IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF PENNSYLVANIA

OPEX CORPORATION, Plaintiff, v. INVATA, LLC and HC ROBOTICS, Defendants.	Civil Action No. ____________ **JURY TRIAL DEMANDED**

COMPLAINT

Plaintiff OPEX Corporation ("OPEX"), for its Complaint against Defendants Invata, LLC (*d/b/a*, Invata Intralogistics) ("Invata") and HC Robotics (*a.k.a.*, Huicang Information Technology Co., Ltd.) ("HC Robotics") (individually or collectively, "Defendant(s)") hereby alleges as follows:

The Parties

1. Plaintiff OPEX is a New Jersey corporation with its principal place of business at 305 Commerce Drive, Moorestown, NJ 08057.

2. On information and belief, Defendant Invata LLC is a Pennsylvania limited liability company with its principal place of business at 1010 Spring Mill Avenue, Suite 300, Conshohocken, PA 19428.

3. On information and belief, Defendant HC Robotics is a company organized and existing under the laws of the People's Republic of China, with its principal place of business located at 3rd Floor, Haiwei Building, No. 101 Binkang Road, Binjiang District, Hangzhou City, Zheijang Province, China.

Related Litigation

4. OPEX has concurrently filed an action in the U.S. International Trade Commission captioned *In the Matter of Certain Automated Put Walls and Automated Storage and Retrieval Systems, Associated Vehicles, Associated Control Software, and Components Thereof II*. That ITC action involves accusations of infringement against the same parties (*i.e.,* Invata and HC Robotics) and the same products (*i.e.,* Defendants' Omnisort system) under the same patent asserted here and one related patent.

5. OPEX has previously filed a complaint in the United States District Court for the Eastern District of Pennsylvania, involving accusations of infringement against the same parties (*i.e.*, Invata and HC Robotics) and the same products (*i.e.*, Defendants' Omnisort system) under related patents to the patent asserted here. (*See OPEX Corporation v. Invata, LLC, et al.*, No. 2-21-cv-05575-BMS, ECF No. 1 (E.D. Pa Dec. 21, 2021).) This case was stayed in view of a concurrently pending ITC action. (*See OPEX Corporation v. Invata, LLC, et al.*, No. 2-21-cv-05575-BMS, ECF No. 4 (E.D. Pa Feb. 9, 2022).)

6. On December 22, 2021, OPEX filed a complaint in the United States International Trade Commission (Inv. No. 337-TA-1293) against the same parties (*i.e.*, Invata and HC Robotics) alleging infringement of related United States Patent No. 8,104,601, United States Patent No. 8,276,740, United States Patent No. 8,622,194, United States Patent No. 10,576,505, and U.S. Patent No. 11,192,144 against the same products (*i.e.,* Defendants' Omnisort system).

Nature of the Action

7. This is a civil action for infringement of one United States patent, arising under the Patent Laws of the United States, 35 U.S.C. § 1 *et seq*.

Jurisdiction and Venue

8. This Court has jurisdiction over the subject matter of this action pursuant to 28 U.S.C. §§ 1331 and 1338(a).

9. Venue is proper in this district pursuant to 28 U.S.C. §§ 1391(b) and (c), and 1400(b), because Defendant Invata resides in this district, is subject to personal jurisdiction in this district, and has committed acts of infringement in this district.

10. Venue is proper in this district pursuant to 28 U.S.C. §§ 1391(b) and (c), and 1400(b), because Defendant HC Robotics is not a resident of the United States, is subject to personal jurisdiction in this district, and has committed acts of infringement in this district.

The Patent-In-Suit

11. United States Patent No. 11,358,175 ("the '175 patent"), entitled "Material handling apparatus for delivering or retrieving items," was duly and legally issued by the United States Patent and Trademark Office on June 14, 2022. A copy of the '175 patent is attached hereto as Exhibit A.

12. The '175 patent is referred to herein as the "patent-in-suit" or "Asserted Patent."

13. OPEX is the exclusive owner of all right, title, and interest in the patent-in-suit, and has the right to bring this suit for injunctive relief and to recover damages for any current or past infringement of the patent-in-suit.

Defendants' Infringing Activities

14. On information and belief, Defendants are engaged in making, using, offering to sell, and/or selling within the United States, and/or importation into the United States, of automated put walls and automated storage and retrieval systems, and their associated vehicles, associated control software, and component parts, including, without limitation, the Omnisort system and its

associated vehicles, associated control software, and component parts (individually or collectively, the "Accused Products"), that infringe at least one valid, enforceable claim of the Asserted Patent.

15. Defendant Invata offers automated put walls for sale on its website, a copy of which is attached as Exhibit B.[1]

16. Defendants imported an Omnisort product into the United States, originating from a port in Shanghai, China and arriving at a port in Long Beach, California on July 4, 2021. Exhibit C is a copy of an importation record confirming this importation. Further, on information and belief, Invata subsequently sold and installed this Omnisort system in San Francisco, California. Exhibit D is the Declaration of Staci Dresher, a licensed private investigator, confirming this sale.

17. Exhibit E is a copy of importation records from importgenius.com showing shipment of Omnisort item sorting machines between Shipper HC Robotics and Consignee Invata, originating from a port in Shanghai, China and arriving at a port in the New York/Newark Area in Newark, New Jersey twice on January 28, 2022 and once on February 12, 2022. The importation records show that two shipments arrived in New York/Newark Area in Newark, New Jersey on January 28, 2022 and the quantity shipped was "14 PKG," indicating that Respondents ship and import the Omnisort in individual component parts or modules and sell and install the Omnisort in the United States. The importation records also show that one shipment arrived in New York/Newark Area in Newark, New Jersey on February 12, 2022 and the quantity shipped was "17 PKG," again indicating that Respondents ship and import the Omnisort in individual component parts or modules and sell and install the Omnisort in the United States.

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[1] On information and belief, Invata's automated put walls are HC Robotics' Omnisort Product. (*See, e.g.*, Exs. C, D, E, F.) Defendant HC Robotics previously offered the Omnisort system on its English-language website, but that website was taken down sometime after May 19, 2022. (*See* Ex. H.)

18. Exhibit F is a copy of importation records from ImportScan showing shipment of an Omnisort item sorting machines between Shipper HC Robotics and Consignee Invata, originating from a port in Shanghai, China and arriving at a port in the New York, New York on July 17, 2022. The importation records show that one shipment arrived in New York, New York on July 17, 2022 and the quantity shipped was "3 CTN," indicating that Respondents ship and import the Omnisort in individual component parts or modules and sell and install the Omnisort in the United States.

<u>COUNT I</u>

Infringement of the '175 Patent

19. Paragraphs 1 through 14 are incorporated by reference as if fully stated herein.

20. The '175 patent is valid and enforceable.

21. Defendants Invata and HC Robotics have infringed, and continue to infringe, one or more claims of the '175 patent under 35 U.S.C. § 271(a), either literally and/or under the doctrine of equivalents, by making, using, selling, and/or offering for sale in the United States, and/or importing into the United States, products and/or methods encompassed by those claims, including for example, by making, using, selling, offering for sale, and/or importing the Accused Products.

22. Third parties, including Defendants Invata and HC Robotics's customers, have infringed, and continue to infringe, one or more claims of the '175 patent under 35 U.S.C. § 271(a), either literally and/or under the doctrine of equivalents, by making, using, selling, and/or offering for sale in the United States, and/or importing into the United States, the Accused Products supplied by Defendants Invata and HC Robotics.

23. Defendants Invata and HC Robotics have had knowledge of and notice of the ’175 patent and its infringement since at least July 27, 2022, through OPEX’s virtual patent marking website. (*See* https://www.opex.com/patents/.) Defendants obtained actual knowledge of the ‘175 patent no later than the filing of this Complaint.

24. Defendants Invata and HC Robotics have induced infringement, and continue to induce infringement, of one or more claims of the ’175 patent under 35 U.S.C. § 271(b). Defendants Invata and HC Robotics actively, knowingly, and intentionally induced, and continue to actively, knowingly, and intentionally induce, infringement of the ’175 patent by selling or otherwise supplying the Accused Products; with the knowledge and intent that third parties will use, sell, and/or offer for sale in the United States, and/or import into the United States, the Accused Products to infringe the ’175 patent; and with the knowledge and intent to encourage and facilitate the infringement through the dissemination of the Accused Products and/or the creation and dissemination of promotional and marketing materials, supporting materials, instructions, product manuals, and/or technical information related to the Accused Products.

25. Defendants Invata and HC Robotics have contributed to the infringement by third parties, including Defendants Invata and HC Robotics’s customers, and continue to contribute to infringement by third parties, of one or more claims of the ’175 patent under 35 U.S.C. § 271(c), by selling and/or offering for sale in the United States, and/or importing into the United States, the Accused Products, knowing that those products constitute a material part of the inventions of the ’175 patent, knowing that those products are especially made or adapted to infringe the ’175 patent, and knowing that those products are not staple articles of commerce suitable for substantial noninfringing use.

26. Attached hereto as Exhibit G is an exemplary claim chart detailing how an Accused Product infringes at least independent claims 1 and 18 of the ’175 patent.

27. OPEX has been and continues to be damaged by Defendants Invata and HC Robotics’s infringement of the ’175 patent, and will suffer irreparable injury unless the infringement is enjoined by this Court.

28. Defendants Invata and HC Robotics’s infringement of the ’175 patent was, and continues to be, willful.

29. Defendants Invata and HC Robotics’s conduct in infringing the ’175 patent renders this case exceptional within the meaning of 35 U.S.C. § 285.

Prayer for Relief

WHEREFORE, OPEX prays for judgment as follows:

A. That Defendants Invata and HC Robotics have infringed the patent-in-suit;

B. That Defendants Invata and HC Robotics’s infringement of the patent-in-suit has been willful;

C. That Defendants Invata and HC Robotics, their officers, agents, and employees, and those persons in active concert or participation with any of them, and their successors and assigns, be permanently enjoined from infringement, inducing infringement, and contributory infringement of the patent-in-suit, including but not limited to the making, using, selling, and/or offering for sale in the United States, and/or importing into the United States, any devices, products, software, or methods that infringe the patent-in-suit before their respective expiration dates;

D. That OPEX be awarded all damages adequate to compensate it for Defendants Invata and HC Robotics’s infringement of the patent-in-suit, such damages to be determined by a jury and, if necessary to adequately compensate OPEX for the infringement, an accounting, and that such damages be trebled and awarded to OPEX with pre-judgment and post-judgment interest;

E. That this case by declared an exceptional case within the meaning of 35 U.S.C. § 285 and that OPEX be awarded the attorney fees, costs, and expenses incurred in connection with this action; and

F. That OPEX be awarded such other and further relief as this Court deems just and proper.

Demand for Jury Trial

Plaintiff OPEX hereby demands a trial by jury on all issues so triable.

Dated: September 9, 2022

By:

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EXHIBIT A

8276240

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office

August 2, 2022

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THIS OFFICE OF:

PATENT NUMBER: ***11,385,175***
ISSUE DATE: ***July 12, 2022***

By Authority of the
Under Secretary of Commerce for Intellectual Property
and Director of the United States Patent and Trademark Office

Trudie Wallace

Trudie Wallace
Certifying Officer

US011385175B2

(12) **United States Patent**
Wang et al.

(10) **Patent No.: US 11,385,175 B2**
(45) **Date of Patent: Jul. 12, 2022**

(54) **CALIBRATION METHOD AND TERMINAL EQUIPMENT OF TERAHERTZ FREQUENCY BAND ON-WAFER S PARAMETER**

(71) Applicant: **THE 13TH RESEARCH INSTITUTE OF CHINA ELECTRONICS TECHNOLOGY GROUP CORPORATION**, Shijiazhuang (CN)

(72) Inventors: **Yibang Wang**, Shijiazhuang (CN); **Aihua Wu**, Shijiazhuang (CN); **Faguo Liang**, Shijiazhuang (CN); **Chen Liu**, Shijiazhuang (CN); **Peng Luan**, Shijiazhuang (CN); **Ye Huo**, Shijiazhuang (CN); **Jing Sun**, Shijiazhuang (CN); **Yanli Li**, Shijiazhuang (CN)

(73) Assignee: **THE 13TH RESEARCH INSTITUTE OF CHINA ELECTRONICS TECHNOLOGY GROUP CORPORATION**, Shijiazhuang (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 16 days.

(21) Appl. No.: **17/123,823**

(22) Filed: **Dec. 16, 2020**

(65) **Prior Publication Data**

US 2021/0181102 A1 Jun. 17, 2021

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2020/083495, filed on Apr. 7, 2020.

(30) **Foreign Application Priority Data**

Dec. 17, 2019 (CN) 201911302541.9

(51) **Int. Cl.**
G01N 21/35 (2014.01)
G01N 21/3586 (2014.01)
(Continued)

(52) **U.S. Cl.**
CPC *G01N 21/3586* (2013.01); *G01N 21/3563* (2013.01); *G01N 27/026* (2013.01); *G01N 2021/3568* (2013.01)

(58) **Field of Classification Search**
CPC G01N 21/3586; G01N 21/3563; G01N 27/026; G01N 2021/3568
See application file for complete search history.

(56) **References Cited**

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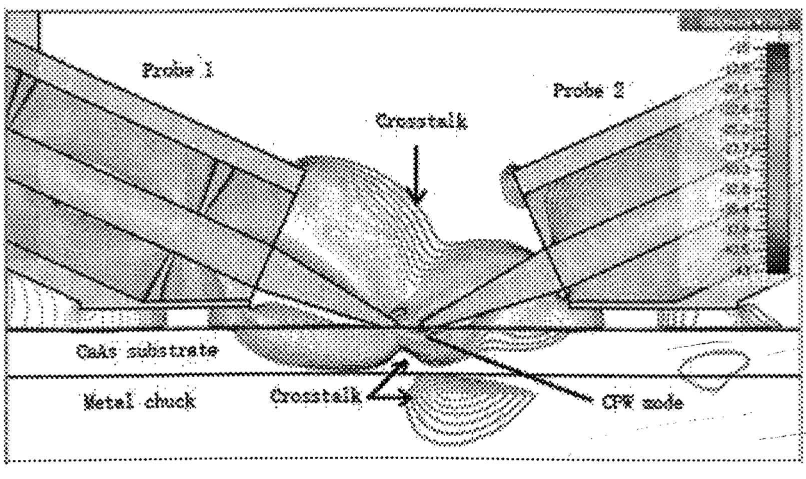
Primary Examiner — Hugh Maupin
(74) *Attorney, Agent, or Firm* — Slater Matsil, LLP

(57) **ABSTRACT**

A calibration method includes: acquiring eight error models obtained after a preliminary calibration of a Terahertz frequency band system; based on the eight error models, determining a first mathematical model according to a first S parameter related to a first calibration piece, the first mathematical model comprising parallel crosstalk terms between probes, and determining a second mathematical model according to a second S parameter related to a second calibration piece, the second mathematical model comprising series crosstalk terms between the probes; determining a third mathematical model according to a third S parameter
(Continued)



related to a measured piece; and solving and obtaining a Z parameter of the measured piece based on the first mathematical model, the second mathematical model and the third mathematical model, and acquiring an S parameter of the measured piece according to the Z parameter of the measured piece.

