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LINTON

Technical Trend of Advanced PV Ingot & Wafer Production

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Linton Crystal Technologies
Linton Technologies Group

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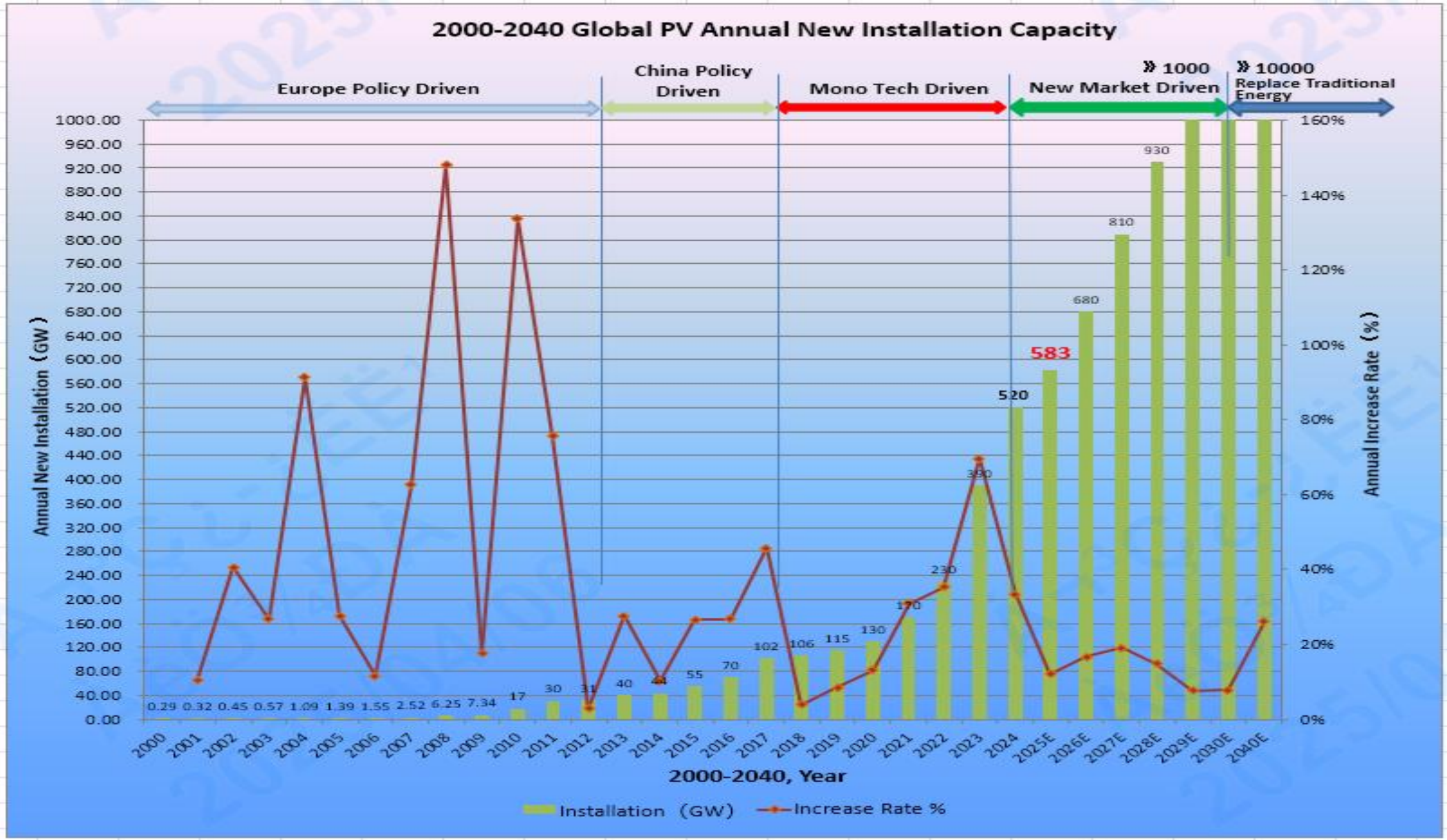
2000-2040 Global PV Annual New Installation Capacity
Europe Policy Driven
China Policy Driven
Mono Tech Driven
New Market Driven
» 1000
» 10000
Replace Traditional Energy
Annual New Installation（GW）
Annual Increase Rate（%）
2000-2040, Year
Installation （GW）
Increase Rate %
0.29 0.32 0.45 0.57 1.09 1.39 1.55 2.52 6.25 7.34 17 30 31 40 44 55 70 102 106 115 130 170 230 350 520 583 680 810 930
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025E 2026E 2027E 2028E 2029E 2030E 2040E

