

CLAIMS

1. A sterile tube connecting device for joining a first tubing with a second tubing, the device comprising:
- 5 a first tube clamp longitudinally moveable forward and backward;
a second tube clamp spaced apart from the first tube clamp and laterally moveable leftward and rightward perpendicular to forward and backward movement of the first tube clamp, the first tube clamp and the second tube clamp provided to simultaneously clamp the first tubing and the second tubing such that a central
10 longitudinal axis of the first tubing is parallel with a central longitudinal axis of the second tubing;
heating elements;
a carriage for supporting and moving a cutting wafer thereon, the carriage being longitudinally moveable forward and backward and vertically moveable upward and
15 downward;
a lead screw rotated by a motor, the lead screw having a lead screw nut fixedly connected to the carriage wherein movement of the carriage is driven by rotation of the lead screw;
wherein the carriage is moveable when supporting the wafer thereon to bring the wafer
20 into contact with the heating elements to heat the wafer to a pre-determined temperature,
wherein movement of the carriage forward and upward after heating of the wafer moves the wafer away from the heating elements and passes the wafer through the first tubing and the second tubing between the first tube clamp and the second tube clamp
25 thereby cutting the first tubing and the second tubing,
wherein the carriage is automatically mechanically connected to the first tube clamp after the first tubing and the second tubing have been cut such that the first tube clamp moves forward together with the carriage when the carriage moves forward after the first tubing and the second tubing have been cut, wherein when the first tube clamp
30 has been moved forward, a retained length of the first tubing clamped by the first tube clamp becomes axially aligned with a retained length of the second tubing clamped by the second tube clamp;
wherein the device is further configured to automatically and mechanically displace the
35 second tube clamp laterally towards the first tube clamp when the carriage moves forward after the retained length of the first tubing has been axially aligned with a

retained length of the second tubing and the wafer has been removed from contact with the first tubing and the second tubing, thereby bringing together melted cut ends of the retained length of the first tubing and the retained length of the second tubing to form a weld between the melted cut ends, thus forming a single length of tubing from the retained length of the first tubing and the retained length of the second tubing; and

an electrical control circuit board programmed to control rotation of the motor to drive movement of the carriage.

2. The sterile tube connecting device of claim 1, wherein the carriage comprises an upper carriage assembly and a lower carriage assembly, the upper carriage assembly being in vertically oriented sliding engagement with the lower carriage assembly, wherein both the upper and lower carriage assemblies are together moveable forward and backward and only the upper carriage assembly is moveable upward and downward.

3. The sterile tube connecting device of claim 2, wherein the device further comprises upstanding first and second cam plates provided one on each side of a path of travel of the carriage, the first and second cam plates each having a cam track facing the path of travel, the upper carriage assembly having first and second upper carriage cam followers configured to rotatably engage the cam tracks of the first and second cam plates respectively, wherein longitudinal and vertical movement of the upper carriage assembly is guided by profiles of the cam tracks.

4. The sterile tube connecting device of any one of claims 2 or 3, wherein the upper carriage assembly comprises an upper carriage block, a longitudinally oriented wafer support slot provided on the upper carriage block for supporting the wafer therein, wafer guide pins provided beside the wafer support slot to guide movement and positioning of the wafer in the wafer support slot, and a wafer latch provided to secure the wafer in the wafer support slot and prevent backward movement of the wafer.

5. The sterile tube connecting device of any one of claims 2 to 4, wherein the first tube clamp is fixedly provided on top of a displacement mechanism assembly that is longitudinally moveable forward and backward, the device further comprising a displacement lock mechanism to lock and unlock the displacement mechanism assembly to prevent and allow longitudinal displacement of the first tube clamp respectively.

6. The sterile tube connecting device of claim 5, wherein the displacement lock mechanism comprises a vertically moveable and longitudinally immovable displacement lock cam guide, a displacement lock pin having a free upper end and a lower end fixedly attached to the displacement lock cam guide, a displacement lock spring that biases the displacement lock cam guide and displacement lock pin upward, and a front pin slot and a back pin slot both provided on the displacement mechanism assembly to separately engage the free upper end of the displacement lock pin at different times to prevent longitudinal displacement of the first tube clamp; wherein the device further comprises a pin provided on the lower carriage assembly to engage the lock cam guide in order to lock the displacement mechanism assembly.
7. The sterile tube connecting device of claim 6, wherein the cam tracks each comprise a first horizontal vector for horizontal movement of the upper carriage assembly to move the carriage to the heating area.
8. The sterile tube connecting device of any one of claims 5 to 7, wherein the cam tracks each comprise a first angled ramp that is angled upward in the forward direction; wherein when the upper carriage cam followers engage the first angled ramp and the carriage is moved forward, the upper carriage assembly moves forward and upward along the first angled ramp for the wafer supported on the upper carriage assembly to cut through the first tubing and the second tubing while the displacement mechanism assembly is locked by the displacement lock mechanism to prevent longitudinal displacement of the first tube clamp while the wafer cuts the first tubing and the second tubing.
9. The sterile tube connecting device of any one of claims 5 to 8, further comprising a displacement catch and a displacement notch, wherein the displacement catch is provided on one of the upper carriage assembly and the displacement mechanism assembly, and wherein the displacement notch is provided on the other of the upper carriage assembly and the displacement mechanism, wherein the displacement catch automatically engages the displacement notch after the first and second tubings have been cut and the displacement lock mechanism has unlocked the displacement mechanism assembly to allow longitudinal movement of the first tube clamp, wherein engagement of the displacement catch with the displacement notch mechanically connects the upper carriage assembly with the first tube clamp to move the first tube clamp forward when the carriage

moves forward after the first tubing and the second tubing have been cut so as to axially align the retained length of the first tubing with the retained length of the second tubing.