13 Claims, 6 Drawing Sheets

(51) **Int. Cl.**
G01N 27/02 (2006.01)
G01N 21/3563 (2014.01)

(56) **References Cited**

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CN	108664717	A	10/2018
CN	109444721	A	3/2019
CN	110286345	A	9/2019

* cited by examiner

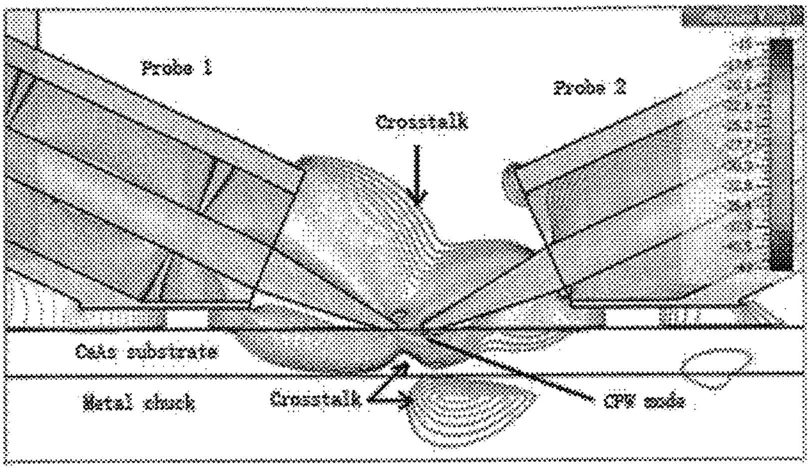

Probe 1
Probe 2
Crosstalk
GaAs substrate
Metal chuck
Crosstalk
CPW mode

Fig. 1

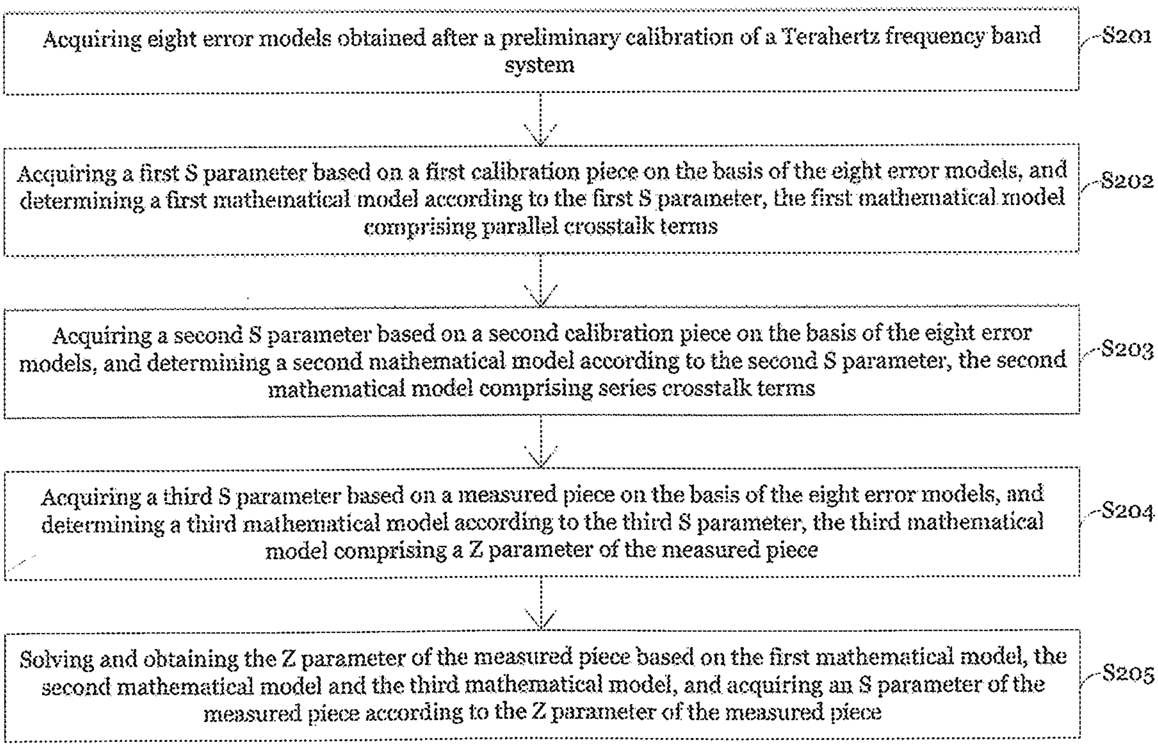

Acquiring eight error models obtained after a preliminary calibration of a Terahertz frequency band system
S201
Acquiring a first S parameter based on a first calibration piece on the basis of the eight error models, and determining a first mathematical model according to the first S parameter, the first mathematical model comprising parallel crosstalk terms
S202
Acquiring a second S parameter based on a second calibration piece on the basis of the eight error models, and determining a second mathematical model according to the second S parameter, the second mathematical model comprising series crosstalk terms
S203
Acquiring a third S parameter based on a measured piece on the basis of the eight error models, and determining a third mathematical model according to the third S parameter, the third mathematical model comprising a Z parameter of the measured piece
S204
Solving and obtaining the Z parameter of the measured piece based on the first mathematical model, the second mathematical model and the third mathematical model, and acquiring an S parameter of the measured piece according to the Z parameter of the measured piece
S205

Fig. 2

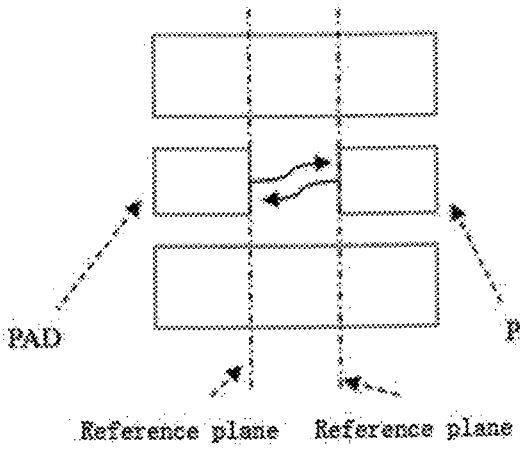


Fig. 3

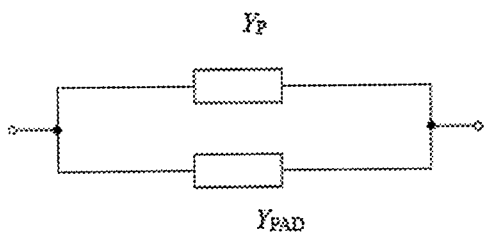


Fig. 4

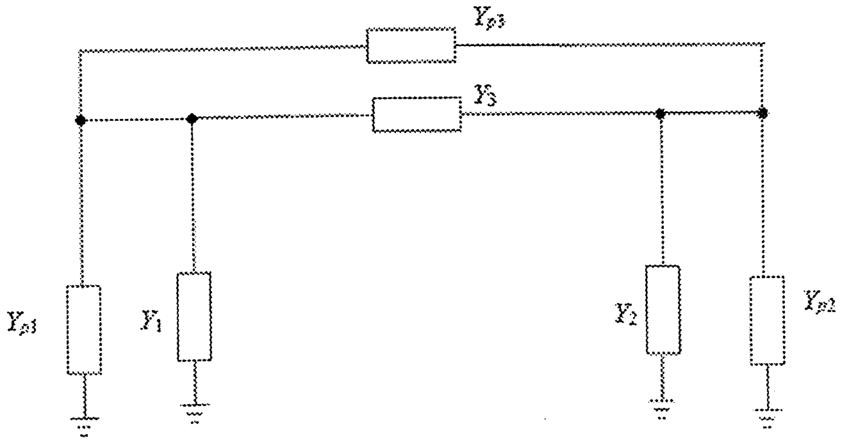


Fig. 5

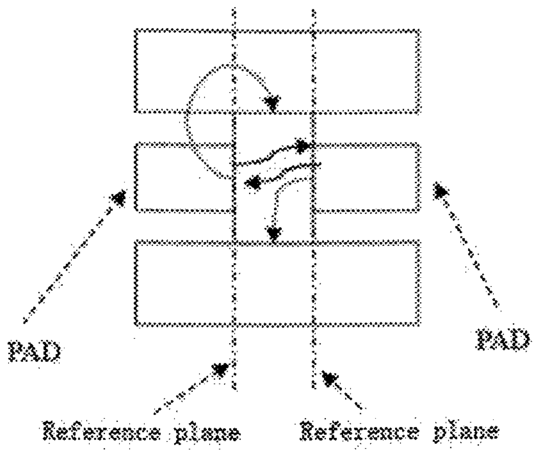


Fig. 6

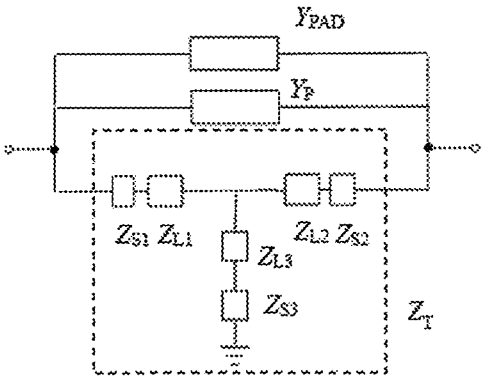


Fig. 7

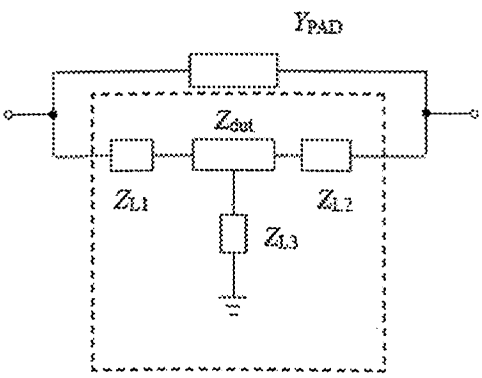


Fig. 8

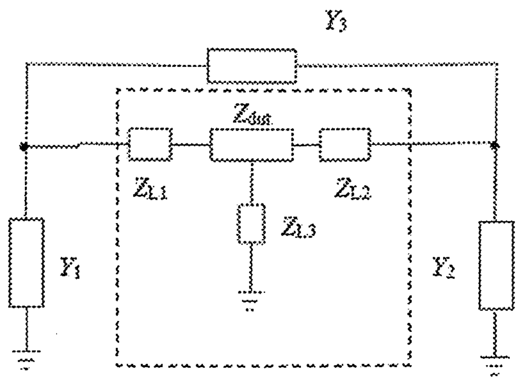


Fig. 9

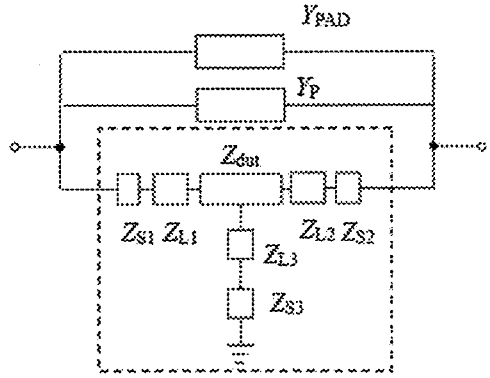


Fig. 10

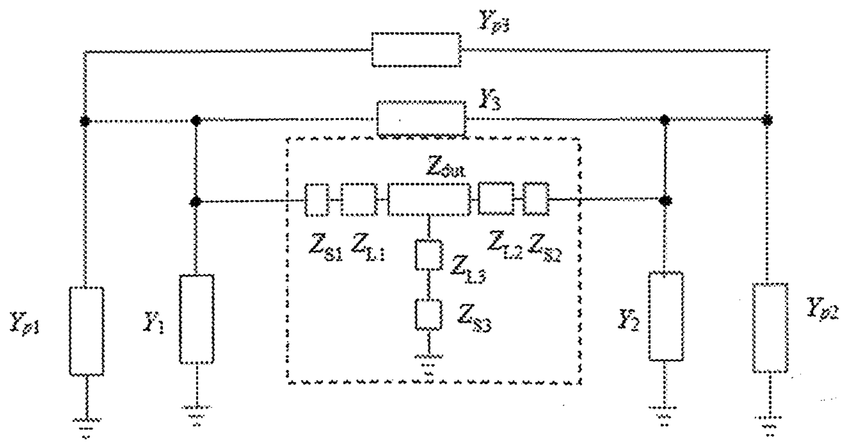


Fig. 11

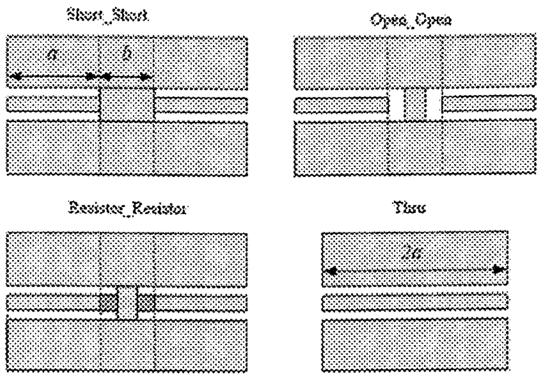


Fig. 12

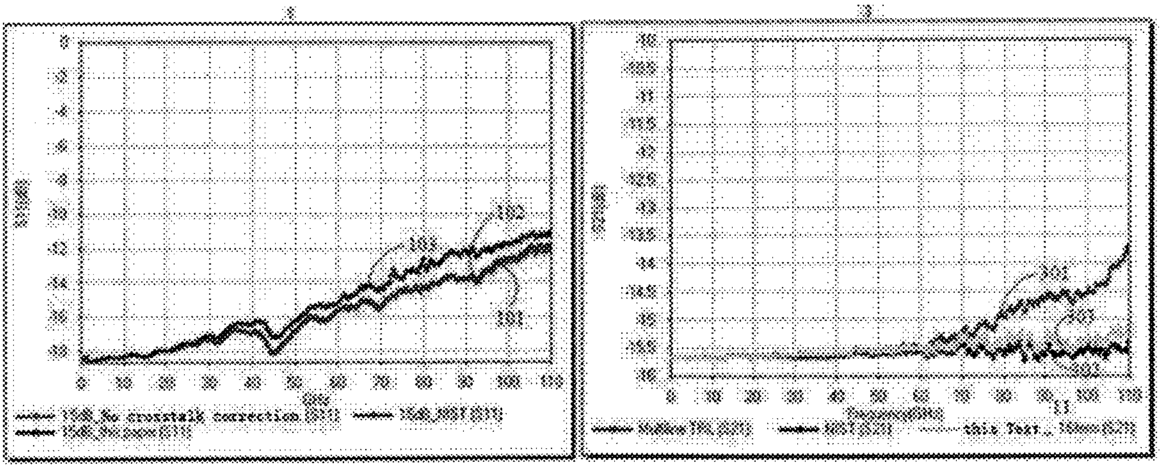


Fig. 13

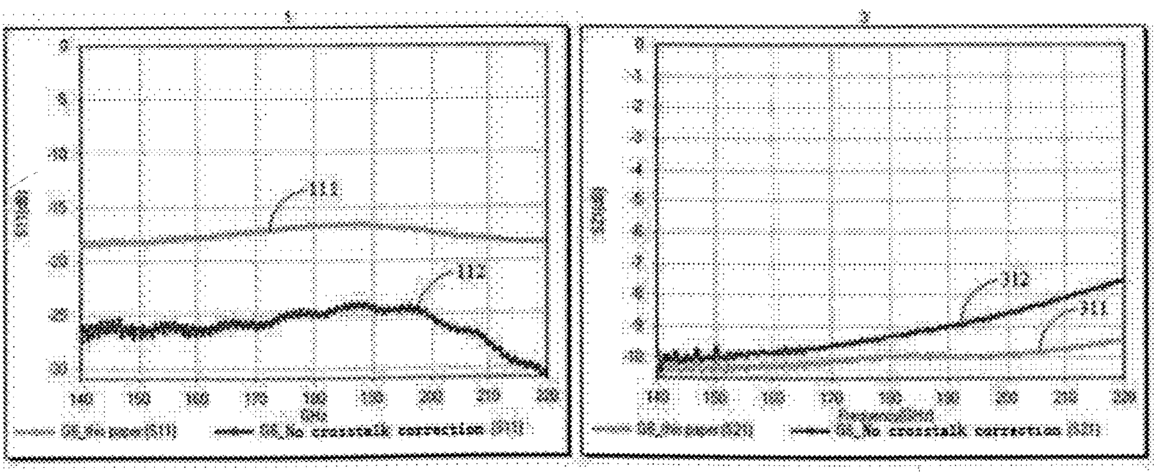


Fig. 14

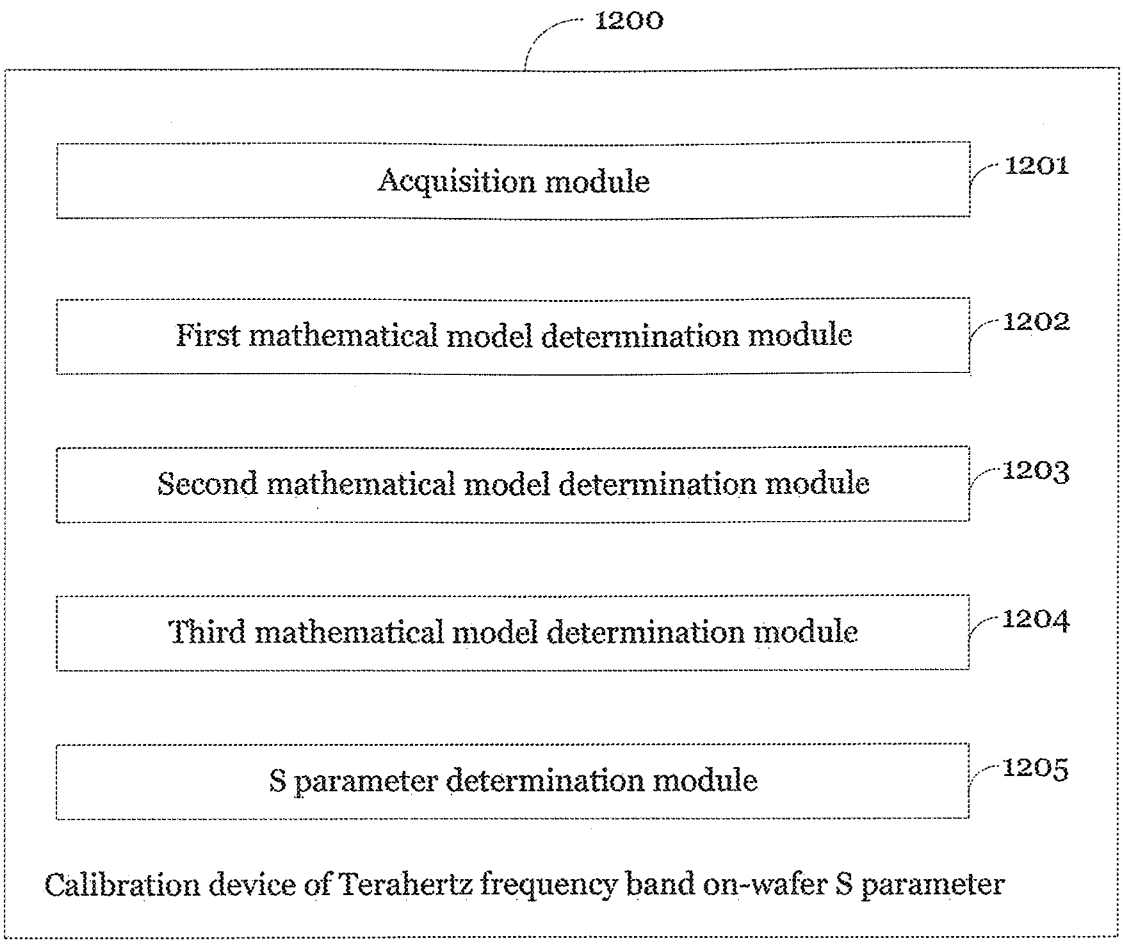

1200
Acquisition module
1201
First mathematical model determination module
1202
Second mathematical model determination module
1203
Third mathematical model determination module
1204
S parameter determination module
1205
Calibration device of Terahertz frequency band on-wafer S parameter