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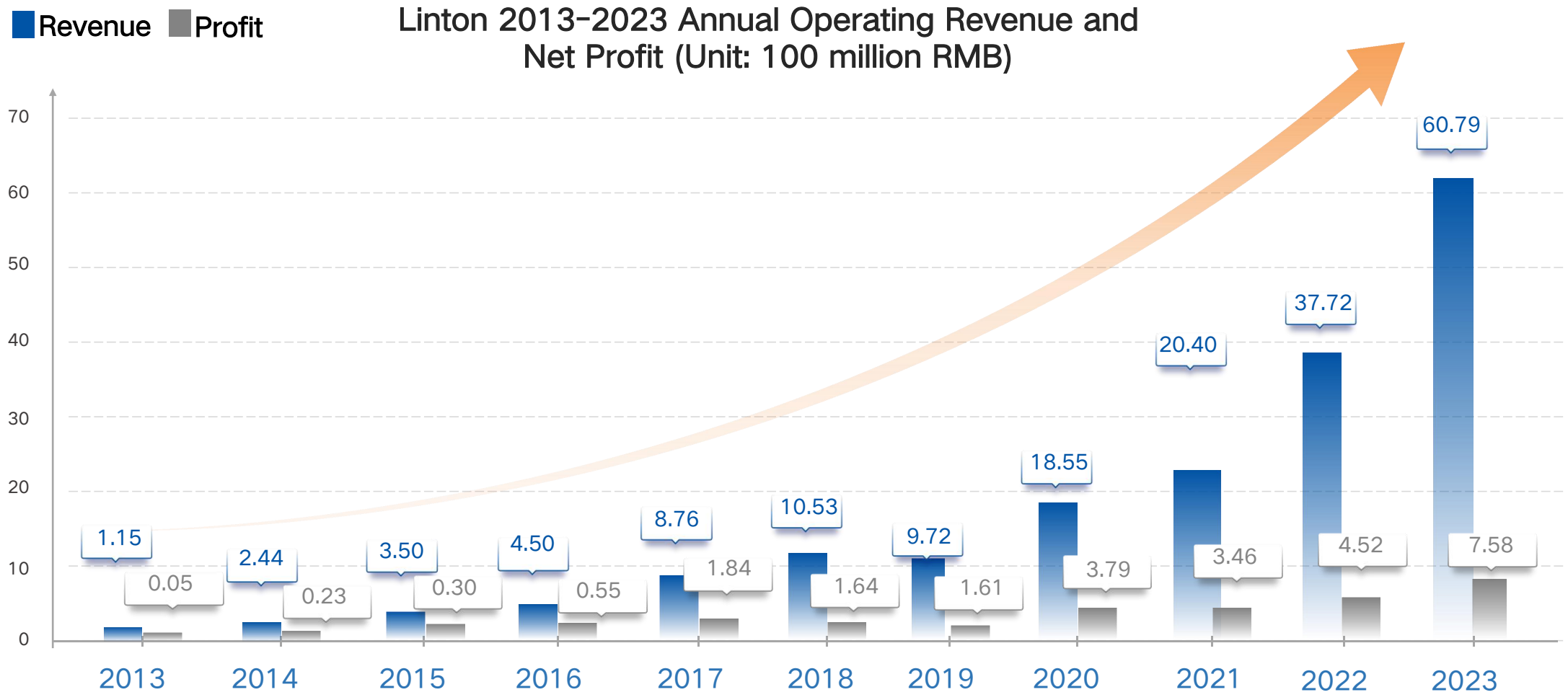
Sustained Growth Trusted Assurance

Total assets in 2023 reached 1.743 billion



Global Presence

Linton has service teams in the USA, Singapore, Russia, India, and Malaysia, with operations spanning 18 countries and regions worldwide.

