Although existing containers are designed to reduce the effects of physical shock which can damage thin and fragile wafers, wafer containers are needed with improved shock reducing properties. There is a need for a wafer carrier specifically designed to be suitable for use with very thin wafers, in particular to accommodate their increased fragility while maintaining low manufacturing cost.

SUMMARY OF THE INVENTION

According to a first aspect, there is provided a wafer shipper comprising a cassette and a cassette container and configured for holding thin wafers, the cassette comprising a pair of sidewalls defining slots for holding wafers, a pair of endwalls extending between the sidewalls, one of the endwalls configured as an H-bar machine interface, and pair of elongate feet extending downwardly from the respective sidewalls; the cassette container comprising a bottom base portion for receiving the cassette therein, and a top cover attachable to bottom base portion, each of the top cover and base portion having four walls and a common wall spanning between the four walls, each of the top cover and base portion having a juncture for closing the top cover to the base portion, the cassette container further comprising an upper cushion attachable to the top cover and a lower cushion that seats in a receiving region in the bottom base portion; wherein the upper cushion is secured to the inside of the top cover and the upper cushion has teeth defining V-shaped grooves for receiving the periphery of the wafers, the V-shaped grooves defining wafer slots, the upper cushion having a plurality of prongs each positioned intermediate the slots defined by the V-shaped grooves whereby the prongs extend inwardly beyond the teeth intermediate the wafers.

According to a second aspect, there is provided a wafer shipper comprising a cassette and a cassette container, the cassette comprising a pair of sidewalls defining slots for holding wafers, a pair of endwalls extending between the sidewalls, one of the endwalls configured as an H-bar machine interface, and pair of elongate feet extending downwardly from the respective sidewalls; the cassette container comprising a bottom base portion for receiving the cassette therein, and a top cover attachable to bottom base portion, each of the top cover and base portion having four walls and a common wall spanning between the four walls, each of the top cover and base portion having a juncture for closing the top cover to the base portion, the cassette container further comprising an upper cushion attachable to the top cover and a lower cushion received in the bottom base portion, the upper cushion being secured to the inside of the top cover and the upper cushion has a pair of rails that attach to the top cover and that support a plurality of wafer engaging segments, the wafer engaging segments each having a V-shaped groove, the upper cushion further comprising a plurality of tapered guides, each with a tip, extending downwardly from the rails, the tapered guides each positioned such that tips of the guides move past the periphery of the wafers before the wafer peripheries enter the V-shaped grooves.

According to a third aspect, there is provided a wafer shipper comprising a cassette and a cassette container, the cassette comprising a pair of sidewalls defining slots for holding wafers, a pair of endwalls extending between the sidewalls, one of the endwalls configured as an H-bar machine interface, and pair of elongate feet extending downwardly from the respective sidewalls; the cassette container comprising a bottom base portion for receiving the cassette therein, and a top cover attachable to bottom base portion, each of the top cover and base portion having four walls and a common wall spanning between the four walls, each of the top cover and base portion having a juncture for closing the top cover to the base portion, the cassette container further comprising an upper cushion attachable to the top cover and a lower cushion received in the bottom base portion, and wherein the lower wafer cushion comprises a pair of rails supporting a plurality wafer engagement portions, and wherein the lower cushion further comprises a plurality of pads extending laterally out from the pair of rails, and wherein the wafer cushion seats on a floor of the base portion by way of the plurality of pads and each of the pads has a top surface and when the cassette is positioned in the base portion, the feet of the cassette seat on top of the pads whereby the pads are sandwiched between the base portion floor and the cassette.