Fig. 15

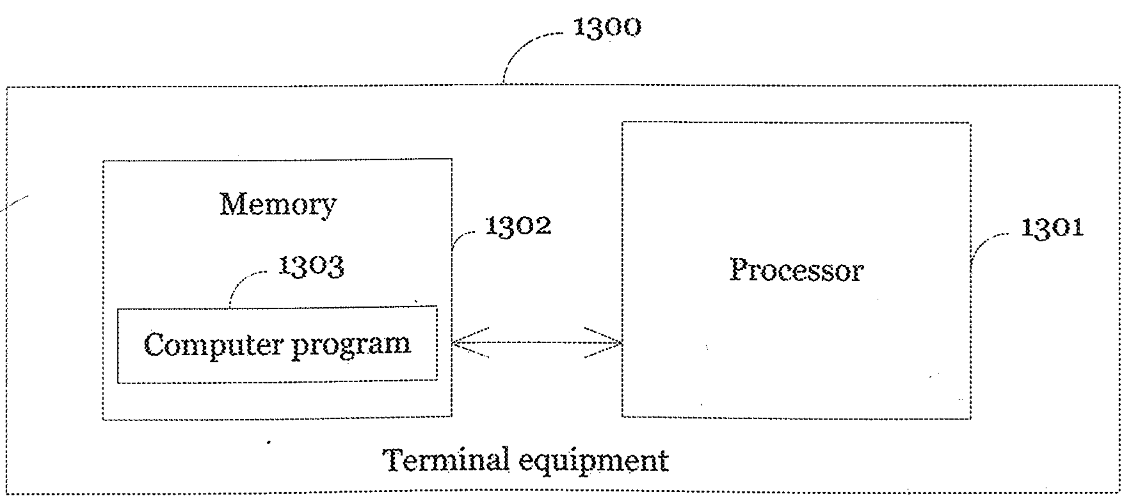

1300
Memory
1302
1303
Computer program
Processor
1301
Terminal equipment

Fig. 16

CALIBRATION METHOD AND TERMINAL EQUIPMENT OF TERAHERTZ FREQUENCY BAND ON-WAFER S PARAMETER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation application of International Application No. PCT/CN2020/083495, filed on Apr. 7, 2020, which claims priority to Chinese Patent Application No. CN201911302541.9, filed on Dec. 17, 2019. The disclosures of the aforementioned applications are hereby incorporated herein by reference in their entireties.

TECHNICAL FIELD

The disclosure belongs to the technical field of semiconductor devices, and particularly relates to a calibration method and terminal equipment of Terahertz frequency band on-wafer S parameter.

BACKGROUND

A large number of "on-wafer S parameter test systems" deployed in the microelectronics industry require vector calibration using on-wafer calibration pieces prior to use. The types of calibration pieces include SOLT (Short-Open-Load-Thru), TRL (Thru-Reflect-Line), LRRM (Line-Reflect-Reflect-Match), etc., each corresponding to a corresponding calibration algorithm. Therefore, the main factors affecting the calibration accuracy are the calibration method and the calibration piece.

Twelve or eight error models are used in conventional calibration methods, which have high accuracy in the on-wafer filed at low frequencies (below 50 GHz), coaxial and waveguide fields. However, as the on-wafer test frequency increases, some systematic errors that can be neglected in the low frequency band are not negligible. For example, the leakage between the probes (crosstalk signal) becomes larger and larger, which affects the accuracy of the test. The error caused by the crosstalk signal to the measurement result becomes larger and larger along with the increase of the frequency. However, the conventional twelve or eight error models obviously cannot represent the crosstalk error amount, and the accuracy of the S parameter obtained by the test is low by using the conventional error model for calibration.

SUMMARY

These and other problems are generally solved or circumvented, and technical advantages are generally achieved, by embodiments of the present disclosure which provide a calibration method and terminal equipment of Terahertz frequency band on-wafer S parameter.

Technical Problems

The embodiment of the disclosure provides a calibration method and terminal equipment of Terahertz frequency band on-wafer S parameter to solve the problems that a conventional error model cannot represent the crosstalk error amount and the accuracy of the S parameter obtained by the test is low by using the conventional error model for calibration.

Technical Solutions

A first aspect of embodiments of the present disclosure provides a calibration method of Terahertz frequency band on-wafer S parameter, comprising the steps of:

acquiring eight error models obtained after a preliminary calibration of a Terahertz frequency band system;

acquiring a first S parameter based on a first calibration piece on the basis of the eight error models, and determining a first mathematical model according to the first S parameter, the first mathematical model comprising parallel crosstalk terms between probes;

acquiring a second S parameter based on a second calibration piece on the basis of the eight error models, and determining a second mathematical model according to the second S parameter, the second mathematical model comprising series crosstalk terms between the probes;

acquiring a third S parameter based on a measured piece on the basis of the eight error models, and determining a third mathematical model according to the third S parameter, the third mathematical model comprising a Z parameter of the measured piece; and

solving and obtaining the Z parameter of the measured piece based on the first mathematical model, the second mathematical model and the third mathematical model, and acquiring an S parameter of the measured piece according to the Z parameter of the measured piece.

A second aspect of embodiments of the present disclosure provides a terminal equipment comprising a memory, a processor and a computer program stored in the memory and executable on the processor, where the processor, when executing the computer program, implements the steps of the calibration method of Terahertz frequency band on-wafer S parameter as described in the first aspect.

A third aspect of embodiments of the present disclosure provides a computer-readable storage medium storing a computer program which, when executed by one or more processors, implements the steps of the calibration method of Terahertz frequency band on-wafer S parameter as described in the first aspect.

Advantageous Effects of the Disclosure

The embodiments of the disclosure comprise firstly acquiring eight error models, and then respectively acquiring the first mathematical model, the second mathematical model and the third mathematical model based on the eight error models, wherein the first mathematical model comprises parallel crosstalk terms between the probes, the second mathematical model comprises series crosstalk terms between the probes, and the third mathematical model comprises the Z parameter of the measured piece; and finally solving and obtaining the Z parameter of the measured piece according to the first mathematical model, the second mathematical model and the third mathematical model, and obtaining the S parameter of the measured piece according to the Z parameter of the measured piece. The embodiments of the disclosure can realize accurate testing of Terahertz frequency band on-wafer S parameter by adding two crosstalk corrections to the eight error models.

The foregoing has outlined rather broadly the features and technical advantages of the present disclosure in order that the detailed description of the disclosure that follows may be better understood. Additional features and advantages of the disclosure will be described hereinafter which form the subject of the claims of the disclosure. It should be appreciated by those skilled in the art that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures or processes for carrying out the same purposes of the present disclosure. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the disclosure as set forth in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to more clearly illustrate the technical solutions in the embodiments of the present disclosure, the following description briefly introduces the drawings used in the embodiments or the prior art, and it is obvious that the drawings in the following description are only some embodiments of the present disclosure, and that other drawings can be obtained from these drawings by a person skilled in the art without involving any inventive effort.

FIG. **1** is a simulation diagram of electromagnetic distribution in an on-wafer test at 110 GHz;

FIG. **2** is a flow diagram illustrating an implementation of a calibration method of Terahertz frequency band on-wafer S parameter according to an embodiment of the present disclosure;

FIG. **3** is a schematic diagram of a test reference surface based on a first calibration piece according to an embodiment of the present disclosure;

FIG. **4** is a schematic diagram of a first equivalent circuit model according to an embodiment of the present disclosure;

FIG. **5** is a schematic diagram of another first equivalent circuit model according to an embodiment of the present disclosure;

FIG. **6** is a schematic diagram of a test reference surface based on a second calibration piece according to an embodiment of the present disclosure;

FIG. **7** is a schematic diagram of a second equivalent circuit model according to an embodiment of the present disclosure;

FIG. **8** is a schematic diagram of an equivalent circuit model with a measured piece and a probe connected by a PAD (or pad) according to an embodiment of the present disclosure;

FIG. **9** is a schematic diagram of another equivalent circuit model of the measured piece connected with the probe by the PAD according to an embodiment of the present disclosure;

FIG. **10** is a schematic diagram of a third equivalent circuit model according to an embodiment of the present disclosure;

FIG. **11** is a schematic diagram of another third equivalent circuit model according to an embodiment of the present disclosure;

FIG. **12** is a schematic diagram of various calibration pieces according to an embodiment of the present disclosure;

FIG. **13** shows verification results from a 0.2 GHz-110 GHz model according to an embodiment of the present disclosure;

FIG. **14** shows verification results from a 140 GHz-220 GHz model according to an embodiment of the present disclosure;

FIG. **15** is a structure diagram illustrating a calibration device of Terahertz frequency band on-wafer S parameter according to an embodiment of the present disclosure; and

FIG. **16** is a structure diagram of the terminal equipment according to an embodiment of the present disclosure.

Corresponding numerals and symbols in the different figures generally refer to corresponding parts unless otherwise indicated. The figures are drawn to clearly illustrate the relevant aspects of the various embodiments and are not necessarily drawn to scale.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

The making and using of the embodiments of this disclosure are discussed in detail below. It should be appreciated, however, that the concepts disclosed herein can be embodied in a wide variety of specific contexts. The specific embodiments discussed are merely illustrative, and do not limit the scope of the claims.

In the following description, for purposes of explanation and not limitation, specific details are set forth such as a particular system architecture, techniques, etc. in order to provide a thorough understanding of the embodiments of the present disclosure. However, it will be apparent to one skilled in the art that the present disclosure may be practiced in other embodiments without these specific details. In other instances, detailed descriptions of well-known systems, installations, circuits, and methods are omitted so as not to obscure the description of the present disclosure with unnecessary details.

In order to illustrate the technical solutions described in this disclosure, specific embodiments are described below.

FIG. **1** shows a simulation diagram of electromagnetic distribution at 110 GHz in an on-wafer test. In particular, two probes at 110 GHz are used to measure the electromagnetic field distribution of a thru transmission line. The microwave probes are in an open free space and left and right probes are positioned between the air and between the substrates, respectively, creating two new energy coupling paths, collectively referred to as crosstalk signals. The measurement error caused by the crosstalk signal increases with increasing frequency. In order to measure the S parameter accurately, a calibration method of Terahertz frequency band on-wafer S parameter is provided. The S parameter is a scattering parameter.

FIG. **2** is a flow diagram illustrating an implementation of a calibration method of Terahertz frequency band on-wafer S parameter provided in an embodiment of the present disclosure. For ease of illustration, only those portions relevant to embodiments of the present disclosure are shown and described in detail below. The executive body of the embodiment of the disclosure can be terminal equipment.

As shown in FIG. **2**, the calibration method of Terahertz frequency band on-wafer S parameter comprises the following steps.

S201: acquire eight error models obtained after a preliminary calibration of a Terahertz frequency band system.

Specifically, the Multiline TRL calibration method can be adopted to obtain the eight error models. The calibration can be carried out at the coaxial or waveguide outlet of the system firstly, then the S parameters of the probes are measured, and the eight error models are obtained by cascade calculation.

The Terahertz frequency band system can be an on-wafer S parameter test system of the Terahertz frequency band. For example, it may be a Terahertz band on-wafer vector network analyzer.

S202: acquire a first S parameter based on a first calibration piece on the basis of the eight error models, and determine a first mathematical model according to the first

S parameter, the first mathematical model comprising parallel crosstalk terms between probes.

In the embodiment of the disclosure, the Terahertz frequency band system is preliminarily calibrated by the eight error models to obtain the Terahertz frequency band system after a preliminary calibration. Then the measured piece is replaced by the first calibration piece, namely the first calibration piece is placed at the position of the measured piece; the S parameter of the first calibration piece is measured by adopting the Terahertz frequency band system after the preliminary calibration to obtain the first S parameter; and the first mathematical model containing the parallel crosstalk terms between the probes is established according to the first S parameter. Here, the first calibration piece may be an Open-Open calibration piece.

In an embodiment of the present disclosure, the step **S202** comprises the steps of:

Generating a first equivalent circuit model corresponding to the first calibration piece based on the first calibration piece;

Acquiring the first S parameter of the first calibration piece obtained by measurement according to the eight error models;

Converting the first S parameter into a first Y parameter; and

Determining a first mathematical model according to the first Y parameter and the first equivalent circuit model.

In an embodiment of the present disclosure, the first mathematical model is

$$Y_{Total}^{OPN}=Y_{PAD}+Y_{P} \quad (1)$$

where Y_{total}^{OPN} is the first Y parameter, Y_{PAD} is a PAD (or pad) parallel parasitic parameter, and Y_P is the parallel crosstalk terms between the probes.

The Y parameter is an admittance parameter. The Y parameter and the S parameter can be interconverted by existing methods, and the Y parameter and the S parameter are 2*2 matrices.

FIG. **3** shows a schematic diagram of a test reference plane based on the first calibration piece, i.e. a schematic diagram of an ideal open test reference plane. In the figure, the PAD is used to connect the measured piece to the probe. In FIG. **3**, the first calibration piece replaces the measured piece, so that the PAD is used to connect the first calibration piece to the probe in FIG. **3**.

FIG. **4** shows a schematic diagram of the first equivalent circuit model corresponding to the first calibration piece. Referring to FIG. **4**, in the first equivalent circuit model, Y_{PAD} is connected in parallel with Y_P, and the first mathematical model as shown in formula (1) can be determined based on the first equivalent circuit model. Each parameter in the first mathematical model is a 2*2 matrix.

Y_{PAD} is a π type two-port network circuit, see FIG. **5**, and

$$Y_{PAD}=\begin{bmatrix} Y_1+Y_3 & -Y_3 \\ -Y_3 & Y_2+Y_3 \end{bmatrix},$$

Y_1, Y_2 and Y_3 are elements in the Y_{PAD} matrix, respectively. Y_P is a π type two-port network circuit, see FIG. **5**, and

$$Y_P=\begin{bmatrix} Y_{p1}+Y_{p3} & -Y_{p3} \\ -Y_{p3} & Y_{p2}+Y_{p3} \end{bmatrix},$$

Y_{p1}, Y_{p2}, and Y_{p3} are elements in the Y_P matrix, respectively.

In the embodiment of the disclosure, firstly, the first S parameter S_{Total}^{OPN} of the first calibration piece is measured by using the Terahertz frequency band system after preliminary calibration, where the first S parameter S_{Total}^{OPN} a comprises crosstalk and an ideal open circuit; then the first S parameter is converted into the first Y parameter Y_{Total}^{OPN} by adopting an existing method; and finally the first mathematical model is determined to be the formula (1) according to the first equivalent circuit model and the first Y parameter Y_{Total}^{OPN}.

S203: acquire a second S parameter based on a second calibration piece on the basis of the eight error models, and determine a second mathematical model according to the second S parameter, the second mathematical model comprising series crosstalk terms between the probes.

The measured piece is replaced by the second calibration piece, namely the second calibration piece is placed at the position of the measured piece; the S parameter of the second calibration piece is measured by adopting the Terahertz frequency band system after the preliminary calibration to obtain the second S parameter; and the second mathematical model containing series crosstalk terms between the probes is established according to the second S parameter. Here, the second calibration piece may be a Short-Short calibration piece.

In an embodiment of the present disclosure, the step **S203** comprises the steps of:

generating a second equivalent circuit model corresponding to the second calibration piece based on the second calibration piece;

acquiring the second S parameter of the second calibration piece obtained by measurement according to the eight error models;

converting the second S parameter into a second Y parameter; and

determining the second mathematical model according to the second Y parameter and the second equivalent circuit model.

In an embodiment of the disclosure, the second mathematical model is

$$Y_{Total}^{SHORT}=Y_{PAD}+Y_P+(Z_S+Z_L)^{-1} \quad (2)$$

where Y_{Total}^{SHORT} is the second Y parameter, Y_{PAD} is a PAD parallel parasitic parameter, Y_P is the parallel crosstalk terms between the probes, Z_S is the series crosstalk terms between the probes, and Z_L is a series parasitic parameter (short-circuit parasitic parameter) of a PAD intraconnection.

The Z parameter is an impedance parameter. The Z parameter, the Y parameter, and the S parameter may be interconverted by existing methods.

FIG. **6** shows a schematic diagram of a test reference plane based on the second calibration piece, i.e. a schematic diagram of an ideal short-circuit test reference plane. In FIG. **6**, the second calibration piece replaces the measured piece, so the PAD in FIG. **6** is used to connect the second calibration piece to the probe.