Client Distribution

- South Korea
- Japan
- Vietnam
- Singapore
- Russia
- Malaysia
- Taiwan, China
- Kazakhstan
- Kyrgyzstan

Global Service Center

- South Korea
- Japan
- Vietnam
- Singapore
- Russia
- Malaysia
- Taiwan, China
- Kazakhstan
- Kyrgyzstan

R&D Center

- Dalian
- Wuxi
- Vietnam
- Rochester, USA

R&D and Manufacturing Base

Wuxi R&D and Manufacturing Base

- PV Crystal growing, si wafer cleaning, cells & modules equipment;
- Semi-conductor Si, Ge crystal growing , crystal growing equipment
- SiC semiconductor powder sythensisi, crystal growing and processing equipment;
- Gallium oxide, sapphire crystal growth, crystal processing equipment

Dalian R&D and Manufacturing Base

- Si microwave crushing equipment;
- PV crystal and wafer processing equipment;
- Semiconductor Si, SiC, Sapphire slicing equipment;
- Automation and smart factocy solution

U.S. Technology R&D Base

- Extended 70 years of experience in the design and manufacture of monocrystalline furnace and crystal growth;
- PV and monocrystalline furnace equipment R &D base in the US
- Advanced R&D of crystal growth
- International Marketing

Vietnam Production and Manufacturing Base

PV equipment manufacturing

- Single cyrstal furnace
- Slicer
- Machining equipment
- Other equipment

Wuxi Base	Dalian Base	Crystal Grower Capacity	Slicer & Ingot Machining	Equivalent to
2,000,000+	1,200,000+	16000+	6000+	300+GW
Square Feet	Square Feet	Set/Year	Set/Year	Annual Capacity

Wuxi Facility of Linton

Over 2,000,000 Square Feet
Floor Space

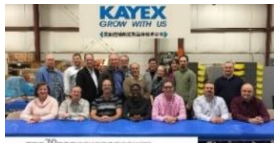
股 票 代 码 ： 8 3 5 3 6 8

Group Development Timeline

2007.09 LINTON
LINTON Technologies Group founded in Dalian

2008
Developed China's first PV multi-wire squaring machine

2013 KAYEX
Acquired SPX's Kayex Puller Division in the USA



2013
Pioneered mass delivery of PV diamond wire slicers in China

2017
Acquired Tokyo Rope's wire cutting division in Japan, entering the semiconductor wafer processing equipment field

2018
Successfully developed the KX320MCZ, a new 24-inch semiconductor-grade puller equipped with a superconducting magnetic field

2019
Co-developed the world's first 1600mm puller with strategic customers, leading mass production

2020
Wuxi base completed and put into production

2021
Listed and started trading on the Beijing Stock Exchange

北京证券交易所
BEIJING STOCK EXCHANGE

2023
Developed the world's first 1700mm puller with strategic customers, leading mass production

2023
First to launch one-click smart crystallization for pullers
Third-gen semi-silicon carbide furnace tech recognized as internationally advanced

2023
Launched the complete PV silicon wafer production line solution

2024.05
Established an overseas base: Vietnam factory

Group Structure and Product Portfolio

LINTON

689 项 国内外专利

2 全资子公司

24 控股子公司

Dalian Victory	Linton Kayex	LCT	Linton NC Machine	Nanya	FIT	Linton Intelligence	Xingbei Energies	Chuanhe New Materials	Lianqiang	Linko
Microwave crushing equipment	PV puller; PV module equipment	R&D of PV and semiconductor puller; Overseas marketing	PV machining&slicing equipment; Semiconductor machining & slicing equipment	Degluing & wafer sigulating & cleaning machine	Cleaning & texturing equipment	PV smart factory of whole line	Additive of texturing	New material technology; Optoelectronic device	Crystal processing equipment	SiC crystal growing furnace, powder synthesis furnace, Semiconductor Si crystal growing furnace

Aihua Semiconductor	Lanyue Technology	Tonglei Crystal
Battery device	Carbon carbon composite material; Graphite material	Gallium oxide crystal

Equity Participation

Laplace	Goldstone
PV cells High performance thermal process, coating and supporting automation equipment	Graphite materials and graphite products

可靠 增值 阳光

To become a strong player in PV industry, it is very important to select the right technical path. Linton made 3 critical decisions in the past 15 years:

First critical decision:

Selected mono-crystal technology while most people in PV industry believed in multi-crystal technology

