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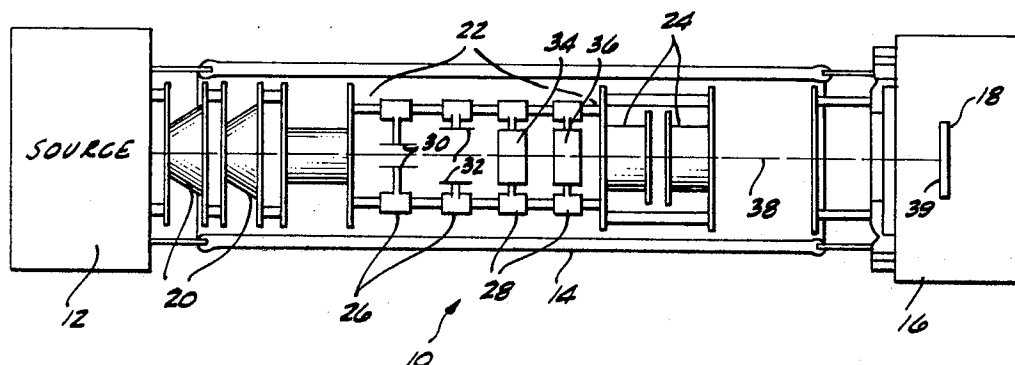
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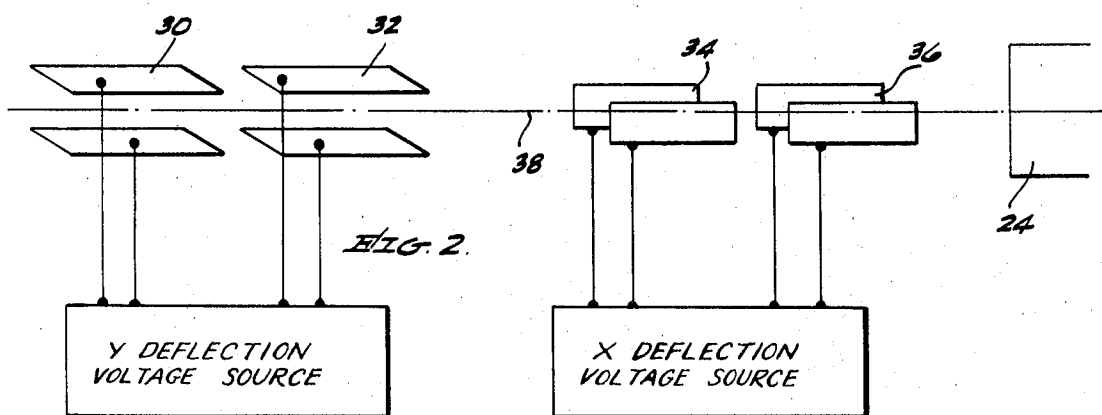
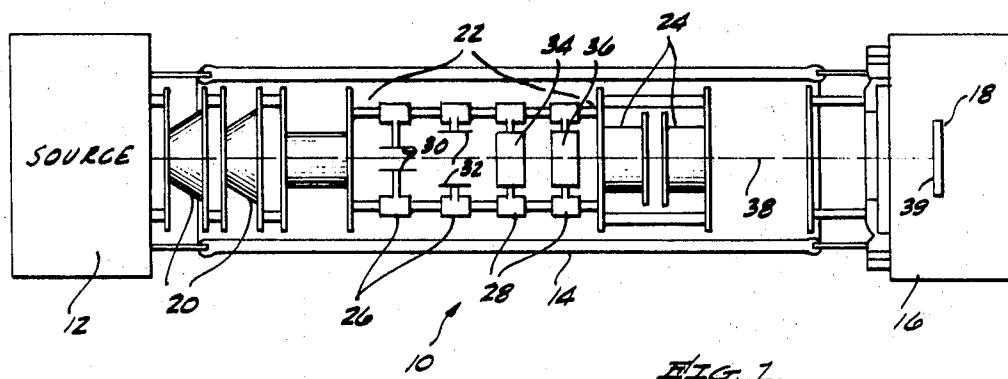
[54] **ACCELERATION SYSTEM FOR IMPLANTING
 IONS IN SPECIMEN**
 1 Claim, 2 Drawing Figs.

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ABSTRACT: A two-dimensional double deflection system for ion implantation of semiconductor devices comprises deflecting an ion beam in orthogonal directions such that the ion incidence angle is always constant with respect to a target. The beam is first deflected in a direction away from a reference axis and thereafter is redeflected along a path which lies parallel to the reference axis. The second double deflection is similarly performed but orthogonal to the first double deflection. The beam can thus be swept over the entire target for uniform device implantation characteristics.