FIG. **7** shows a schematic diagram of the second equivalent circuit model corresponding to the second calibration piece. As seen in FIG. **7**, in the second equivalent circuit model, Y_{PAD} is connected in parallel with Y_P, which is connected in parallel with the portion in a dashed box, the interior of the dashed box is denoted as Z_T, which is converted into a corresponding Y parameter $(Z_T)^{-1}$. Z_T is an intermediate parameter containing the series parasitic parameter and the series crosstalk term, $Z_T = Z_S + Z_L$, both Z_S and Z_L are T type two-port network circuits,

$$Z_S = \begin{bmatrix} Z_{S1} + Z_{S3} & Z_{S3} \\ Z_{S3} & Z_{S2} + Z_{S3} \end{bmatrix}, Z_L = \begin{bmatrix} Z_{L1} + Z_{L3} & Z_{L3} \\ Z_{L3} & Z_{L2} + Z_{L3} \end{bmatrix},$$

Z_{S1}, Z_{S2} and Z_{S3} are elements in Z_S matrix, respectively, and Z_{L1}, Z_{L2} and Z_{L3} are elements in the Z_L matrix, respectively.

The second mathematical model can be determined based on the second equivalent circuit model, as shown in the formula (2). Each parameter in formula (2) is a 2*2 matrix.

In the embodiment of the disclosure, the second S parameter S_{Total}^{SHORT} of the second calibration piece is measured by using the Terahertz frequency band system after a preliminary calibration, where the second S parameter S_{Total}^{SHORT} comprises crosstalk and parasitic parameters; then the second S parameter S_{Total}^{SHORT} is converted into the second Y parameter Y_{Total}^{SHORT} by adopting an existing method; and finally the second mathematical model is determined to be the formula (2) according to the second equivalent circuit model and the second Y parameter Y_{Total}^{SHORT}.

S204: acquire a third S parameter based on a measured piece on the basis of the eight error models, and determine a third mathematical model according to the third S parameter, the third mathematical model comprising a Z parameter of the measured piece.

The S parameter of the measured piece is measured by adopting the Terahertz frequency band system after the preliminary calibration to obtain the third S parameter; and the third mathematical model containing the Z parameter of the measured piece is established according to the third S parameter.

In an embodiment of the present disclosure, the step **S204** comprises the steps of:

generating a third equivalent circuit model corresponding to the measured piece based on the measured piece;

acquiring the third S parameter of the measured piece obtained by measurement according to the eight error models;

converting the third S parameter into a third Y parameter; and

determining the third mathematical model according to the third Y parameter and the third equivalent circuit model.

In an embodiment of the present disclosure, the third mathematical model is

$$Y_{Total}^{DUT} = Y_P + Y_{PAD} + (Z_S + Z_L + Z_{DUT})^{-1} \quad (3)$$

where Y_{Total}^{DUT} is the third Y parameter, Y_P is the parallel crosstalk terms between the probes, Y_{PAD} is a PAD parallel parasitic parameter, Z_S is the series crosstalk terms between the probes, Z_L is a series parasitic parameter of a PAD intraconnection, and Z_{DUT} is the Z parameter of the measured piece.

FIG. **8** shows a schematic diagram of an equivalent circuit model with a measured piece DUT and a probe connected by a PAD, i.e., a schematic diagram of a PAD parasitic equivalent circuit model. Y_{PAD} is a π type two-port network circuit, see FIG. **9**, and

$$Y_{PAD} = \begin{bmatrix} Y_1 + Y_3 & -Y_3 \\ -Y_3 & Y_2 + Y_3 \end{bmatrix},$$

Y_1, Y_2 and Y_3 are elements in the Y_{PAD} matrix, respectively.

FIG. **1** shows a schematic diagram of the third equivalent circuit model, which is an error model including PAD parasitic and crosstalk. Referring to FIG. **10**, in the third equivalent circuit model, Y_{PAD} is connected in parallel with Ye, which is connected in parallel with the portion in the dashed box, the interior of the dashed box is denoted as $Z_T + Z_{DUT}$, which is converted to the corresponding Y parameter $(Z_T + Z_{DUT})^{-1}$, i.e., $(Z_S + Z_L + Z_{DUT})^{-1}$. The third mathematical model can be determined based on the third equivalent circuit model as shown in the formula (3). Each parameter in the third mathematical model is a 2*2 matrix.

Y_P is a π type two-port network circuit, see FIG. **11**, and

$$Y_P = \begin{bmatrix} Y_{p1} + Y_{p3} & -Y_{p3} \\ -Y_{p3} & Y_{p2} + Y_{p3} \end{bmatrix},$$

Y_{p1}, Y_{p2} and Y_{p3} are elements in the Y_P matrix, respectively.

The electromagnetic field distribution of the Terahertz frequency band test is analyzed, see FIG. **1**, a leakage path exists between the probes. Similarly, the leakage path also exists between the probe and the ground. Based on this, the third equivalent circuit model is established.

In the embodiment of the disclosure, firstly, the third S parameter S_{Total}^{DUT} of the measured piece is measured by using the Terahertz frequency band system after the preliminary calibration; then the third S parameter S_{Total}^{DUT} is converted into the third Y parameter Y_{Total}^{DUT} by adopting an existing method; and finally the third mathematical model is determined to be the formula (3) according to the third equivalent circuit model and the third Y parameter Y_{Total}^{DUT}.

S205: solve and obtain the Z parameter of the measured piece based on the first mathematical model, the second mathematical model and the third mathematical model, and acquire an S parameter of the measured piece according to the Z parameter of the measured piece.

Specifically, the following formula (4) can be obtained by subtracting the formula (1) from the formula (2):

$$(Z_S + Z_L)^{-1} Y_{Total}^{SHORT} -_{Total}^{OPN} \quad (4)$$

The following formula (5) can be obtain by subtracting the formula (1) from the formula (3):

$$(Z_S + Z_L + Z_{DUT})^{-1} Y_{Total}^{DUT} -_{Total}^{OPN} \quad (5)$$

$Z_S + Z_L$ may be obtained by the formula (4), $Z_S + Z_L + Z_{DUT}$ can be obtained by the formula (5), and Z_{DUT} can be obtained by the formula (6), i.e. the Z parameter of the measured piece is obtained. By means of the existing method, the Z parameter of the measured piece can be converted into the S parameter of the measured piece, where the S parameter of the measured piece is the S parameter of the calibrated measured piece.

$$Z_{DUT} = Z_S + Z_L + Z_{DUT} - (Z_S + Z_L) \quad (6)$$

In an embodiment of the present disclosure, the first calibration piece is an Open-Open calibration piece, and the second calibration piece is a Short-Short calibration piece.

Alternatively, orthogonal autoregressive algorithm can be used to reduce random errors and improve test accuracy.

It can be seen from the above description that two times of crosstalk correction are added to the eight error models in the embodiment of the present disclosure. Therefore, the accurate test of Terahertz frequency band on-wafer S parameter can be realized, the accuracy of the S parameter is improved, and the connection structure and the crosstalk error of the measured piece can be eliminated at the same time, achieving a better index, and meeting the commercial on-wafer S parameter calibration work on the market.

In particular, by conventional calibration and test of the Open-Open and Short-Short calibration pieces, the problem of de-embedding the connection structure PAD of the measured piece in the Terahertz test can be solved, the crosstalk (leakage) between microwave probes can be eliminated, and the effective test end face is extended to the root of the die. The solving method is given by establishing the connection structure PAD of the measured piece and the error model between the crosstalk and the measured piece. The conventional calibration method is adopted to carry out primary calibration, data of a measured piece, Open-Open and Short-Short are obtained by the test, data of the root of the measured piece for eliminating high-frequency crosstalk are ultimately obtained by the established error model, and finally the test accuracy of on-wafer S parameter can be improved.

In order to verify the above methods, 3 mm frequency band and 140 GHz-220 GHz calibration pieces and crosstalk verification pieces are developed. The schematic diagram of some calibration pieces is shown in FIG. **12**. The calibration pieces are divided into a Multiline TRL calibration piece and a crosstalk calibration piece. A Coplanar Waveguide (CPW) transmission line with a thru length of 400 μm is designed in the Multiline TRL calibration piece with the remaining extra lengths of 100 m, 300 μm, 500 μm, 2000 μm, 5000 μm, 7000 μm, 11000 μm and the reflection standard of Short-Short; and the two port standards are Open-Open, Short-Short, Resistor-Resistor (for definition of the Multiline TRL calibration piece), and the single port offset is half of Thru, 200 μm. The measured piece is a passive attenuator, left and right ports are connected in series at 50 ohms, and upper and lower floors are connected in parallel at 75 ohms, so that the attenuator structure is most sensitive to crosstalk. In FIG. **12**, a=200 μm, and b=220 μm.

Firstly, a basic on-wafer vector network analyzer is calibrated by adopting the multiline TRL calibration method to obtain an 8 error models, and then a measurement is performed to obtain a measurement result of a passive attenuator which is not corrected by crosstalk. Secondly, two crosstalk calibration pieces are measured by using the calibrated on-wafer vector network analyzer to obtain ideal Open-Open and Short-Short. Finally, a measurement result corrected by the crosstalk of the passive attenuator is obtained according to the measurement model. After the measurement is finished, the passive attenuator needs to be subjected to electromagnetic field simulation to obtain S parameters of the passive attenuator, and measurement results and simulation results before and after crosstalk correction are compared.

The passive attenuator is measured by the on-wafer vector network analyzer to obtain the S parameter without crosstalk correction, and the S parameter of the final measured piece is obtained according to the formulas (4), (5) and (6), namely the calibrated S parameter. The measurement results are shown in FIGS. **13** and **14**.

In FIG. **13**, and in the graph on the left, 15 dB represents a measured piece. "15 dB_no crosstalk correction (S11)" is a measurement result of S11 with no crosstalk correction, corresponding to a curve **101** in the figure. "15 dB_this paper (S11)" is a measurement result of **S11***by* the calibration method provided in the embodiment of the present disclosure, corresponding to a curve **103** in the figure. "15 dB_NIST (S11)" is a measurement result of S11 for NIST, corresponding to a curve **102** in the figure. In the graph on the right, "Multiline TRL (S 21)" is a measurement result of **S21** with no crosstalk correction, corresponding to a curve **301** in the figure. "NIST (S21)" is a measurement result of S21 with NIST crosstalk correction, corresponding to a curve **302** in the figure. "This paper_16term (S21)" is a measurement result of S21 by the calibration method provided in the embodiments of the present disclosure, corresponding to a curve **303** in the figure. S21 is improved by more than 1.3 dB, which is more consistent with the trend of simulation value.

In FIG. **14**, G6 represents a measured piece. In the graph on the left, "G6_no crosstalk correction (S11)" is a measurement result of S11 with no crosstalk correction, corresponding to a curve **112** in the figure. "G6_this paper (S11)" is a measurement result of S11 by the calibration method provided in the embodiment of the present disclosure, corresponding to a curve **111** in the figure. In the graph on the right, "G6_no crosstalk correction (S21)" is a measurement result of S21 with no crosstalk correction, corresponding to a curve **312** in the figure. "G6_this paper (S21)" is a measurement result of S21 by the calibration method provided in the embodiment of the present disclosure, corresponding to a curve **311** in the figure. It can be seen that S21 is improved by 1.5 dB or more, which is more consistent with the trend of simulation values.

It should be understood that the sequence numbers of the steps in the above-described embodiments are not meant to imply a sequential order of execution, and that the order of execution of the processes should be determined by their function and inherent logic, and should not be construed as limiting the implementation of the embodiments of the present disclosure in anyway.

FIG. **15** is a schematic block diagram illustrating an implementation of a calibration device of Terahertz frequency band on-wafer S parameter provided in an embodiment of the present disclosure. For ease of illustration, only those portions relevant to embodiments of the present disclosure are shown and described in detail below.

In the embodiment of the disclosure, the calibration device **1200** of Terahertz frequency band on-wafer S parameter can comprise an acquisition module **1201**, a first mathematical model determination module **1202**, a second mathematical model determination module **1203**, a third mathematical model determination module **1204**, and an S parameter determination module **1205**.

The acquisition module **1201** is configured for acquiring eight error models obtained after a preliminary calibration of a Terahertz frequency band system.

The first mathematical model determination module **1202** is configured for acquiring a first S parameter based on a first calibration piece on the basis of the eight error models, and determining a first mathematical model according to the first S parameter, the first mathematical model comprising parallel crosstalk terms between probes.

The second mathematical model determination module **1203** is configured for acquiring a second S parameter based on a second calibration piece on the basis of the eight error models, and determining a second mathematical model according to the second S parameter, the second mathematical model comprising series crosstalk terms between the probes.

The third mathematical model determination module **1204** is configured for acquiring a third S parameter based on a measured piece on the basis of the eight error models, and determining a third mathematical model according to the third S parameter, the third mathematical model comprising a Z parameter of the measured piece.

The S parameter determination module **1205** is configured for solving and obtaining a Z parameter of the measured piece based on the first mathematical model, the second mathematical model and the third mathematical model, and acquiring an S parameter of the measured piece according to the Z parameter of the measured piece.

Optionally, the first mathematical model determination module **1202** is specifically configured for:

generating a first equivalent circuit model corresponding to the first calibration piece based on the first calibration piece;

acquiring a first S parameter of the first calibration piece obtained by measurement according to the eight error models;

converting the first S parameter into a first Y parameter; and

determining a first mathematical model according to the first Y parameter and the first equivalent circuit model.

Alternatively, the first mathematical model is $Y_{Total}^{OPN}=Y_{PAD}+Y_P$, where Y_{Total}^{OPN} is the first Y parameter, Y_{PAD} is a PAD parallel parasitic parameter, and Y_P is the parallel crosstalk terms between the probes.

Alternatively, the second mathematical model determination module **1203** is specifically configured for:

generating a second equivalent circuit model corresponding to the second calibration piece based on the second calibration piece;

acquiring a second S parameter of the second calibration piece obtained by measurement according to the eight error models;

converting the second S parameter into a second Y parameter; and

determining a second mathematical model according to the second Y parameter and the second equivalent circuit model.

Alternatively, the second mathematical model is $Y_{Total}^{SHORT}=Y_{PAD}+Y_P+(Z_X+Z_L)^{-1}$, where Y_{Total}^{SHORT} is the second Y parameter, Y_{PAD} is a PAD parallel parasitic parameter, Y_P is the parallel crosstalk terms between the probes, Z_S is the series crosstalk terms between the probes, and Z_L is a series parasitic parameter of a PAD intraconnection.

Optionally, the third mathematical model determination module **1204** is specifically configured for:

generating a third equivalent circuit model corresponding to the measured piece based on the measured piece;

acquiring a third S parameter of the measured piece obtained by measurement according to the eight error models;

converting the third S parameter into a third Y parameter; and

determining a third mathematical model according to the third Y parameter and the third equivalent circuit model.

Alternatively, the third mathematical model is $Y_{Total}^{DUT}=Y_P+Y_{PAD}+(Z_S+Z_L+Z_{DUT})^{-1}$, where Y_{Total}^{DUT} is the third Y parameter, Y_P is a parallel crosstalk terms between the probes, Y_{PAD} is a PAD parallel parasitic parameter, Z_S is the series crosstalk terms between the probes, Z_L is the series parasitic parameter of a PAD intraconnection, and Z_{DUT} is the Z parameter of the measured piece.

Alternatively, the first calibration piece is an Open-Open calibration piece, and the second calibration piece is a Short-Short calibration piece.

It can be clearly understood by a person skilled in the art that, for convenience and conciseness of description, only the division of the above-mentioned functional elements and modules is exemplified. In practical applications, the above-mentioned distribution of functions can be completed by different functional elements and modules according to requirements, i.e. the internal structure of calibration device of Terahertz frequency band on-wafer S parameter is divided into different functional elements or modules so as to complete all or part of the functions described above. The functional elements and modules in the embodiments may be integrated in one processing unit, may be physically separate from each other, or may be integrated in one unit by two or more units. The integrated units may be either in the form of hardware or in the form of software functional units. In addition, the specific names of the functional elements and modules are merely for convenience of mutual distinction, and are not used to limit the scope of protection of the present disclosure. The specific working process of the elements and modules can refer to the corresponding process in method embodiment 1, which is not described in detail herein.

FIG. **16** is a schematic block diagram of terminal equipment provided in an embodiment of the present application. As shown in FIG. **16**, the terminal equipment **1300** of this embodiment comprises one or more processors **1301**, a memory **1302**, and a computer program **1303** stored in the memory **1302** and executable on the processor **1301**. The processor **1301**, when executing the computer program **1303**, implements the steps in the embodiments of the calibration method of Terahertz frequency band on-wafer S parameter, e.g. steps **S201** to **S205** shown in FIG. **2**. Alternatively, the processor **1301**, when executing the computer program **1303**, performs functions of each modules/units in the embodiments of the calibration device of Terahertz frequency band on-wafer S parameter, such as the functions of the modules **1201** to **1205** shown in FIG. **15**.

Illustratively, the computer program **1303** may be partitioned into one or more modules/units that are stored in the memory **1302** and executed by the processor **1301** to complete the present disclosure. The one or more modules/units may be a series of computer program instruction segments capable of performing specific functions for describing the executive process of the computer program **1303** in the terminal equipment **1300**. For example, the computer program **1303** may be partitioned into an acquisition module, a first mathematical model determination module, a second mathematical model determination module, a third mathematical model determination module, and an S parameter determination module, each having the following specific functions.

The acquisition module is used for acquiring eight error models obtained after a preliminary calibration of a Terahertz frequency band system.

