course, on the accuracy with which the average resistivity of the dopant dice resulting from step 6 can be ascertained. It has been established that closely reproducible average resistivity values of dopant dice are obtained provided that the number of dice selected from a given batch in step 6 exceeds a minimum statistical number and provided that the dice are adequately mixed within their respective batch. As previously mentioned, experience has shown that the conventional polishing, dicing and cleaning operations of step 5 provide sufficient mixing for many applications of the present invention.

Additional deliberate mixing may be introduced between steps 5 and 6, if necessary. With adequate mixing, closely reproducible average resistivity values are achieved when at least 25 dopant dice are taken from a respective batch in step 6. It is convenient in the dicing operation of step 5 to cut a given wafer into individual dice of the order of a hundredth of an inch. Using such sized dice, the aforementioned twenty-five dice minimum quantity is exceeded several fold in constituting the dopant charge required for even the smallest semiconductor device crystal melts used in ordinary production runs.

The diced impurity source provided by the method of the present invention possesses a much smaller surface to volume ratio than the individual particles of prior art pulverized dopant source material. The dice exhibit a much reduced tendency to attract moisture and to react with oxygen and other contaminants than powdered source material. Moisture, in particular, is reduced in diced dopant material in relation to powdered dopant material. These unique characteristics in combination facilitate the accurate determination of the amount of dopant material included in semiconductor device crystal melt to closely and reproducibly control the impurity concentration thereof. A feature of the present method is that different dopant source material can be simply identified by visual inspection by cutting the wafers of different resistivity dopant material into distinctively sized and shaped dice. Such visual identification is not possible where all dopant source material of different impurity concentrations are reduced to powdered form.

The minimum surface area exhibited by the diced impurity material minimizes the probability of contamination while the impurity material is being processed and before it is put to use in doping a host crystal. Such minimum surface area, however, is no deterrent to the efficient use of the desired impurities within the diced material because it is reduced to a melt along with the host semiconductor material when it is put to use.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. In a method for making a semiconductor device crystal of desired resistivity, the steps comprising:
providing dilute impurity source material in single crystal form,
measuring the resistivity of said source crystal along the length thereof,
selecting a portion of said source crystal having resistivities within a desired range,
slicing said portion into wafers,
dicing said wafers, and
using an amount of said dice as the impurity source for making said semiconductor device crystal of desired resistivity.



2. The method defined in claim 1 wherein:
said amount of dice is used by including said amount of dice in a melt from which a semiconductor device crystal is grown.

3. In a method for producing a semiconductor device crystal of desired resistivity, the steps comprising:
providing dilute impurity source material in single crystal form,
measuring the resistivity of said crystal along the length thereof,
selecting a portion of said crystal having resistivities within a desired range,
slicing said portion into individual wafers,
measuring the resistivity of each said wafer,
segregating said wafers into respective batches according to the measured resistivities,
separately dicing the wafers of each said batch, and
using an amount of said dice from the same batch as the impurity source in making said semiconductor device crystal.

4. The method defined in claim 3 wherein:
said amount of dice is used by including said amount of dice in a melt from which said semiconductor device crystal is grown.

5. The method defined in claim 3 wherein:
each wafer is polished before being diced, and
each dice is cleaned before being used in making said semiconductor device crystal.

6. The method defined in claim 3 wherein:
said amount of dice is determined by weighing out the required amount of said dice as needed for the making of said semiconductor device crystal.

7. The method defined in claim 3 wherein:
said dice of a respective batch are mixed before being used in the making of said semiconductor device crystal.

8. The method defined in claim 3 wherein:
said amount of said dice exceeds 25.

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L. DEWAYNE RUTLEDGE, Primary Examiner

E. L. WEISE, Assistant Examiner

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