Linton Solar CZ Furnaces
连城光伏单晶炉系列

LINTON

CG3000
TankID 580mm
RC ID 220mm
Height 4000mm

CG6000
TankID760mm
RC ID 280mm
Height
5700mm

KX100
TankID
900mm
RC ID
300mm
Height
7000mm

KX150
TankID
1100mm
RC ID 350mm
Height
8000mm

KX170
TankID
1200mm
RC ID
350mm
Height
9000mm

KX240
TankID
1300mm
RC ID 350mm
Height
10000mm

KX280
TankID
1400mm
RC ID 350mm
Height
11000mm

KX380
TankID 1600mm
RC ID 450mm
Height 13800mm

KX380PV
Crystal Grower

A 15 GW Crystal Growth Facility

Typical silicon mono-crystals produced with a Linton CZ furnace

G12
Length > 5 meters, Weight > 800 kg, Diameter = 301 mm

M10
Length > 7 meters, Weight > 800 kg, Diameter = 254 mm

Increase of Crucible size
坩埚尺寸不断增大

2023年
42"英寸
Crucible
1200kg Silicon
Life：450 hours

2007年
16"英寸Crucible
35kg Silicon
Life：100hrs

2009年
18"英寸
Crucible

2011年
20"英寸
Crucible

2013年
22"英寸
Crucible

2015年
24"英寸
Crucible

2017年
26"英寸
Crucible

2019年
28"英寸
Crucible

2020年
32"英寸
Crucible

2021年
36"英寸
Crucible
880kg Silicon

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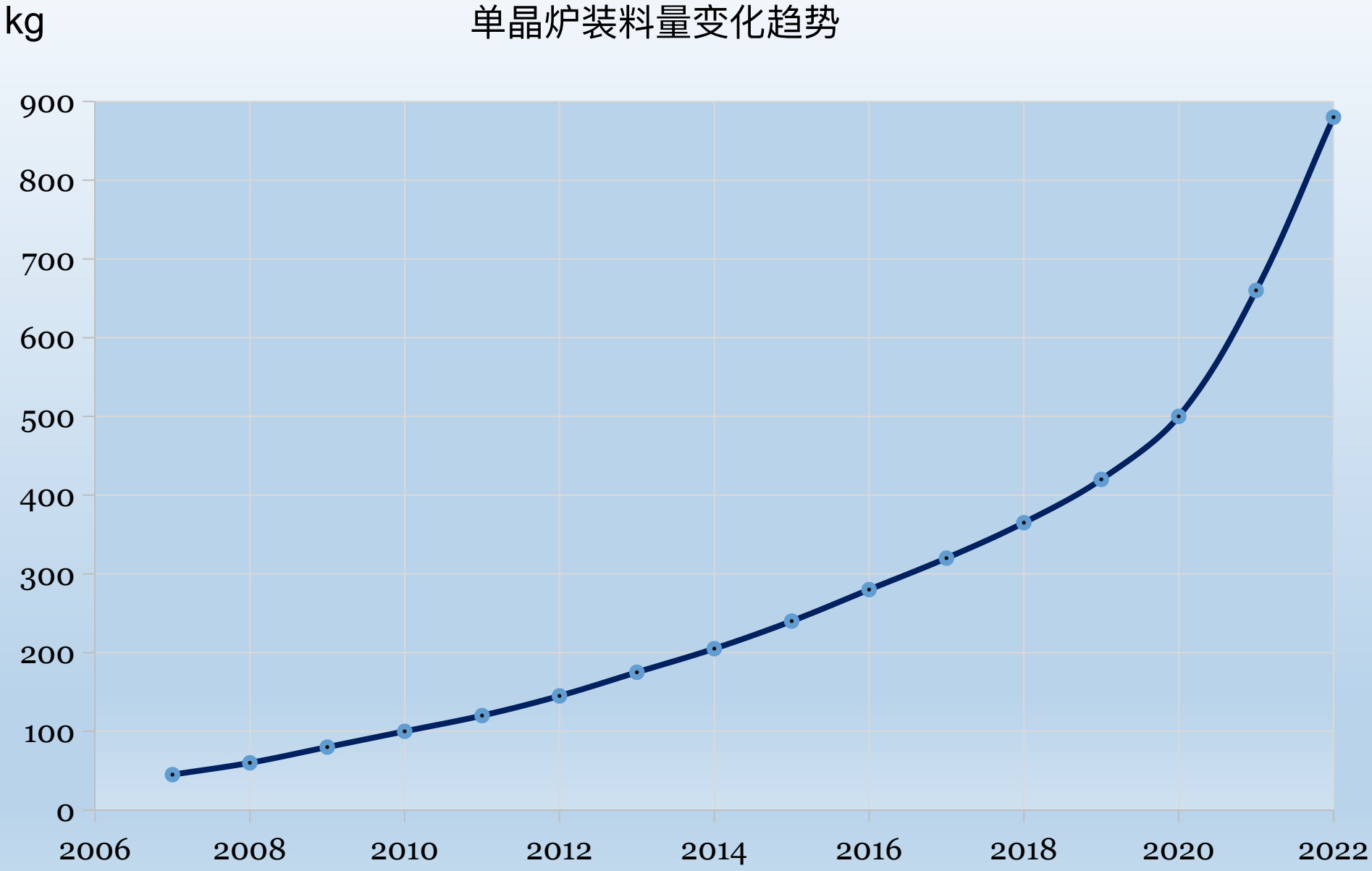
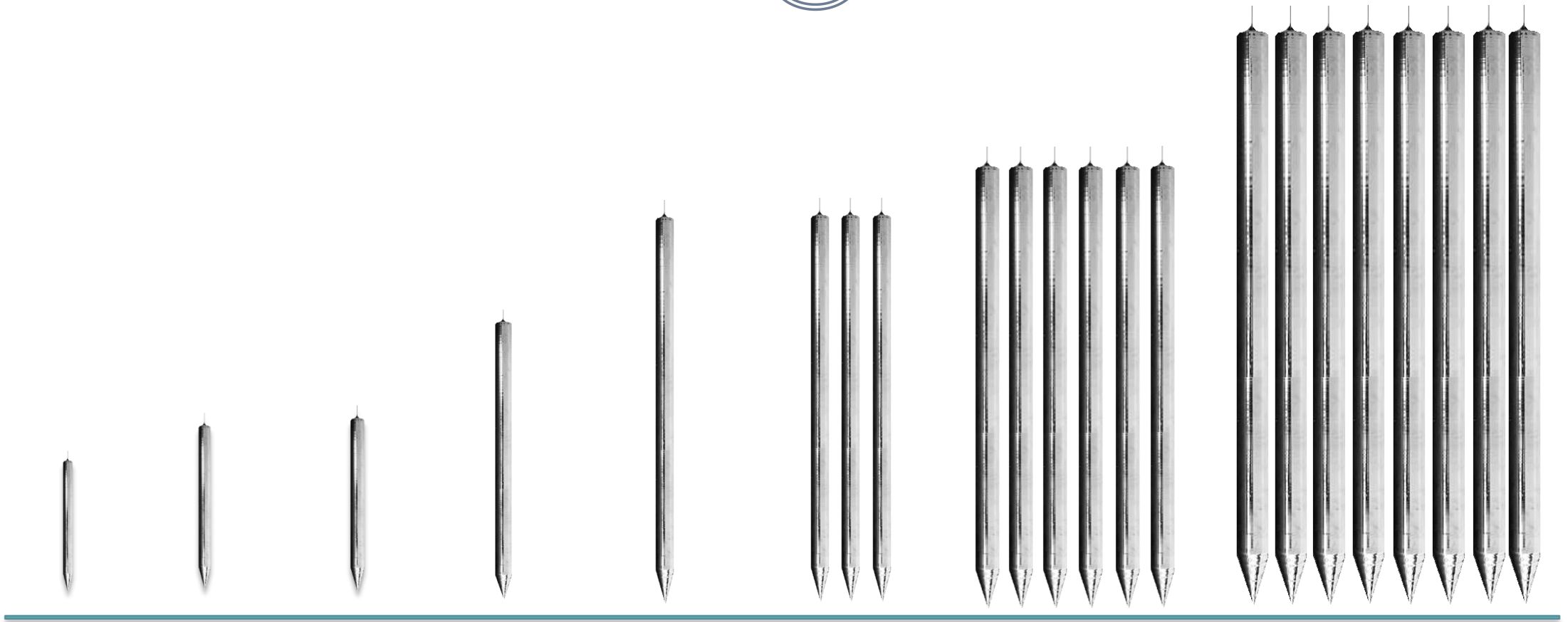
Trend of CZ Crystal Growth Charge Size
单晶炉装料量变化趋势