The first mathematical model determination module is configured for acquiring a first S parameter based on a first calibration piece on the basis of the eight error models, and determining a first mathematical model according to the first S parameter, the first mathematical model comprising parallel crosstalk terms between probes.

The second mathematical model determination module is configured for acquiring a second S parameter based on a second calibration piece on the basis of the eight error models, and determining a second mathematical model according to the second S parameter, the second mathematical model comprising series crosstalk terms between the probes.

The third mathematical model determining module is configured for acquiring a third S parameter based on a measured piece on the basis of the eight error models, and determining a third mathematical model according to the third S parameter, the third mathematical model comprising a Z parameter of the measured piece.

The S parameter determination module is configured for solving and obtaining a Z parameter of the measured piece based on the first mathematical model, the second mathematical model and the third mathematical model, and acquiring an S parameter of the measured piece according to the Z parameter of the measured piece.

Other modules or units may be described with reference to the embodiment shown in FIG. **15** and will not be described in detail herein.

The terminal equipment **1300** may be a computing device such as a desktop computer, a notebook, a palmtop computer, or a cloud server, and may also be a DSP (digital signal processor). The terminal equipment includes, but is not limited to, a processor **1301**, and a memory **1302**. Those skilled in the art will appreciate that FIG. **16** is merely an example of terminal equipment **1300** and is not to be construed as limiting the terminal equipment **1300**, and may include more or fewer components than shown, or may combine certain components, or different components, e.g., the terminal equipment **1300** may also include input and output devices, a network access device, a bus, etc.

The processor **1301** may be a central processing unit (CPU) or other general purpose processor, a Digital Signal Processor (DSP), an Application Specific Integrated Circuit (ASIC), Field-Programmable Gate Array (FPGA) or other programmable logic devices, discrete gate or transistor logic devices, discrete hardware components, etc. A general purpose processor may be a microprocessor or the processor may be any conventional processor or the like.

The memory **1302** may be an internal storage unit of the terminal equipment **1300**, such as a hard disk or a memory of the terminal equipment **1300**. The memory **1302** may also be an external storage device of the terminal equipment **1300**, such as a plug-in hard disk, a Smart Media Card (SMC), a Secure Digital (SD) card, a Flash Card, etc. provided on the terminal equipment **1300**. Further, the memory **1302** may also comprise both an internal storage unit and an external storage device of the terminal equipment **1300**. The memory **1302** is used for storing the computer program **1303**, and other programs and data required by the terminal equipment **1300**. The memory **1302** may also be used to temporarily store data that has been or will be output.

In the embodiments described above, emphasis has been placed on the description of various embodiments. Parts of an embodiment that are not described or illustrated in detail may be found in the description of other embodiments.

Those of ordinary skill in the art will recognize that the elements and algorithm steps described in connection with the embodiments disclosed herein may be implemented by an electronic hardware, or a combination of computer software and electronic hardware. Whether such functions are implemented by hardware or software depends upon the particular application and design constraints of the technical solutions. Skilled artisans may implement the described functions in varying ways for each particular application, but such implementation is not intended to exceed the scope of the present disclosure.

In the embodiments provided herein, it should be understood that the calibration device and method of Terahertz frequency band on-wafer S parameter may be implemented in other ways. For example, the embodiments of the calibration device of Terahertz frequency band on-wafer S parameter described above are merely illustrative, e.g., a division of the modules or elements into only one logical function, and there may be additional divisions in actual implementation. For example, multiple elements or components may be combined or integrated into another system, or some features may be omitted, or not performed. Alternatively, the couplings or direct couplings or communicative connections shown or discussed with respect to one another may be indirect couplings or communicative connections via some interface, devices or units, and may be electrical, mechanical or otherwise.

The units described as separate components may or may not be physically separate, and the components shown as units may or may not be physical units, i.e. may be located in one place, or may be distributed over a plurality of network elements. Some or all of the units may be selected to achieve the objectives of the solution of the present embodiment according to practical requirements.

In addition, the functional units in the embodiments may be integrated in one processing unit, may be physically separate from each other, or may be integrated in one unit by two or more units. The integrated units described above can be implemented either in the form of hardware or software functional units.

The integrated module/unit, if implemented in the form of a software functional unit and sold or used as a stand-alone product, may be stored in a computer-readable storage medium. Based on such an understanding, the present application may implement all or part of the processes of the above-described embodiments, and may also be implemented by a computer program instructing related hardware. The computer program as described may be stored in a computer-readable storage medium and performs the steps of the various method embodiments described above when executed by the processor. Therein, the computer program comprises computer program code, which may be in the form of source code, object code, executable files or some intermediate form, etc. The computer-readable medium may include: any entity or device capable of carrying the computer program code, recording media, U-disk, removable hard disk, magnetic disk, optical disk, computer memory, Read-Only Memory (ROM), Random Access Memory (RAM), electrical carrier wave signals, telecommunications signals, and software distribution media. It should be noted that the computer-readable medium may contain content that may be appropriately augmented or subtracted as required by legislation and patent practice within judicial jurisdictions, e.g., the computer-readable medium does not include electrical carrier wave signals and telecommunications signals in accordance with legislation and patent practices in some jurisdictions.

The above-described embodiments are merely illustrative of the technical solutions of the present disclosure and are not intended to be limiting thereof. Although the present disclosure has been described in detail with reference to the foregoing embodiments, those skilled in the art will appreciate that the technical solutions of the above-mentioned embodiments can still be modified, or some of the technical features thereof can be equivalently substituted; and such modifications and substitutions do not cause the nature of the corresponding technical solution to depart from the spirit and scope of the embodiments of the present disclosure, and are intended to be included within the scope of this application.

Although embodiments of the present disclosure have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the disclosure as defined by the appended claims.

Moreover, the scope of the present disclosure is not intended to be limited to the particular embodiments described here. As one of ordinary skill in the art will readily appreciate from the disclosure of the present disclosure that processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed, may perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

What is claimed is:

1. A calibration method of Terahertz frequency band on-wafer S parameter, comprising:
- acquiring eight error models obtained after a preliminary calibration of a Terahertz frequency band system;
- acquiring a first S parameter based on a first calibration piece on the basis of the eight error models, and determining a first mathematical model according to the first S parameter, the first mathematical model comprising parallel crosstalk terms between probes;
- acquiring a second S parameter based on a second calibration piece on the basis of the eight error models, and determining a second mathematical model according to the second S parameter, the second mathematical model comprising series crosstalk terms between the probes;
- acquiring a third S parameter based on a measured piece on the basis of the eight error models, and determining a third mathematical model according to the third S parameter, the third mathematical model comprising a Z parameter of the measured piece;
- obtaining the Z parameter of the measured piece based on the first mathematical model, the second mathematical model and the third mathematical model; and
- calibrating an S parameter of the measured piece according to the Z parameter of the measured piece; and
- wherein acquiring the first S parameter based on the first calibration piece on the basis of the eight error models, and determining the first mathematical model according to the first S parameter comprises:
  - generating a first equivalent circuit model corresponding to the first calibration piece based on the first calibration piece;
  - acquiring the first S parameter of the first calibration piece according to the eight error models;
  - converting the first S parameter into a first Y parameter; and
  - determining the first mathematical model according to the first Y parameter and the first equivalent circuit model, wherein the first mathematical model is represented as $Y_{Total}^{OPN}=Y_{PAD}+Y_P$, Y_{Total}^{OPN} is the first Y parameter, Y_{PAD} is a PAD (pad) parallel parasitic parameter, and Y_p is the parallel crosstalk terms between the probes.

2. The calibration method according to claim 1, wherein the first calibration piece is an open-open calibration piece, and the second calibration piece is a short-short calibration piece.

3. The calibration method according to claim 1, wherein acquiring the second S parameter based on the second calibration piece on the basis of the eight error models, and determining the second mathematical model according to the second S parameter comprises:
- generating a second equivalent circuit model corresponding to the second calibration piece based on the second calibration piece;
- acquiring the second S parameter of the second calibration piece obtained by measurement according to the eight error models;
- converting the second S parameter into a second Y parameter; and
- determining the second mathematical model according to the second Y parameter and the second equivalent circuit model.

4. The calibration method according to claim 3, wherein the first calibration piece is an open-open calibration piece, and the second calibration piece is a short-short calibration piece.

5. The calibration method according to claim 3, wherein, the second mathematical model is represented as $Y_{Total}^{SHORT}=Y_{PAD}+Y_P+(Z_S+Z_L)^{-1}$, wherein Y_{Total}^{SHORT} is the second Y parameter, Y_{PAD} is the PAD parallel parasitic parameter, Y_P is the parallel crosstalk terms between the probes, Z_S is the series crosstalk terms between the probes, and Z_L is a series parasitic parameter of a PAD intraconnection.

6. The calibration method according to claim 5, wherein the first calibration piece is an open-open calibration piece, and the second calibration piece is a short-short calibration piece.

7. The calibration method according to claim 1, wherein acquiring the third S parameter based on the measured piece on the basis of the eight error models, and determining the third mathematical model according to the third S parameter comprises:
- generating a third equivalent circuit model corresponding to the measured piece based on the measured piece;
- acquiring the third S parameter of the measured piece obtained by measurement according to the eight error models;
- converting the third S parameter into a third Y parameter; and
- determining the third mathematical model according to the third Y parameter and the third equivalent circuit model.

8. The calibration method according to claim 7, wherein the first calibration piece is an open-open calibration piece, and the second calibration piece is a short-short calibration piece.

9. The calibration method according to claim 7, wherein, the third mathematical model is represented as $Y_{Total}^{DUT}=Y_P+Y_{PAD}+S+Z_L+Z_{DUT})^{-1}$, wherein Y_{Total}^{DUT} is the third Y parameter, Y_P is the parallel crosstalk terms between the probes, Y_{PAD} is the PAD parallel parasitic parameter, Z_S is the series crosstalk terms between the probes, Z_L is a series parasitic parameter of a PAD intraconnection, and Z_{DUT} is the Z parameter of the measured piece.

10. The calibration method according to claim 9, wherein the first calibration piece is an open-open calibration piece, and the second calibration piece is a short-short calibration piece.

11. The calibration method according to claim 1, wherein the first calibration piece is an open-open calibration piece, and the second calibration piece is a short-short calibration piece.

12. A terminal equipment comprising a non-transitory memory, a processor and a computer program stored in the memory and executable on the processor, wherein the pro-

cessor, when executing the computer program, causes the terminal equipment to perform:

acquiring eight error models obtained after a preliminary calibration of a Terahertz frequency band system;

acquiring a first S parameter based on a first calibration piece on the basis of the eight error models, and determining a first mathematical model according to the first S parameter, the first mathematical model comprising parallel crosstalk terms between probes;

acquiring a second S parameter based on a second calibration piece on the basis of the eight error models, and determining a second mathematical model according to the second S parameter, the second mathematical model comprising series crosstalk terms between the probes;

acquiring a third S parameter based on a measured piece on the basis of the eight error models, and determining a third mathematical model according to the third S parameter, the third mathematical model comprising a Z parameter of the measured piece;

obtaining the Z parameter of the measured piece based on the first mathematical model, the second mathematical model and the third mathematical model, and

calibrating an S parameter of the measured piece according to the Z parameter of the measured piece; and

wherein acquiring the first S parameter based on the first calibration piece on the basis of the eight error models, and determining the first mathematical model according to the first S parameter comprises:

generating a first equivalent circuit model corresponding to the first calibration piece based on the first calibration piece;

acquiring the first S parameter of the first calibration piece according to the eight error models;

converting the first S parameter into a first Y parameter; and

determining the first mathematical model according to the first Y parameter and the first equivalent circuit model, wherein the first mathematical model is represented as $Y_{Total}^{OPN}=Y_{PAD}+Y_p$, Y_{Total}^{OPN} is the first Y parameter, Y_{PAD} is a PAD (pad) parallel parasitic parameter, and Y_p is the parallel crosstalk terms between the probes.

13. A non-transitory computer-readable storage medium storing a computer program that, when executed by one or more processors, causes the one or more processors to perform:

acquiring eight error models obtained after a preliminary calibration of a Terahertz frequency band system;

acquiring a first S parameter based on a first calibration piece on the basis of the eight error models, and determining a first mathematical model according to the first S parameter, the first mathematical model comprising parallel crosstalk terms between probes;

acquiring a second S parameter based on a second calibration piece on the basis of the eight error models, and determining a second mathematical model according to the second S parameter, the second mathematical model comprising series crosstalk terms between the probes;

acquiring a third S parameter based on a measured piece on the basis of the eight error models, and determining a third mathematical model according to the third S parameter, the third mathematical model comprising a Z parameter of the measured piece;

obtaining the Z parameter of the measured piece based on the first mathematical model, the second mathematical model and the third mathematical model, and

calibrating an S parameter of the measured piece according to the Z parameter of the measured piece; and

wherein acquiring the first S parameter based on the first calibration piece on the basis of the eight error models, and determining the first mathematical model according to the first S parameter comprises:

generating a first equivalent circuit model corresponding to the first calibration piece based on the first calibration piece;

acquiring the first S parameter of the first calibration piece according to the eight error models;

converting the first S parameter into a first Y parameter; and

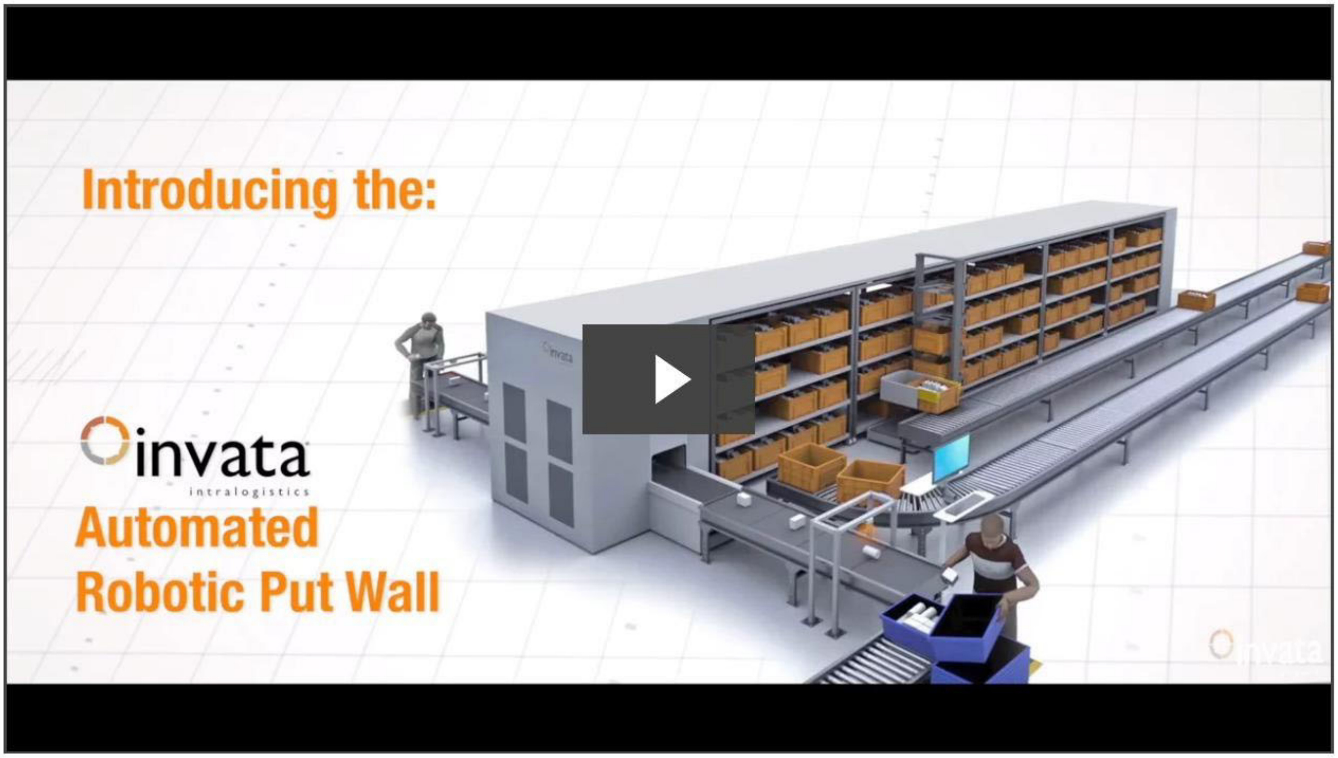
determining the first mathematical model according to the first Y parameter and the first equivalent circuit model, wherein the first mathematical model is represented as $Y_{Total}^{OPN}=Y_{PAD}+Y_p$, Y_{Total}^{OPN} is the first Y parameter, Y_{PAD} is a PAD (pad) parallel parasitic parameter, and Y_p is the parallel crosstalk terms between the probes.

* * * * *

PTO-1683
(Rev. 7-96)

EXHIBIT B

Invata Automated Robotic Put Wall Solutions



Fill a Lot More Orders — a Whole Lot Faster!

The Invata Automated Put Wall enables high-speed automated pick-up and sortation of picked items for discrete order consolidation purposes. In doing so, it more than **doubles (2x+) the put rate of manual put walls** and increases the number of orders that can be processed at the same time by **over 700%**.

The impressive efficiencies of the automated put wall translate to **put rates of 1800 - 2200 units per hour** (human v. robotic induction) and processing capabilities for up to **500 orders at once**.