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ACCELERATION SYSTEM FOR IMPLANTING IONS IN SPECIMEN

The present invention relates to a system for affecting the surface characteristics of a specimen by means of ion implantation techniques and, more particularly, to such a system for precisely deflecting and accelerating an ion beam toward the specimen. The acceleration and deflection system is especially useful for impacting the ion beam on the specimen under identical conditions of incidence angle and current density as the beam is swept over the target.

The control and deflection of charged submolecular particles has been known for many years, in particular, with respect to the control and deflection of electron beams within cathode-ray tubes and the like. In such prior art devices, an electron beam is directed to desired positions or areas on a phosphor surface or screen in order to cause specific luminescence of these areas and, for this purpose, the angle of incidence at which the screen is struck is unimportant.

In ion implantation techniques, however, the surface characteristics of a target or specimen are purposely altered by impaction and implantation of ions, for example, for the introduction of impurity of doping atoms into semiconductor devices. For such implantation purposes, prior electron control and deflection techniques are not directly applicable because the lattice structure of the specimen imparts a preferred direction to the incident ions.

The targets or specimens used in the ion implantation techniques, for example, comprise high quality and high purity crystals, that is, a crystal which has a few impurities. In such a crystal, the atoms are aligned in such a manner that channels occur between aligned rows of atoms. In order to fabricate a suitable specimen, the crystal is cut in such a manner that the channels and aligned atoms are disposed at a known angle to the surface of the crystal. When ions are directed at the surface, crystal atoms are dislocated from their lattice positions, that is, radiation damage occurs, and some of the lattice atoms are caused to move into the channels, thereby disturbing the electrical and physical characteristics of the crystal. In order to alleviate radiation damage, such crystals are heated to increase lattice vibration and to permit movement of dislocated atoms back into their proper lattice positions.

Such radiation damage occurs regardless of the incident angle of the ion beam; however, such radiation damage can be reduced by directing the ion beam in such a manner that it impacts the crystal along the axis of a channel so that there will be less probability for the ions to strike crystal atoms and so that there will be increased likelihood for undisturbed implantation of ions within the channels.

In ion implantation techniques, it is especially important to obtain uniform implantation characteristics of the specimen, including a uniform crystal volume density, in terms of ions per cubic centimeter. In addition, it is also desired to obtain uniform depth of penetration of ions into the specimen. The angle of incidence of the ion beam with respect to the crystal channels has a profound effect on the depth to which they penetrate the crystal and, consequently, on the doped density profile.

The present invention accomplishes these ends by doubly deflecting an ion beam with respect to a reference axis in such a way that the ion incidence angle is always constant. The beam is first deflected in a direction away from the axis and thereafter is redeflected along a path which lies parallel to the reference axis. A similar deflection and redeflection is obtained orthogonally to the above deflection and redeflection. For example, if the reference axis is normal to the surface of a specimen, the beam will always strike the specimen surface at right angles, even as the beam is electrically deflected over a large surface area of the crystal.

It is therefore, an object of the present invention to provide a means for double deflection of an ion beam;

Another object is the provision of a means for deflecting an ion beam from a reference axis to a path which lies parallel to the reference axis; and

Another object is to provide a means by which an ion beam is suitably focused and deflected so that the density of the ion beam and the incidence angle of the ions at the target are constant as the beam is swept over the target.

Other aims and objects as well as a more complete understanding of the present invention will appear from the following explanation of an exemplary embodiment and the accompanying drawings thereof, in which;

FIG. 1 is a schematic view of a double deflection and acceleration apparatus; and

FIG. 2 is a schematic of the orthogonally placed deflection plates.

Accordingly, with reference to FIGS. 1 and 2, an ion beam system 10 comprises a source 12 for producing an ion beam, a deflection and acceleration system 14 for controlling and twice doubly deflecting the ion beam, and a target chamber 16 enclosing and supporting a target or specimen 18 therein.

Source 12 creates a stream of ions which enter system 14 and may comprise only an ionizing source or an ionizing source and a mass separator. The acceleration and double deflection system includes a conical focusing mechanism 20, such as an Einzel lens, to accelerate the beam with a minimum of focusing, when mass separation is utilized, to adjust the ion trajectories to suitable paths after emergence from the mass separator, a two-dimensional double deflection mechanism 22, and an accelerator 24.

The focusing mechanism may be formed in any conventional manner, as is well known in the art, which is consistent with the deflection means and the objects of the implantation.