Comparison of Mono-Crystal Ingots fron a single Run
单一炉次生产的单晶硅棒尺寸比较



To become a strong player in PV industry, it is very important to select the right technical path. Linton made 3 critical decisions in the past 15 years:

Second critical decision:

Being the first to promote diamond wire wafer slicing technology while most people in PV industry believed in slurry cutting technology

QP850 金刚线多线切片机

QP850 Diamond Wire Multi-wire Wafer Slicing Machine

基本性能参数

加工能力

装载长度（mm） 最大850 单排装料

截面尺寸（mm） 最大166×166

切片厚度（mm） 0.12~0.20

Basic Performance Parameter

Processing Ability

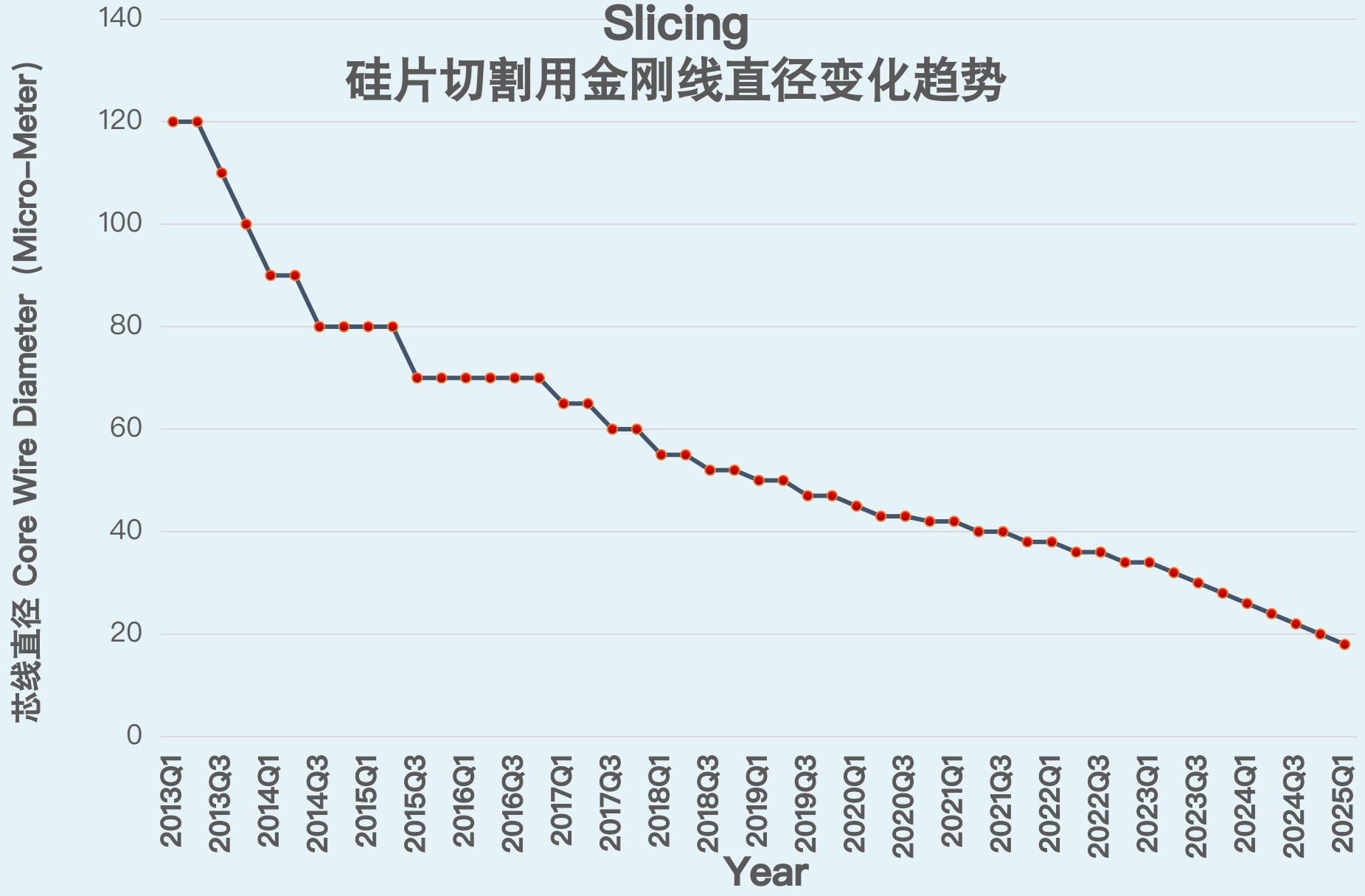
Loading length (mm)	Max 850 material loading on single row
Workpiece size (mm)	Max 166 × 166
Wafer slicing thickness (mm)	0.12~0.20