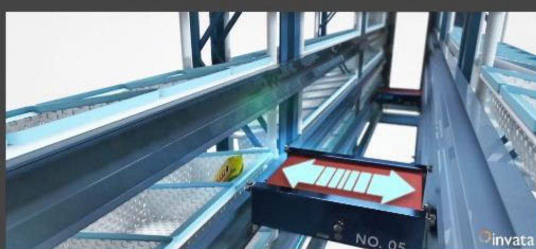
SCHEDULE A FREE DEMO

Process a Wide Product Mix in a Manner that Fits Your Process

The Invata Automated Robotic Put Wall:

- Can be ordered in **varying sizes**, so it can be used by small and large scale operations alike.
- Can be configured with the destination locations that work best for your operation, including **totes, chutes, carts, racking**.
- **Accommodates the largest product mix** on the market: Up to 19.6" in length, 16.5" in width, 7.87” in height, and 11 lbs in weight. Items can be as small as 2"overall.
- Can be configured for a variety of completed order management options including: **Cart to Pack, Tote to Pack, AMR to Pack.**

LET'S TALK ABOUT MY NEEDS



Benefit from Enhanced Picking Efficiencies without Even Trying...

Invata's Automated Robotic Put Wall Solutions change the way you fulfill orders and/or process returns. And the enhances operational efficiencies benefit all aspects of your operation.

The increase in processing capabilities yields 1.5-2x greater efficiencies in the pick process as more orders can be released to picking at the same time, which in turn creates a much denser pick path for pickers.

SHOW ME HOW

Let's Get Started...

- What's not working?
- What do you need to accomplish that you can't with the tools you have?
- What do you want to achieve?

Tell us about the challenges you face, and we can show you how we can help solve them.

Do you want to:

☐ Schedule a free demo of our capabilities?
☐ Have us call you to discuss your challenges?
☐ Plan an on-site tour to discuss your operation?

First Name * Last Name * Your Title

Company Name * Your Email * Phone (Optional, but very helpful)

We respect your privacy! We will never sell, rent, or share your personal information with any 3rd party outside our business network, unless required by law.

☑ Add me to your mailing list!

Submit

invata

Science Software Systems Resources About Contact

1010 Spring Mill Avenue, Suite 300 | Conshohocken, PA 19428 | Inquiries: (610) 397-1050 | Support: (877) ASK INVATA

EXHIBIT C

CONTACT INFO

Type	Name	Address
CONSIGNEE	INVATA LLC	1010 SPRING MILL AVE SUITE 300,CONS HOHOCKEN PA 1942819428,US
NOTIFY PARTY	-NOT AVAILABLE-	-NOT AVAILABLE-
SHIPPER	HANGZHOU HUICANG INFORMATION TECHNO Get Credit Report	101BINKANG ROAD, HIWELL BUILDING 3/ F PODIUM,BINJIANG ZHEJIANG, CHINA,HANGZHOU,CN

PRODUCT DETAILS

Container No.	Description Area
EITU1349480	OMNISORT - ITEM SORTING MACHINE

TRANSIT DETAILS

CARRIER	HGSO
SHIP REGISTERED IN	UNITED STATES
VESSEL	OOCL LONDON
VOYAGE	085E
US PORT	LONG BEACH, CALIFORNIA
FOREIGN PORT	SHANGHAI
COUNTRY OF ORIGIN	CHINA
PLACE OF RECEIPT	SHANGHAI
BILL OF LADING	HGSOGSOE21060374
ARRIVAL DATE	2021-07-04
QUANTITY	15 PKG
CONTAINER COUNT	1
WEIGHT (LB / KG)	12,857 / 5,844
CBM	0
HOUSE VS MASTER	H
MASTER BILL OF LADING	EGLV142102054543

OTHER INFO

Container No.	Marks and Numbers Area
EITU1349480	N/M

RELATED B/L	
Type (House/Master)	B / L
H	HGSOGSOE21060374

0.1862

EXHIBIT D

UNITED STATES INTERNATIONAL TRADE COMMISSION
WASHINGTON, D.C.

Before the Honorable ___________________
Administrative Law Judge

In the Matter of CERTAIN AUTOMATED PUT WALLS AND AUTOMATED STORAGE AND RETRIEVAL SYSTEMS, ASSOCIATED VEHICLES, ASSOCIATED CONTROL SOFTWARE, AND COMPONENT PARTS THEREOF	Investigation No. 337-TA-____

DECLARATION OF STACI DRESHER

I, Staci Dresher, hereby swear and affirm, subject to the penalty of perjury under the laws of the United States, all of the following:

1. I am a private investigator licensed to offer investigative services in the State of California (CA PI license no. 29132). I have worked as a private investigator since July 2006. I am the owner of Dresher Consulting & Investigations (d/b/a "DCI"). Staci Dresher is my maiden name. I also professionally go by Staci E. Freedman, which is my married name.

2. The facts set forth below are based upon my personal knowledge, as well as my own education, training and experience. If called to testify in this matter, I could and would competently testify as follows.

3. DCI is a research, consulting and private investigation firm, with an office in Oakland, California. DCI offers a variety of research and investigative services, including asset investigation and tracing, and evidence gathering in legal disputes often related to allegations of intellectual property infringement, corruption and fraud. With respect to my education, training and experience, I have extensive experience in finding hidden assets and connections, gathering cross-examination material on experts and adverse parties, and assisting counsel during white collar criminal defense matters.

4. DCI was retained by Desmarais LLP on behalf of its client, OPEX Corporation. DCI conducted an investigation into HC Robotics, a Chinese company, and Invata Intralogistics, d/b/a Invata, LLC ("Invata"), a U.S. Company.

5. In conducting this investigation, I performed initial online research on HC Robotics, Invata, automated put walls and automated storage and retrieval systems, and the warehouse automation industry more broadly. After conducting this initial research, I reached out to Invata via multiple channels, including online, by email, and by telephone.

6. In September of 2021, I spoke by telephone with Invata's Vice President of Sales. Invata's Vice President of Sales told me that Invata had recently made its first U.S. sale of its automated put wall solution to a customer in San Francisco, California, and the product was scheduled to "go live" on October 10, 2021. Based on the importation record showing a shipment of an Omnisort system from HC Robotics to Invata, delivered at Long Beach, California on July 4, 2021 (Exhibit 18 to OPEX's Complaint) and Invata's website advertising only one automated put wall, I am confident that the Invata automated put wall sold and installed in San Francisco in or around October of 2021 was an Omnisort. Invata's Vice President of Sales also told me that Invata had "four to six" additional U.S. customers who were scheduled to "go live" with their Invata automated put wall systems in the first half of 2022.

7. I hereby swear and affirm that all of the foregoing is true and correct to the best of my knowledge, information, and belief.

Sworn and affirmed on December 20, 2021
at Los Angeles, California

Staci Dresher

EXHIBIT E

PRODUCT DESCRIPTION	CONSIGNEE	SHIPPER	ARRIVAL DATE	GROSS WEIGHT (LB)	GROSS WEIGHT (KG)	FOREIGN PORT	US PORT	VESSEL NAME	COUNTRY OF ORIGIN	MARKS & NUMBERS	CONSIGNEE ADDRESS	SHIPPER ADDRESS	ZIP CODE	NO. OF CONTAINERS	CONTAINER	CONTAINER TYPE	QUANTITY	QUANTITY UNIT	MEASUREMENT	MEASUREMENT UNIT	BILL OF LADING	HOUSE VS MASTER	DISTRIBUTION PORT	MASTER B/L	VOYAGE NUMBER	SEAL	SHIP REGISTERED IN	IN-BOND ENTRY TYPE	CARRIER CODE	CARRIER NAME	CARRIER CITY	CARRIER STATE	CARRIER ZIP	CARRIER ADDRESS	NOTIFY PARTY	NOTIFY ADDRESS	PLACE OF RECEIPT
PICKING MAST	INVATA	ZHEJIANG GUOZI ROBOTICS CO LTD	05/09/2022	1100	500	Shanghai	New York/Newark Area, Newark, New Jersey	EVER FULL	China	N M	530 WEST ST	66 DONGXIN AVE BUILDING 4 FLOOR 5 BINJIANG HANGZHOU CN	2184	1	EITU180022	45G0	1	PKG	0	CM	SHPT16095079	H		EGLV142253016528	47001	EMCNEP6151	LIBERIA		SHPT	SHIPCO TRANSP ORT INC	HOBOKE N	NJ	7030	80 WASHIN GTON STREET	INVATA	530 WEST ST BRAINTR EE, MA 02184 US	SHANGH AI
PICKING-HOLD / CHARGING STATION	INVATA INC.	ZHEJIANG GUOZI ROBOTICS CO.,LTD.	04/29/2022	7920	3600	Pusan	New York/Newark Area, Newark, New Jersey	HYUNDAI FORWARD	South Korea	NO MARKS NO MARKS	530 WEST ST	66 DONGXIN AVE BUILDING 4 FLOOR 5 , BINJIANG DISTRICT, HANGZHOU CITY, ZHEJIANG,310053, CHINA T	2184	1	HMMU2137	2CG0	8	PKG	0		HDMUSHAZ993 935A1	H		HDMUSHAZ99393500	0127E	211687360	MARSHALL ISLANDS		HDMU	HYUNDA I MERCHA NT MARINE	SEOUL			879 W 190TH ST 7TH FL	FANATIC S	727 OLD PHILADEL PHIA ROAD ABERDEE N, MD 21001 DOMINIC PIRIANO ELEPHON E (972) 467-8616	SHANGH AI,CHINA
PICKING PLUS	INVATA INC.	ZHEJIANG GUOZI ROBOTICS CO.,LTD.	04/28/2022	12760	5800	Shanghai	New York/Newark Area, Newark, New Jersey	CMA CGM ADONIS	China	N/M	530 WEST ST	66 DONGXIN AVE BUILDING 4FLOOR 5 ,B INJIANG DISTRICT,HANGZHO U CITY, ZHE JIANG,	2184	1	EISU926940	45G0	2	PKG	0		CHIASEF220312 761	H		EGLV142250130389	0MBAZ	EMCNFJ1551	MALTA		CHIA	CHINATR ANS INTERNA TIONAL LIMITED	SHENZH EN		518010	23/F SEC A TAIPINGY ANG COMMER CIAL & TRADE BLDG NO	INVATA INC.	530 WEST ST, BRAINTR EE,MA 02184 CON TACT: TRICIACIL IBERTO .	SHANGH AI
PICKING PLUS	INVATA INC.	ZHEJIANG GUOZI ROBOTICS CO.,LTD.	04/20/2022	12760	5800	Shanghai	New York/Newark Area, Newark, New Jersey	CMA CGM APOLLON	China	N/M	530 WEST ST	66 DONGXIN AVE BUILDING 4 FLOOR 5 , BINJIANG DISTRICT, HANGZHOU CITY, HANGZHOU CN	2184	1	CMAU42532	4500	2	PKG	0		SHRFSGH13922 2	H		CMDUCNWW065806	0MBAX	P3760024	MALTA		SHRF	SUN RICH FRESH FOODS INC USA					INVATA INC.	530 WEST ST, BRAINTR EE, MA 02184	SHANGH AI CHINA
PICKING PLUS	INVATA INC.	ZHEJIANG GUOZI ROBOTICS CO.,LTD.	04/20/2022	12760	5800	Shanghai	New York/Newark Area, Newark, New Jersey	CMA CGM APOLLON	China	N/M	530 WEST ST	66 DONGXIN AVE BUILDING 4 FLOOR 5 , BINJIANG DISTRICT, HANGZHOU CITY, HANGZHOU CN	2184	1	SEKU563650	4500	2	PKG	0		SHRFSGH13922 6	H		CMDUCNWW065807	0MBAX	C4730888	MALTA		SHRF	SUN RICH FRESH FOODS INC USA					INVATA INC.	530 WEST ST, BRAINTR EE, MA 02184	SHANGH AI CHINA
LOGISTICS ROBOT TOOL BOX	BOSTON CONVENTION C	SHANGHAI YUNKE LOGISTICS CO LTD	04/20/2022	8360	3800	Yangshan	New York/Newark Area, Newark, New Jersey	CMA CGM APOLLON	China	NO MARKS	415 SUMME	ROOM12187 60 NO 465 LIANGCHENG ROAD SHANGHAI CN		1	SEKU465575	4500	2	PKG	0		EURFL21D1752 6BOS	H		OOLU2692925130	MBAXE	OOLGYQ4448	MALTA		EURF	EURASIA EXPRESS	INGLEW OOD	CA	90304	11222 LA CIENEGA BLVD - #220	INVATA INTRALO GISTICS	530 WEST ST BRAINTR EE MA02184 US	YANGSHA N
PICKING AGV	INVATA INC	ZHEJIANG GUOZI ROBOTICS CO LTD	03/06/2022	2105	957	Shanghai	New York/Newark Area, Newark, New Jersey	CMA CGM PEGASUS	China	N M	530 WEST ST	66 DONGXIN AVE BUILDING 4 FLOOR 5 BINJIANG DISTRICT ZHEJIANG HANGZHOU CN	2184	1	TGHU983916	45G0	3	PKG	0	CM	SHPT16076441	H		CMDUCNSE645895	0VCAX	C3252310	MALTA		SHPT	SHIPCO TRANSP ORT INC	HOBOKE N	NJ	7030	80 WASHIN GTON STREET	INVATA INC	530 WEST ST BRAINTR EE, MA 02184 US	SHANGH AI
PICKING PLUS PICKING-HOLD PICKING PLUS PICKING-HOLD	INVATA INC.	ZHEJIANG GUOZI ROBOTICS CO.,LTD.	03/06/2022	22440	10200	Ningpo	New York/Newark Area, Newark, New Jersey	NEW YORK EXPRESS	China	N/A N/A	727 OLD PHI	66 DONGXIN AVE BUILDING 4 FLOOR 5 , BINJIANG DISTRICT, HANGZHOU CITY, ZHEJIANG,310053, CHINA TE 571 8111 9370	21001	2	TRHU642317	45G1 45G1	6	PKG	96	CM	PVIDNB2020148 6	H		ONEYNB1IVR331300	045E	CNBV51987 CNBV47416	GERMANY		PVID						INVATA INC.	727 OLD PHILADEL PHIA ROAD ABERDEE N, MD 21001 DOMINIC PIRIANO	NINGBO
CONVEYER PARTS	INVATA INC.	-NOT AVAILABLE-	03/03/2022	4752	2160	Stade	Baltimore, Maryland	ATLANTIC SEA	Germany	INVATA INC.	1010 SPRING	-NOT AVAILABLE-	19428	1	GCNU47694	45G0	4	PKG	0		BWSS6022332	H		ACLUSA00755613	8322	WWA0101591 13	MALTA		BWSS	BLUE WATER SHIPPIN G US INC	UNION	NJ	07083-3320	1185 MORRIS AVE STE 302	-NOT AVAILAB LE-	-NOT AVAILABL E-	ARDEN
PER INVOICE NO 25291 DATED 06.01.22 NET WEIGHT 540 KGS HS CODE 84238220 / LIEBHERR SPARE PARTS MAN-32296 HS-CODE 84314980 AMS-REF. BTI209336 FINAL DELIVERY ADDRESS MORROW EQUIPMENT COMPANY LLC PHONE 703-368-1650 11800 LIVINGSTON ROAD USA - MANASSAS, VA 20109 / 1X 60X40X35 CM / 51,00 KGS TRIP BLOCK CPL 1X 120X80X75 CM / 460,00 KGS PACKING RING, GROUND-FAULT DETECT, LEAKAGE AIR FILTER, BRUSH HOLDER, GROUNDING BUSH, BEARING SHELL, SIMATIC S7-300 COUNTER MODUL FM 350-1 HS-CODES 840690, 681510,	SHIPCO TRANSPORT	SACO SHIPPING GMBH	03/03/2022	22090	10041	Stade	Baltimore, Maryland	ATLANTIC SEA	Germany	2051 INTERMOD AL AVENUE 17225-550 GREENCAST LE USA . MORROW EQUIPMEN T COMPANY LLC 11800 LIVINGSTO N ROAD USA - MANASSAS, VA 20109 . . SIEMENS US SHELL CHEM APPALACHI A LLC MONACA PA MONACA, PA 15061 UNITED STATES OF AMERICA	699 KAPKOW	WOLLKAEMMEREIS TRASSE 1 HAMBURG 21107 DE	7201	1	GCNU47694	45G0	161	PCS	49	X	ACLUSA007556 13	M			ATE83	WWA0101591 13	MALTA		ACLU	ATLANTI C CONTAI NER LINE AB	ISELIN	NJ	8830	PO BOX 4120	SHIPCO TRANSP ORT	699 KAPKOW SKI ROAD ELIZABET H NJ 07201 US	HAMBUR G