Deflection system 22 comprises a first mechanism 26 for double deflection of an ion beam along the Y-axis and a second mechanism 28 for double deflection of the ion beam along the X-axis. Mechanism 26 comprises, for example, two pairs of parallel spaced plates 30 and 32 while mechanism 28 comprises two pairs of parallel spaced plates 34 and 36. Focusing mechanism 20, two-dimensional double deflection mechanism 22, accelerator 24, and target or specimen 18, are all disposed along a central reference axis 38 which is positioned at the desired angle with respect to surface 39 of specimen 18.

As shown in FIG. 1, plates 30 are more closely spaced to each other and from the reference axis than plates 32 while plates 34 are also more closely spaced from axis 38 than plates 36. In this configuration plates 30 and 34 have less of an electrostatic potential than plates 32 and 36 in order to provide the proper acceleration and deflection. However, as depicted in FIG. 2, plates 30 and 32 and plates 34 and 36 may all be equally spaced from reference axis 38 and be provided with equal potentials. In addition, plates 30 and 32 are orthogonally disposed with respect to plates 34 and 36 in order to provide the Y-double deflection and the X-double deflection of the ion beam.

In operation, the ion beam enters from source 12 and is focused along axis 38 by means of a lens 20. As the beam passes between plates 30, the beam is deflected away from axis 38. The beam, upon entering plates 32, is then deflected back into parallel disposition with respect to axis 38, both deflections being a first double deflection and being effected in the Y-direction. Plates 34 and 36 perform the same operation as plates 30 and 32 except that this second double deflection takes place in the X-direction. In order to accomplish both double deflections in the X- and Y-directions, the transverse gradients in sets of plates 30 and 32 and sets of plates 34 and 36 must each be opposite. The plates of deflection mechanism 22 may be so arranged as to be provided with constantly changing voltages so that the ion beam will scan or sweep the entire surface area of target 18 at right angles. If however, the ion beam were sufficiently narrow, spot implantations could be as easily produced.

Accelerator 24 comprises a series of cylinders or plates having central openings therein. To provide acceleration, these plates may be equally spaced from one another and have a constant voltage gradient imposed thereon. Equally as effec-

tive, the plates may be nonequally spaced from one another in constantly decreasing distances and have a constant and equal voltage imposed on all the plates. Moreover, the accelerator may be placed in front of the double deflection mechanism 22 rather than behind the mechanism, as shown.

Although the invention has been described with reference to particular embodiments thereof, it should be realized that various changes and modifications may be made therein without departing from the spirit and scope of the invention.

We claim:

1. An ion implantation system for implanting ions into a specimen, said ion implantation system having an axis, said ion implantation system comprising:

an ion source for producing an ion beam;

target means on said axis for receiving ions by beam impingement, said target means having a surface on which the ions impinge;

a first pair of substantially parallel spaced plates downstream along said axis from said source and substantially equispaced with respect to said axis and lying substantially parallel to said axis, deflection voltage means connected to said first pair of parallel spaced plates for applying a potential difference for deflecting the beam away from the axis at an angle with respect to said axis;

a second pair of parallel spaced plates downstream along said axis from said first pair of parallel spaced plates, said second pair of parallel spaced plates being substantially parallel to said first pair of parallel spaced plates and being substantially equispaced from said axis, deflection voltage means connected to said second pair of parallel spaced plates for applying an opposite potential such that

the ion beam deflected away from said axis by said first pair of parallel spaced plates is deflected toward said axis by said second pair of parallel spaced plates to a path substantially parallel to said axis so that the beam impinges the target along a path substantially parallel to said axis, irrespective of the deflection of the beam from the axis;

a third pair of parallel spaced plates positioned about said axis downstream from said second pair of parallel spaced plates;

a fourth pair of parallel spaced plates positioned about said axis downstream from said third pair of parallel spaced plates, said third and fourth pairs of parallel spaced plates each being substantially parallel to said axis and to each other and said third pair and said fourth pair of parallel spaced plates each being substantially equidistantly spaced from said axis, said third and fourth pairs of parallel spaced plates being at substantially right angles to said first and second pairs of parallel spaced plates;

deflection voltage means connected to said third pair of parallel spaced plates for applying a potential gradient thereto to deflect the beam at an angle away from said axis; and

deflection voltage means connected to said fourth pair of parallel spaced plates for applying a potential gradient thereto to redeflect the beam toward said axis onto a path substantially parallel to said axis so that the beam impinges the target along a path substantially parallel to said axis, irrespective of the deflection of the beam from the axis.

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