- 5 10. The sterile tube connecting device of claim 9, wherein the cam tracks each comprise a second horizontal vector for forward movement of the carriage assembly after the first tubing and the second tubing have been cut.
- 10 11. The sterile tube connecting device of any one of claims 3 to 10, wherein the cam tracks each comprise a second angled ramp that is angled downward in the forward direction; wherein when the upper carriage cam followers engage the second angled ramp and the carriage is moved forward, the upper carriage assembly moves forward and downward to remove the wafer supported on the upper carriage assembly from the cut first tubing and the cut second tubing.
- 15 12. The sterile tube connecting device of any one of claims 3 to 11, wherein the second tube clamp is fixedly provided on the second cam plate, wherein the second cam plate is laterally displaceable leftward and rightward and biased towards the first cam plate by welding mechanism springs provided between the second cam plate and an immovable welding mechanism back plate, wherein the second cam plate comprises a welding cam guide facing the path of travel of the carriage, wherein the lower carriage assembly comprises a lower carriage cam follower that rotatably engages the welding cam guide, wherein the welding cam guide has a step extending laterally outward such that when the lower carriage cam follower travels over the step, the welding mechanism springs displace the second cam plate towards the first cam plate, thereby displacing the second tube clamp towards the first tube clamp to bring together melted cut ends of the retained length of the first tubing and the retained length of the second tubing.
- 20 25 30 35 13. The sterile tube connecting device of any one of the preceding claims, further comprising a loading mechanism configured to load the wafer onto the carriage when the carriage moves backward from a heating area to a loading area, the loading mechanism comprising: a loading lower rack moveable backward from a forward position to a backward position by backward movement of the carriage when the carriage is in contact with a forward end of the loading lower rack; a loading pinion gear in engagement with the loading lower rack; a loading upper rack in engagement with the pinion gear such that the loading upper rack moves in an opposite direction from movement of the loading lower rack; and a loading

block fixedly attached to the loading upper rack to push a wafer forward out of a wafer cartridge onto the carriage when the loading upper rack moves forward as a result of the loading lower rack moving backward when the carriage moves backward to the loading position.

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14. The sterile tube connecting device of claim 13, wherein the loading mechanism further comprises a loading lower rack spring provided about the loading lower rack between a loading lower rack plunger head provided at the forward end of the loading lower rack and a loading mechanism housing supporting the loading lower rack, wherein the loading lower rack spring returns the loading lower rack from the backward position to the forward position when the carriage moves forward away from the loading position.

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15. The sterile tube connecting device of any one of the preceding claims, further comprising an extraction mechanism configured to remove the wafer from the carriage, the extraction mechanism comprising: an extraction lower rack moveable forward from a backward position to a forward position by forward movement of the carriage when the carriage is in contact with a backward end of the extraction lower rack; an extraction pinion gear in engagement with the extraction lower rack; an extraction upper rack in engagement with the pinion gear such that the extraction upper rack moves in an opposite direction from movement of the extraction lower rack; an extraction linkage fixedly attached to the extraction upper rack; and an extraction catch moveable connected to the extraction linkage and laterally displaceable leftward and rightward relative to the extraction linkage; the extraction catch engaging a rear edge of a used wafer supported on the carriage when the extraction upper rack moves backward as a result of the extraction lower rack moving forward when the carriage moves forward to the extraction position after the first tubing and the second tubing have been cut; wherein the wafer is pulled forward off the carriage by the extraction catch when the carriage moves backward away from the extraction position and the extraction lower rack is returned to the backward position by an extraction spring provided between an extraction lower rack plunger head provided at the backward end of the extraction lower rack and an upstanding front plate of the device.

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16. The sterile tube connecting device of claim 15 when dependent on claim 13 or 14, wherein the device further comprises a locating pin provided on the carriage to interface with: a heating position sensor provided at the heating area, a loading position sensor provided at the loading area, and an extraction position sensor provided at the extraction area, in order

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to automatically detect arrival of the carriage at the heating area, the loading area and the extraction area respectively.

17. The sterile tube connecting device of claim 16, wherein in one cycle of use of the device,
5 the electrical control circuit board is programmed to control rotation of the motor to move the carriage from the heating position backward to the loading position to load the wafer onto the carriage, from the loading position forward to the heating position to heat the wafer, from the heating position forward to the extraction position to cut and join the first tubing and the second tubing, and from the extraction position backward to the heating
10 position to remove the wafer from the carriage.
18. A cutting wafer for use with the sterile tube connecting device of any one of claims 1 to 17, the cutting wafer comprising a wafer working area of a single layer of a metallic material provided to be heated to the pre-determined temperature to cut through the first tubing and
15 the second tubing, a wafer heating area comprising multiple layers of metallic material provided for receiving heat from the heating elements and to supply heat to the wafer working area.
19. The cutting wafer of claim 18, wherein the wafer heating area comprises two layers of the
20 metallic material of the wafer working area, the two layers of the metallic material connected by a fold.
20. The cutting wafer of any one of claims 18 or 19 when dependent on claim 4, further
25 comprising a wafer latch slot for engagement by the wafer latch to secure the wafer in the wafer support slot and prevent backward movement of the wafer.