PICKING AGV	GUOZI USA LLC	ZHEJIANG GUOZI ROBOTICS CO LTD	02/25/2022	12760	5800	Yangshan	New York/Newark Area, Newark, New Jersey	MSC MANZANILL O	China	N/M	MIN LI SOLE	66 DONGXIN AVE BUILDING 4 FLOOR 5 ZHEJIANG CHINA	28078	1	MSDU55075	4510	2	PKG	60	CM	LFFVSHA112118 79	H		MEDUHC642715	150A	FX21559382	PORTUGAL		LFFV						INVATA INC	727 OLD PHILADEL PHIA ROAD ABERDEE N MD 21001 USA	SHANGH AI
PICKING AGV PICKING- HOLD	GUOZI USA LLC	ZHEJIANG GUOZI ROBOTICS CO LTD	02/25/2022	14080	6400	Yangshan	New York/Newark Area, Newark, New Jersey	MSC MANZANILL O	China	N/M	MIN LI SOLE	66 DONGXIN AVE BUILDING 4 FLOOR 5 ZHEJIANG CHINA	28078	1	MSCU53443	4510	8	PKG	46	CM	LFFVSHA112125 47	H		MEDUHC642749	150A	FX21559348	PORTUGAL		LFFV						INVATA INC	727 OLD PHILADEL PHIA ROAD ABERDEE N MD 21001 USA	SHANGH AI
PICKING AGV	GUOZI USA LLC	ZHEJIANG GUOZI ROBOTICS CO LTD	02/25/2022	12760	5800	Yangshan	New York/Newark Area, Newark, New Jersey	MSC MANZANILL O	China	N/M	MIN LI SOLE	66 DONGXIN AVE BUILDING 4 FLOOR 5 ZHEJIANG CHINA	28078	1	MSDU55164	4510	2	PKG	60	CM	LFFVSHA112118 78	H		MEDUHC642707	150A	FX21559424	PORTUGAL		LFFV						INVATA INC	727 OLD PHILADEL PHIA ROAD ABERDEE N MD 21001 USA	SHANGH AI
PICKING AGV	GUOZI USA LLC	ZHEJIANG GUOZI ROBOTICS CO LTD	02/25/2022	12760	5800	Yangshan	New York/Newark Area, Newark, New Jersey	MSC MANZANILL O	China	N/M	MIN LI SOLE	66 DONGXIN AVE BUILDING 4 FLOOR 5 ZHEJIANG CHINA	28078	1	MSDU55109	4510	2	PKG	60	CM	LFFVSHA112118 80	H		MEDUHC642731	150A	FX21559438	PORTUGAL		LFFV						INVATA INC	727 OLD PHILADEL PHIA ROAD ABERDEE N MD 21001 USA	SHANGH AI
SORTING MACHINE	INVATA LLC,	HUICANG	02/12/2022	16896	7680	Shanghai	Area, Newark, New	SHIPPING	China	N M	1010 SPRING	ROAD, HIWELL	19428	1	OOLU92638	45G0	17	PKG	0		767	H		OOLU2128774150	013E	OOLHFN3872	KONG		SXCO						AVAILAB	AVAILABL	AI
HOLD CHARGING	GUOZI USA LLC	ROBOTICS CO.,LTD.	02/12/2022	12650	5750	Shanghai	Area, Newark, New	FORTUNE	China	N/M	MIN LI SOLE	BUILDING 4 FLOOR	28078	1	EITU168739	4EB0	7	PKG	0		21036	H		EGLV142104589576	060E	EMCNAK6331	STATES		HGSO						INC.	PHILADEL	AI
SORTING MACHINE	INVATA LLC	HUICANG	01/28/2022	18381	8355	Shanghai	Area, Newark, New	EDINBURGH	China	N M	1010 SPRING	ROAD, HIWELL	19428	1	MRKU37962	45G0	14	PKG	0		317	H		MAEU291455937	150E	CN0454887	DENMARK		SXCO						AVAILAB	AVAILABL	AI
SORTING MACHINE	INVATA LLC	HUICANG	01/28/2022	18381	8355	Shanghai	Area, Newark, New	EDINBURGH	China	N M	1010 SPRING	ROAD, HIWELL	19428	1	MRKU54244	45G0	14	PKG	0		327	H		MAEU291455958	150E	CN0454789	DENMARK		SXCO						AVAILAB	AVAILABL	AI
PICKING AGV	GUOZI USA LLC	ROBOTICS CO.,LTD.	01/20/2022	12760	5800	Ningpo	Area, Newark, New	SHIPPING	China	N/M	MIN LI SOLE	BUILDING 4 FLOOR	28078	1	EITU150084	40R0	2	PKG	0	CM	1401	H		EGLV143152630597	013E	EMCKCZ1281	CANADA		NGWI						INC.	PHILADEL	NINGBO
CONVEYOR	INVATA INC	CHAIN A S	01/02/2022	19734	8970	Stade	Baltimore, Maryland	STAR	Germany	INVATA INC	1010 SPRING	ARDEN 9510 DE	19428	1	FSCU834068	45G0	9	PKG	0		BWSS5492360	H		HLCUCPH210910503	AST82		MALTA		BWSS	WATER	UNION	NJ	3320	MORRIS	AVAILAB	AVAILABL	ARDEN
OBLIQUE STRUTS AND	INVATA INC.	-NOT AVAILABLE-	12/11/2021	8008	3640	Aarhus	Baltimore, Maryland	STAR	Denmark	INVATA INC.	1010 SPRING	-NOT AVAILABLE-	19428	1	GCNU47364	45G0	6	PKG	0		BWSS5652715	H		ACLUSA00725085	ATK78	38033	MALTA		BWSS	WATER	UNION	NJ	3320	MORRIS	AVAILAB	AVAILABL	ARDEN
CONVEYOR	INVATA INC	CHAIN A S	12/03/2021	9944	4520	Stade	Baltimore, Maryland	SUN	Germany	INVATA INC	1010 SPRING	ARDEN 9510 DE	19428	1	TGBU964399	45G0	2	PKG	0		BWSS5492356	H		HLCUCPH210910485	ASU82	BWS37320	MALTA		BWSS	WATER	UNION	NJ	3320	MORRIS	AVAILAB	AVAILABL	ARDEN
PALLETSTANDS	INVATA INC	CHAIN A S	11/26/2021	54413	24733	Stade	Baltimore, Maryland	STAR	Germany	INVATA INC	1010 SPRING	ARDEN 9510 DE	19428	2	BEAU470859	45G0 45G0	24	PKG	0		BWSS5492358	H		HLCUCPH210910496	AST80	BWS37318	MALTA		BWSS	WATER	UNION	NJ	3320	MORRIS	AVAILAB	AVAILABL	ARDEN
X AXIS X AXIS	INVATA INC	CHAIN A S	11/03/2021	80916	36780	Stade	Baltimore, Maryland	SKY	Germany	K & CO NO	1010 SPRING	ARDEN 9510 DE	19428	2	FCIU940655	45G0 45G0	8	PKG	0		BWSS5492357	H		ACLUSA00712053	ATK76	1902923	MALTA		BWSS	WATER	UNION	NJ	3320	MORRIS	AVAILAB	AVAILABL	ARDEN
SORTING MACHINE	INVATA LLC	HUICANG	07/04/2021	12857	5844	Shanghai	Long Beach, California	LONDON	China	N/M	1010 SPRING	ROAD, HIWELL		1	EITU134948	4EB0	15	PKG	0		60374	H		EGLV142102054543	085E	EMCGNF0451	STATES		HGSO						AVAILAB	AVAILABL	AI

CONTACT INFO

Type	Name	Address
CONSIGNEE	INVATA LLC Follow	1010 SPRING MILL AVE SUITE 300, CONSHOHOCKEN PA 1 US
NOTIFY PARTY	-NOT AVAILABLE-	-NOT AVAILABLE-
SHIPPER	HANGZHOU HUICANG INFORMATION TECHNO Follow Get Credit Report	101BINKANG ROAD, HIWELL BUILDING 3 F PODIUM, BINJI ZHEJIANG, CHINA ZHEJIANG CN

PRODUCT DETAILS

Container No.	Description Area
MRKU5424427	OMNISORT-ITEM SORTING MACHINE

TRANSIT DETAILS

CARRIER	SXCO
SHIP REGISTERED IN	DENMARK
VESSEL	MAERSK EDINBURGH
VOYAGE	150E
US PORT	NEW YORK/NEWARK AREA, NEWARK, NEW JERSEY
FOREIGN PORT	SHANGHAI
COUNTRY OF ORIGIN	CHINA
PLACE OF RECEIPT	SHANGHAI
BILL OF LADING	SXCOSHE21123327
ARRIVAL DATE	2022-01-28
QUANTITY	14 PKG
CONTAINER COUNT	1
WEIGHT (LB / KG)	18,381 / 8,355
CBM	0
HOUSE VS MASTER	H
MASTER BILL OF LADING	MAEU291455958

OTHER INFO

Container No.	Marks and Numbers Area
MRKU5424427	N M

RELATED B/L

Type (House/Master)	B / L
H	SXCOSHE21123327

CONTACT INFO

Type	Name	Address
CONSIGNEE	INVATA LLC, Follow	1010 SPRING MILL AVE SUITE 300, CONSHOHOCKEN PA 1 US
NOTIFY PARTY	-NOT AVAILABLE-	-NOT AVAILABLE-
SHIPPER	HANGZHOU HUICANG INFORMATION TECHNO Follow Get Credit Report	101BINKANG ROAD, HIWELL BUILDING 3 F PODIUM, BINJI/

PRODUCT DETAILS

Container No.	Description Area
OOLU9263860	OMNISORT - ITEM SORTING MACHINE

TRANSIT DETAILS

CARRIER	SXCO
SHIP REGISTERED IN	HONG KONG
VESSEL	COSCO SHIPPING LOTUS
VOYAGE	013E
US PORT	NEW YORK/NEWARK AREA, NEWARK, NEW JERSEY
FOREIGN PORT	SHANGHAI
COUNTRY OF ORIGIN	CHINA
PLACE OF RECEIPT	SHANGHAI
BILL OF LADING	SXCOSHE21123767
ARRIVAL DATE	2022-02-12
QUANTITY	17 PKG
CONTAINER COUNT	1
WEIGHT (LB / KG)	16,896 / 7,680
CBM	0
HOUSE VS MASTER	H
MASTER BILL OF LADING	OOLU2128774150

OTHER INFO

Container No.	Marks and Numbers Area
OOLU9263860	N M

RELATED B/L

Type (House/Master)	B / L
H	SXCOSHE21123767

EXHIBIT F

CONTACT INFO

Type	Name	Address
CONSIGNEE	INVATA INC. Follow	530 WEST ST,,BRAINTREE,MASSACHUSETT S 02184,US
NOTIFY PARTY	-NOT AVAILABLE-	-NOT AVAILABLE-
SHIPPER	HANGZHOU HUICANG INFORMATION TECHNO Follow	101BINKANG ROAD, HIWELL BUILDING 3/ F PODIUM,,HANGZHOU,,CN

PRODUCT DETAILS

Container No.	Description Area
KOCU9012879	OMNISORT - ITEM SORTING MACHINE

TRANSIT DETAILS

CARRIER	PEVH
SHIP REGISTERED IN	UNITED STATES
VESSEL	YM WARRANTY
VOYAGE	014E
US PORT	NEW YORK, NEW YORK
FOREIGN PORT	SHANGHAI
COUNTRY OF ORIGIN	CHINA
PLACE OF RECEIPT	SHANGHAI
BILL OF LADING	PEVHDRN22053319
ARRIVAL DATE	2022-07-17
QUANTITY	3 CTN
CONTAINER COUNT	1
WEIGHT (LB / KG)	946 / 430

CBM	0
HOUSE VS MASTER	H
MASTER BILL OF LADING	HDMUSHAZ99666900

OTHER INFO

Container No.	Marks and Numbers Area
KOCU9012879	N/M

RELATED B/L

Type (House/Master)	B / L
H	CHQFSHA20284413P
H	CHQFSHA20291415U
H	TLKPSHACHI26025X
H	PEVHDRN22053053
H	PEVHDRN22053057
H	PEVHDRN22053179
H	PEVHDRN22053183
H	PEVHDRN22053193
H	PEVHDRN22053319
H	PEVHDRN22053367

0.2055

EXHIBIT G

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

U.S. Patent No. 11,358,175

Claim 1

Limitation	Supporting Documentation
A delivery vehicle operable with a material handling system having a plurality of storage locations and a vertical guide, wherein the delivery vehicle comprises:	To the extent that the preamble is limiting, the Respondents' Generation-Two Omnisort system (hereinafter "Accused Product") comprises a delivery vehicle operable with a material handling system having a plurality of storage locations and a vertical guide.  

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
	Automated Put Wall Solutions, INVATA INTRALOGISTICS, https://www.invata.com/automated-put-wall-solutions/?li (last visited Sept. 2, 2022) (Exhibit 8) ("*Automated Put Wall Solutions*").[1]  Roboware, 立体型仕分けロボット Omni Sorter ご紹介動画, YOUTUBE, https://www.youtube.com/watch?v=1_yRIGCCaxM, (last visited Sept. 2, 2022) (hereinafter "*Roboware Video*") (Exhibit 9).[2]

[1] The illustrations in this claim chart are exemplary, and not intended to limit the scope or applicability of the claims. To the extent any element is not literally met by the Accused Product, it is met under the doctrine of equivalents, at least because the Accused Product performs the same function in the same way to achieve the same result.

[2] Invata's relevant product page consist primarily of embedded videos, copies of which OPEX will provide on request. Additionally, Respondents' alleged Generation-One Omnisort product is still the only automated put wall system displayed on Invata's website, despite their alleged discontinuation of that product and transition to the alleged Generation-Two Omnisort product months

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
a drive system comprising a plurality of wheels cooperable with the vertical guide to guide the vehicle to one of the storage locations, wherein the wheels are configured to maintain the orientation of the vehicle as the vehicle changes between a first direction of travel and a second direction of travel, wherein the first direction is a horizontal direction and the second direction is a vertical direction;	The Accused Product comprises a delivery vehicle comprising a drive system comprising a plurality of wheels cooperable with the vertical guide to guide the vehicle to one of the storage locations, wherein the wheels are configured to maintain the orientation of the vehicle as the vehicle changes between a first direction of travel and a second direction of travel, wherein the first direction is a horizontal direction and the second direction is a vertical direction. 

ago. *See generally* EDIS DocID No. 759776 at 1-4; *Automated Put Wall Solutions*. HC Robotics English language website, which was last visited successfully on May 19, 2022, appears to no longer be working as of May 24, 2022. *OmniSort*, HC ROBOTICS, http://en.hc-robots.com/omniSort (last visited May 19, 2022) (hereinafter "*OmniSort English Webpage*") (Exhibit 10). OPEX has used the available public sources as illustrative documentation for claim elements that Respondents have not identified as allegedly different between their Generation-One and Generation-Two Omnisort. *See* EDIS DocID No. 759776 at 2-3.

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
	

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

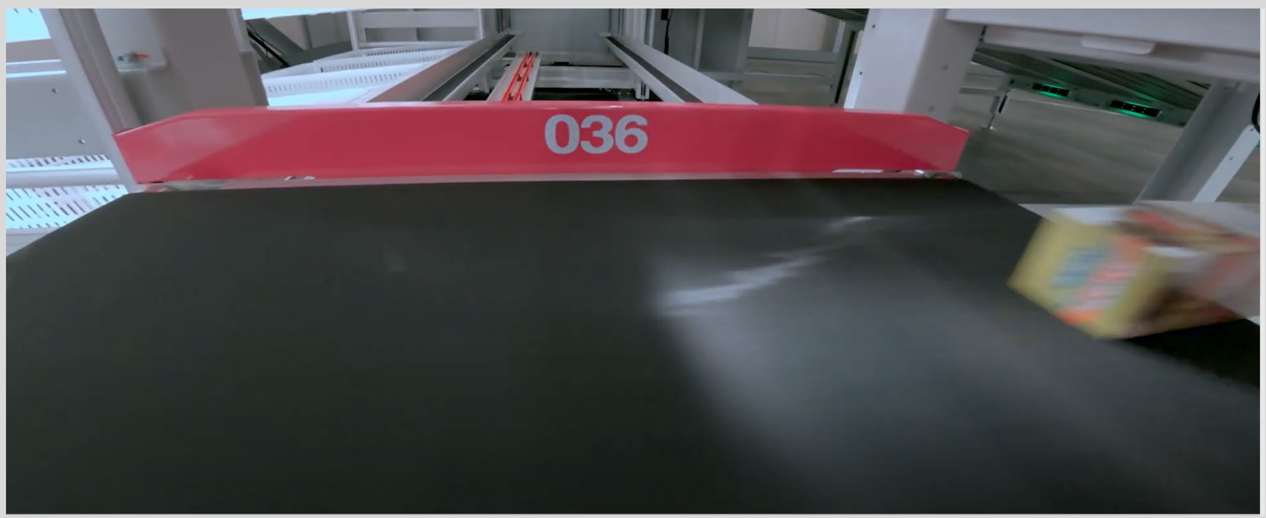
Limitation	Supporting Documentation
	  *Roboware Video.*
an onboard motor connected with the drive system to drive the vehicle to the storage locations;	The Accused Product comprises a delivery vehicle that comprises an onboard motor connected with the drive system to drive the vehicle to the storage locations.

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
	 *Automated Put Wall Solutions*
a rechargeable power source for powering the motor,	The Accused Product comprises a delivery vehicle that comprises a rechargeable power source for powering the motor.

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
	 *Roboware Video.*
an electrical contact for contacting a charging rail positioned along a portion of the guide system to recharge the rechargeable power source as the vehicle moves along the portion of the guide system wherein the electrical contact is configured to facilitate a charging current to flow to the vehicle when the electrical contact contacts the charging rail wherein the charging current has sufficient amperage to recharge the rechargeable power source within several seconds as the vehicle travels along the charging rail;	The Accused Product comprises a delivery vehicle that comprises an electrical contact for contacting a charging rail positioned along a portion of the guide system to recharge the rechargeable power source as the vehicle moves along the portion of the guide system wherein the electrical contact is configured to facilitate a charging current to flow to the vehicle when the electrical contact contacts the charging rail wherein the charging current has sufficient amperage to recharge the rechargeable power source within several seconds as the vehicle travels along the charging rail.