According to a fourth aspect, there is provided a method of protecting thin wafers in an H-bar cassette during shipment, the H-bar wafer cassette having a plurality of slots with each slot having a rigid edge portion at the bottom of the slot, the method comprising: raising the wafers out of contact with the cassette by suspending the wafers between a row of end suspended upper arcuate wafer engagement portions engaging an arcuate edge portion centered about top dead center of the wafers and a row of end suspended lower arcuate wafer engagement portions engaging an arcuate edge portion centered about the bottom top dead center of the wafers; spacing the wafers from the cassette such that there is a predetermined radial gap between each of the wafers and each respective rigid edge portion and positioning a lower cushion such that there is a predetermined circumferential gap between the end of each lower arcuate wafer engagement portion and the rigid edge portion; and providing one or both of the following steps: providing further a pair of rows of rigid upper arcuate support portions, each arcuate support portion spaced from an end of the end suspended upper arcuate wafer engagement portions, the positioning of the pair of rows of rigid upper arcuate support portions in substantial vertical alignment with the rigid edge portions, and providing a pair of rows of prongs extending from a top cushion positioned for extending intermediate adjacent wafers, each row of prongs in vertical alignment with one of the respective rows of rigid edge portions.

According to a fifth aspect, there is provided a method of protecting thin wafers in an H-bar cassette during shipment, the H-bar wafer cassette having a plurality of slots with each slot having a rigid edge portion at the bottom of the slot, the method comprising: raising the wafers out of contact with the cassette by suspending the wafers between a row of end suspended upper arcuate wafer engagement portions engaging an arcuate edge portion centered about top dead center of the wafers

and a row of end suspended lower arcuate wafer engagement portions engaging an arcuate edge portion centered about the bottom top dead center of the wafers; spacing the wafers from the cassette such that there is a predetermined radial gap between each of the wafers and each respective rigid edge portion and positioning the lower cushion such that there is a predetermined circumferential gap between the end of each lower arcuate wafer engagement portion and the rigid edge portion; providing further a pair of rows of rigid upper arcuate support portions, each arcuate support portion spaced from an end of the end suspended upper arcuate wafer engagement portions, the positioning of the pair of rows of rigid upper arcuate support portions in substantial vertical alignment with the rigid edge portions, and spacing each rigid upper arcuate support portion such that it has a radial gap corresponding to the predetermined radial gap between each of the wafers and each respective rigid edge portion; and providing a pair of rows of prongs positioned for extending intermediate adjacent wafers, each row of prongs in vertical alignment with one of the respective rows of rigid edge portions, each prong extending inwardly a maximum radial distance substantially equivalent to the maximum radial distance that the teeth extend inwardly.

According to a sixth aspect, there is provided a method of protecting thin wafers during shipment comprising: suspending the wafers between a row of upper arcuate wafer engagement portions and lower arcuate wafer engaging portions each with V-shaped grooves for engaging the wafers, the upper arcuate wafer engagement portions and lower arcuate wafer engagement portions each being supported spanning arcs at top dead center of the respective wafers and rows of lower arcuate wafer engagement portions spanning arcs at bottom dead center of the respective wafers, the upper and lower arcuate wafer engagement portions each having a pair of ends; providing further more rigid arcuate support at pairs of rigid supports spaced from each ends of the upper arcuate wafer engagement portions and spaced from each end at the lower arcuate wafer engagement portions each end of the arcuate wafer cushions, the more rigid supports not engaged with the wafers during shipment except when in a shock condition; providing further prongs extending downwardly intermediate the wafers, the prongs not engaging the wafers except in a shock condition.

According to a seventh aspect, there is provided the above wafer shipper or the above method of protecting thin wafers, wherein each of the components are formed of polypropylene.

According to an eighth aspect, there is provided a wafer cushion for placement at the open top of an H-bar wafer cassette, the cushion having a plurality of separate and end supported arcuate wafer engaging segments each having a V-shaped groove, a U-shaped spring extending from each end of each wafer engaging segment, each U-shaped spring connecting to a rail portion, the rail portion providing a rigid arcuate wafer engagement surface that is radially spaced outward from the respective arcuate wafer engaging segments, each rail further having a plurality of prongs extending radially inward for placement inbetween wafers secured by the wafer engaging segments.