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
	 *Roboware Video.*
a transfer mechanism configured to transfer an item from the vehicle toward the one storage location; and	The Accused Product comprises a delivery vehicle that comprises a transfer mechanism configured to transfer an item from the vehicle toward the one storage location.

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

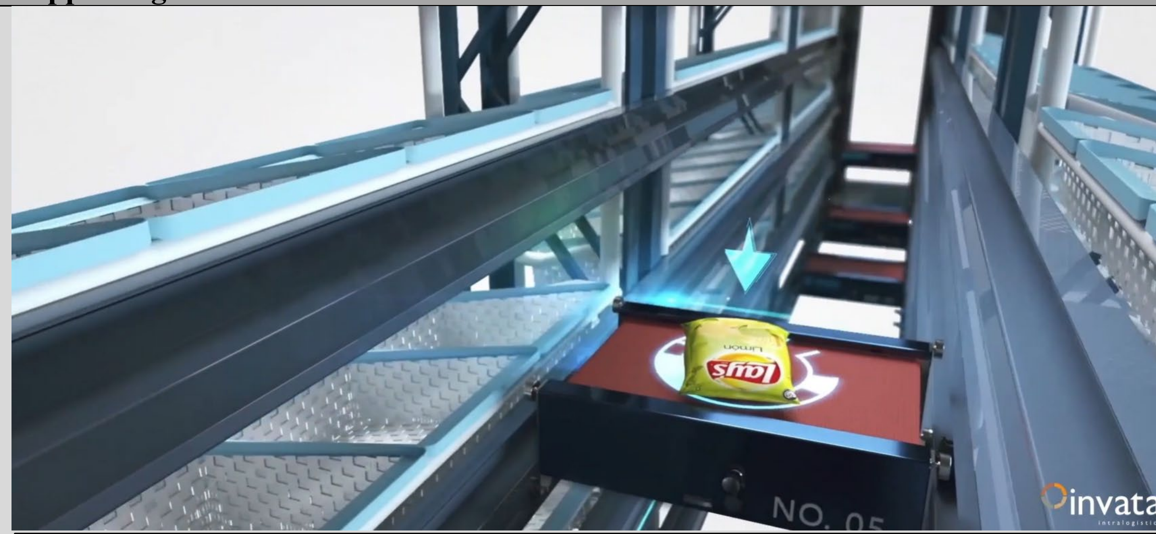
Limitation	Supporting Documentation
	  *Automated Put Wall Solutions.*

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

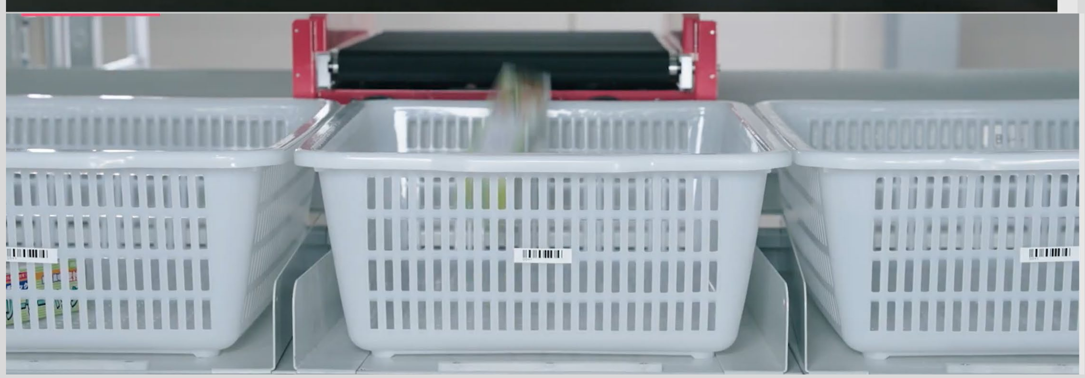
Limitation	Supporting Documentation
	   *Roboware Video.*

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
wherein the transfer mechanism is configured to transfer the item along a second horizontal direction that is transverse the first horizontal direction.	The Accused Product comprises a delivery vehicle that comprises wherein the transfer mechanism is configured to transfer the item along a second horizontal direction that is transverse the first horizontal direction.   *Automated Put Wall Solutions.*

Limitation	Supporting Documentation
	 *Roboware Video.*

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Claim 18

Limitation	Supporting Documentation
A material handling system comprising:	The Accused Product comprises a material handling system.   *Automated Put Wall Solutions.*

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
	 *Roboware Video.*
a plurality of storage locations arranged in a plurality of columns or rows;	The Accused Product comprises a material handling system comprising a plurality of storage locations arranged in a plurality of columns or rows.  *Automated Put Wall Solutions.*

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
	 *Roboware Video.*
a plurality of the vehicles comprising;	The Accused Product comprises a material handling system comprising a plurality of vehicles.  *Roboware Video.*

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

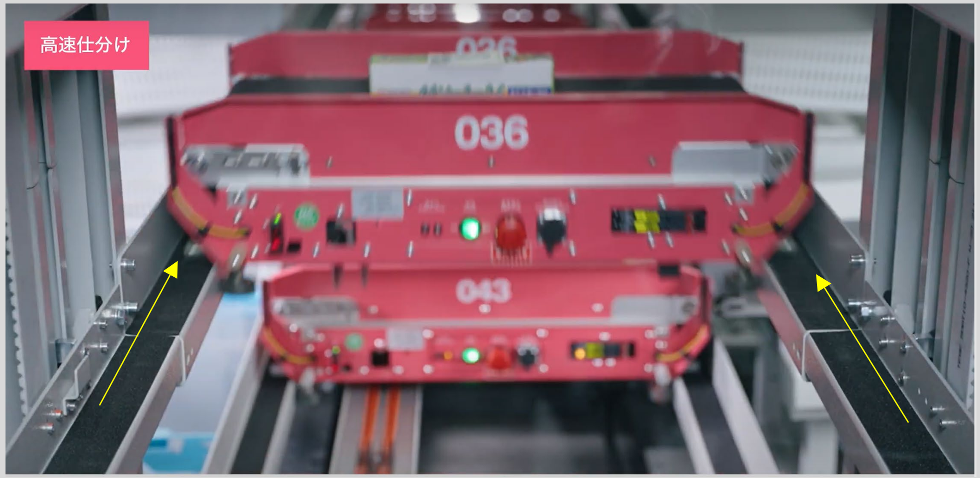
Limitation	Supporting Documentation
a drive system for guiding the vehicle to one of the storage locations;	The Accused Product comprises a material handling system comprising a plurality of vehicles wherein the plurality of vehicles comprise a drive system for guiding the vehicle to one of the storage locations.  

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

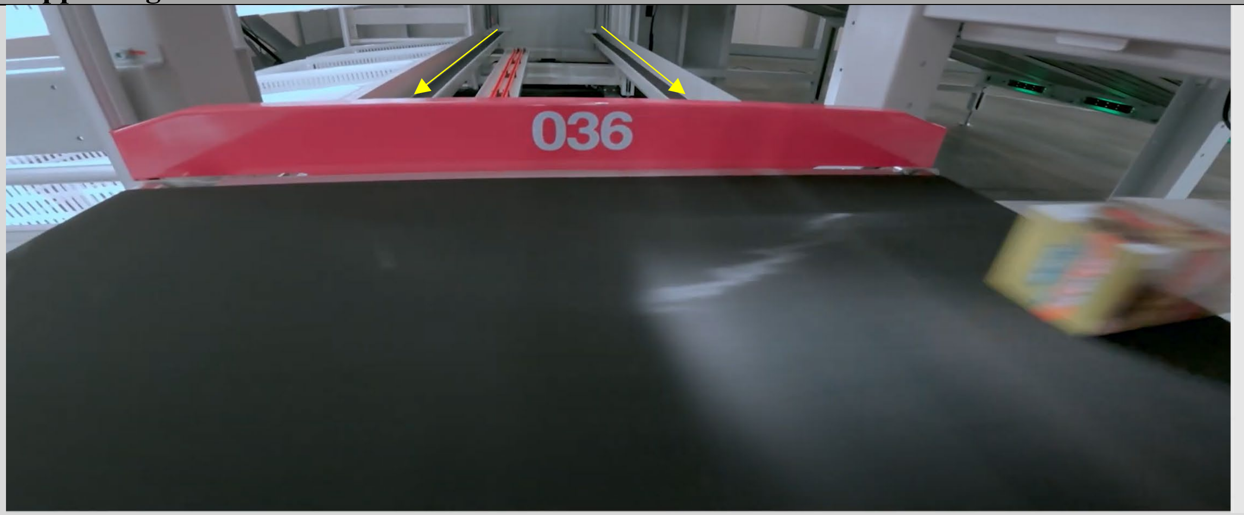
Limitation	Supporting Documentation
	*Roboware Video.*
an onboard motor connected with the drive system to drive the vehicle;	The Accused Product comprises a material handling system comprising a plurality of vehicles wherein the plurality of vehicles comprise an onboard motor connected with the drive system to drive the vehicle. *Automated Put Wall Solutions.*
a rechargeable power source for powering the motor;	The Accused Product comprises a material handling system comprising a plurality of vehicles wherein the plurality of vehicles comprise a rechargeable power source for powering the motor.

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
	 *Roboware Video.*
an electrical contact; and	The Accused Product comprises a material handling system comprising a plurality of vehicles wherein the plurality of vehicles comprise an electrical contact.

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
	 *Roboware Video.*
a transfer mechanism for transferring an item from the vehicle toward the one storage location;	The Accused Product comprises a material handling system comprising a plurality of vehicles wherein the plurality of vehicles comprise a transfer mechanism for transferring an item from the vehicle toward the one storage location.

<u>Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product</u>

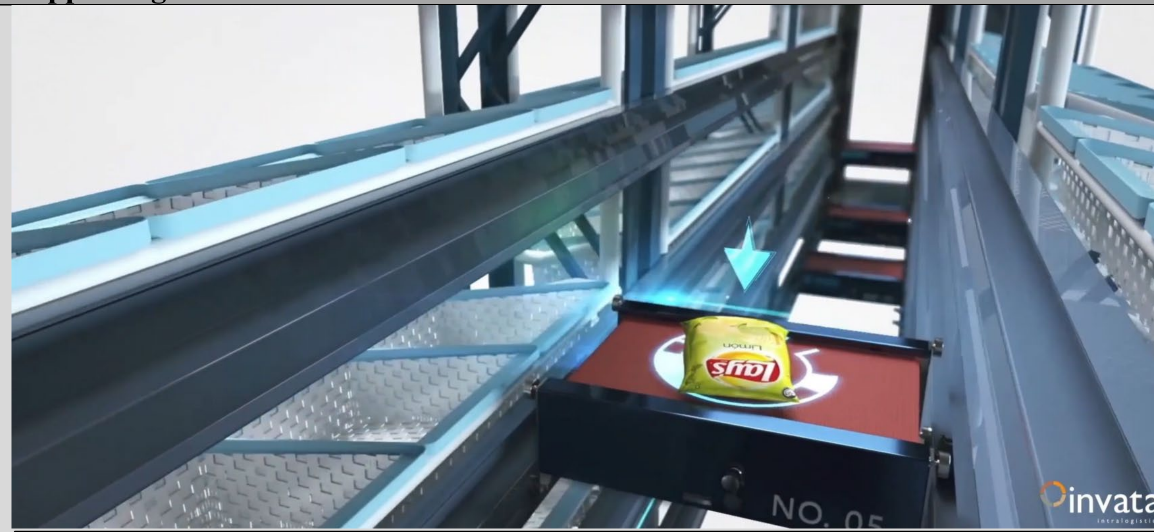
Limitation	Supporting Documentation
	  *Automated Put Wall Solutions.*

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
	 *Roboware Video.*

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
a plurality of vertical guide elements for guiding the delivery vehicles in a vertical direction; and	The Accused Product comprises a material handling system comprising a plurality of vertical guide elements for guiding the delivery vehicles in a vertical direction. 

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
	 

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
	 *Roboware Video.*
a charging rail, wherein the charging rail is disposed at a location such that the charging rail provides a charging current to the electrical contacts of a plurality of the delivery vehicles upon startup of the system;	The Accused Product comprises a material handling system comprising a charging rail, wherein the charging rail is disposed at a location such that the charging rail provides a charging current to the electrical contacts of a plurality of the delivery vehicles upon startup of the system.

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
	 *Roboware Video.*
wherein the electrical contact of each delivery vehicle is configured to contact the charging rail to recharge the rechargeable power source while the delivery vehicle travels along a horizontal or vertical path.	The Accused Product comprises a material handling system wherein the electrical contact of each delivery vehicle is configured to contact the charging rail to recharge the rechargeable power source while the delivery vehicle travels along a horizontal or vertical path.

Exhibit G: Claim chart comparing U.S. Patent No. 11,358,175 to Respondents' Generation-Two Omnisort Product

Limitation	Supporting Documentation
	 *Roboware Video.*

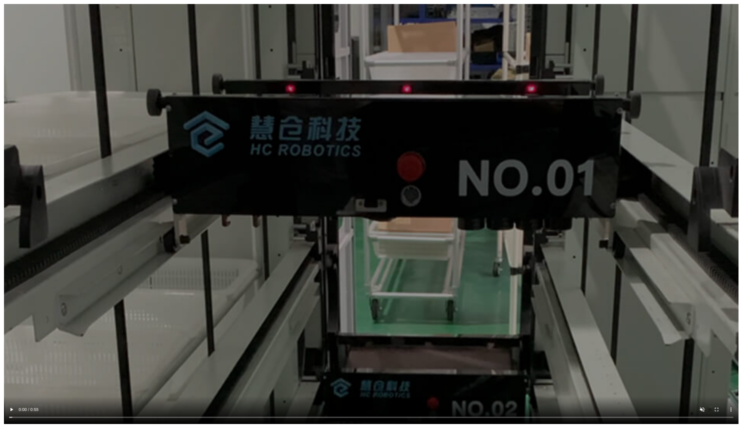
EXHIBIT H

OmniSort

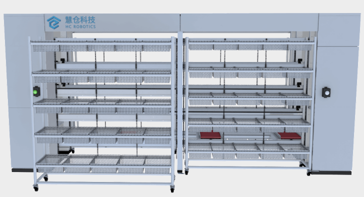
The OmniSort is a high-performance, modular and flexible automated sorting system. It can handle complex order scenarios and accurately deliver items to their designated locations at high speed. OmniSort supprts a variety of sorting modules, including batch sorting and individual sorting. It is many times faster than manual sorting.

Within OmniSort, a fleet of autonomous high speed robots are responsible for the delivery of items. It is highly scalable and configurable in size and thought. Multiple OmniSort can be easily integrated to meet demand of growing performance. Hence, OmniSort is ideal for both small and large warehouse for order fulfilment.

The OmniSort integrates easily with existing WMS systems to archive plug and play operation. Combining OmniSort with OminiStorage systems can realize fully automated order processing flow.

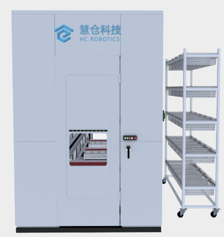


Product Features



Up to 2600 pcs/h

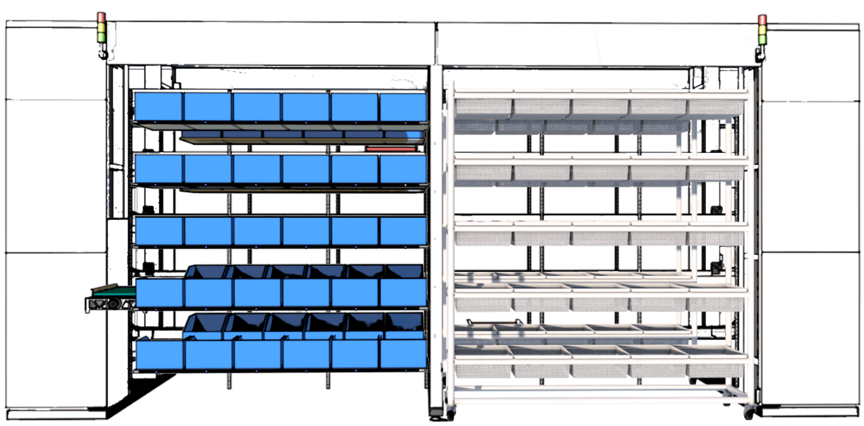
Automatic Barcode Scanning



Putaway Carts and/or Individual Bins

Key Features

Modular design, high mobility. Suitable for e-commerce warehouse, distribution center, etc. Support batch sorting and individual sorting. Highly scalable. High cost performance ratio. Maximum item weight 5kg. High picking throughput. Easily integrated with auto scanning and auto item picking systems.



Technical Specifications

Size	10 x 2 x 2.2 m (L x W x H,Customizable)	Picking Module	Multiple induction modules
Number of Delivery Bin			Easily integrated with auto scanning and auto picking systems
Delivery Bin	450 x 350 x 140 mm(Customizable)		
Number of Robots	10 - 20	Performance	Up to 2600 items/hour
Robot Load	5 kg		Deployment time is down to few hours
Robot Speed	2 - 4 m/s		

Download Product Literature>>