According to a ninth aspect, there is provided a wafer shipper having a cassette with opposing sidewalls, the sidewalls connected by opposing end walls, each sidewall having a vertical upper portion and a converging lower portion, interior surfaces of the sidewalls defining a plurality of teeth with slots therebetween for holding axially aligned wafers, a cushion for placement at the open top of the H-bar wafer cassette, the cushion having a plurality of arcuate wafer engaging segments each having a V-shaped groove, each V-shaped groove having a height measured in a radial direction, the cushion further having a plurality of guides positioned proximate the ends of the wafer engaging segments, the guides extending radially inward for placement in vertical alignment with the teeth of the cassette.

Embodiments of the invention disclose~~The invention as depicted is an embodiment of~~ an improved wafer container for use in transporting, storing or processing thin data semiconductor wafers or other thin substrates. Embodiments of t~~T~~he present invention comprises generally a cassette portion and a container

portion. The cassette portion wafer cassette is a single molded part generally comprising a front end having an H-bar machine interface portion, a back end having a panel, and sidewalls having slots comprising lower curved or converging portions following the curvature of the wafers, and with an open top and open. Parallel feet portions extend downwardly from the bottoms of the converging portions and present feet edge surfaces.

This cassette is placed into a two-piece container portion for transport. Thi s container portion comprises a top cover which attaches to a bottom cover. The top and bottom covers also include a cushion assembly which is designed to ensure that the wafers do not cross-slot and that they are sufficiently held in place during transportation to avoid damage. The top cover wafer retaining cushion assembly is removable and is formed so that it contacts the edge periphery of the wafer from the top of the side wall ribs on one side of the cassette to the top of the side wall ribs on the opposite side of the cassette. This upper cushion includes spring features, configured as U-shaped sections, on each rib section near each side of the cushion assembly that provide controlled compressive force to the wafers to prevent wafer rotation during transit and shipping. This upper cushion also contains an extended tooth guide-in portion segment, configured as a prong, on the end of each rib section at the sides of the cushion assembly. Upon placement of the top cover onto the base portion the wafer edges first encounter and possibly engage the wafer guides to prevent the wafers from cross-slotting. Wafer cross-slotting is defined as the condition where a wafer locates in a top cushion and in the adjacent lower cushion of between cushion segments. The bottom cover also includes a removable wafer retaining cushion assembly. This cushion assembly is formed so that it contacts the edge periphery of the wafer from the bottom of the side wall ribs on one side of the cassette to the bottom of the side wall ribs on the opposite side of the cassette. The bottom cushion may simply

between the wafer cassette portion feet and the base portion. Thus the lower wafer cushion, in certain embodiments, provides direct engagement and cushioning to the wafers as well as providing cushioning the cassette portion.

Additional embodiment~~objects~~, advantages, and novel features of the invention will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following or may be learned by practice of the invention. The embodiment~~objects~~ and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of a wafer shipper according to the invention herein.

Figure 2 is an exploded view of a wafer shipper according to the invention herein.

Figure 3 is a cross section view of the wafer shipper of Figure 1 according to the invention herein.

Figure 4 is a top perspective view of the base portion of the shipper of Figure 3.

Figure 5 is a top perspective view of the upper wafer cushion to be seated in the base portion.

Figure 6 is a perspective view of the bottom side of the wafer cushion of Figure 5.

Figure 7 is a cross sectional view of the wafer cushion of Figures 5 and 6.

Figure 8 is a cross sectional view taken at line 8-8 of Figure 7.

Figure 9 is a top perspective view of the base portion with the wafer cushion seated therein.

Figure 10 is a front elevational view of the assembled shipper with portions broken away to disclose the pad of the wafer cushion sandwiched between the base portion and the wafer cassette foot.

Figure 11 is a top perspective view of a wafer cushion suitable for the top cover and in accord with the invention herein.

Figure 12 is a bottom perspective view of the wafer cushion of Figure 11.

Figure 13 is a cross sectional view through the wafer cushion of Figure 11 and 12.