Linton Diamond Wire Slicer.mp4

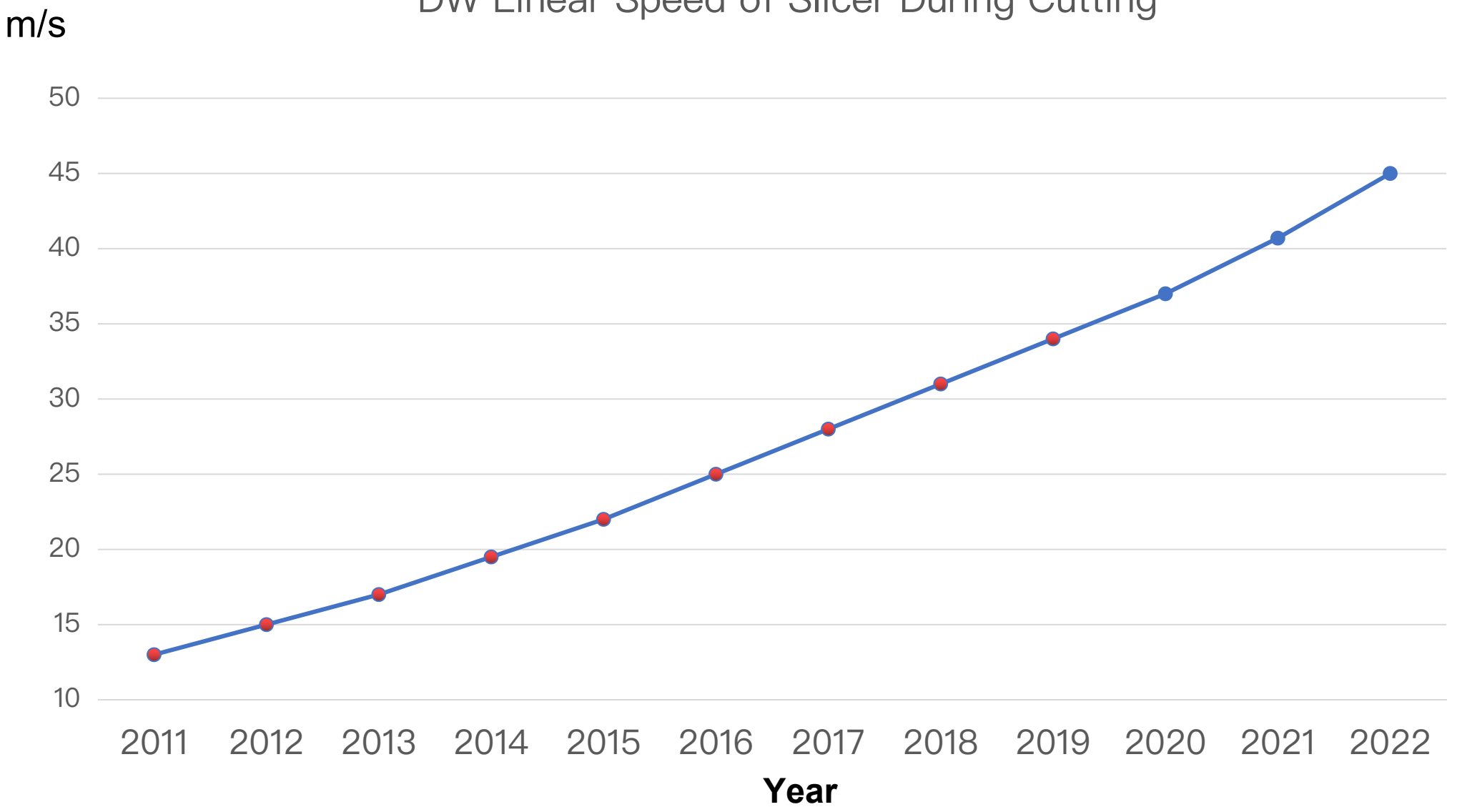
Linton DW Slicer Performance

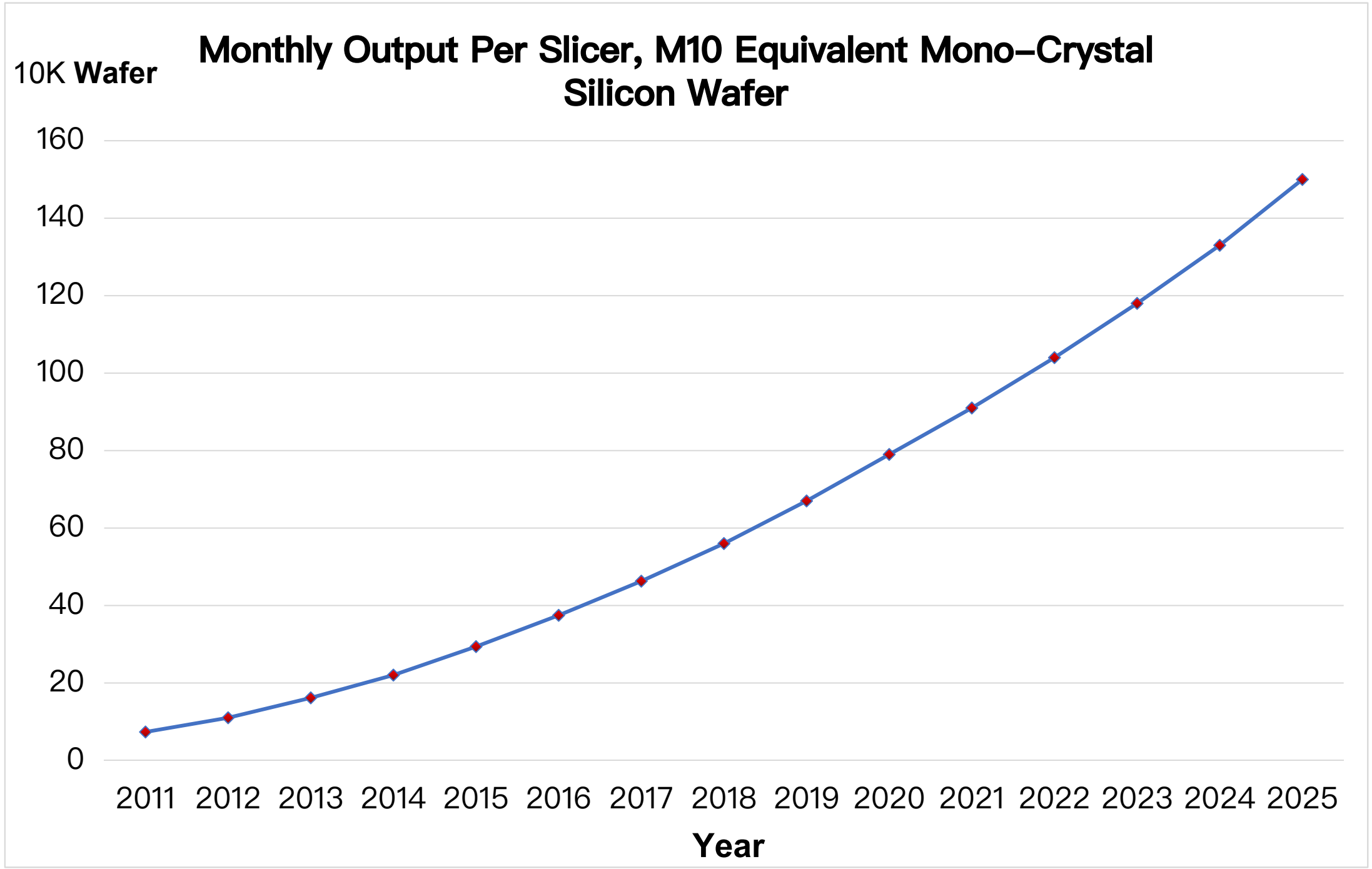
- 45 meters/sec wire speed
- Capable of using 28 micron steel wire, 18 micron tungsten wire
- > 1,200,000 wafers per month per slicer
- Slicing cost < $0.02 per wafer

Trend of DW Wire Diameter for Silicon Wafer Slicing
硅片切割用金刚线直径变化趋势

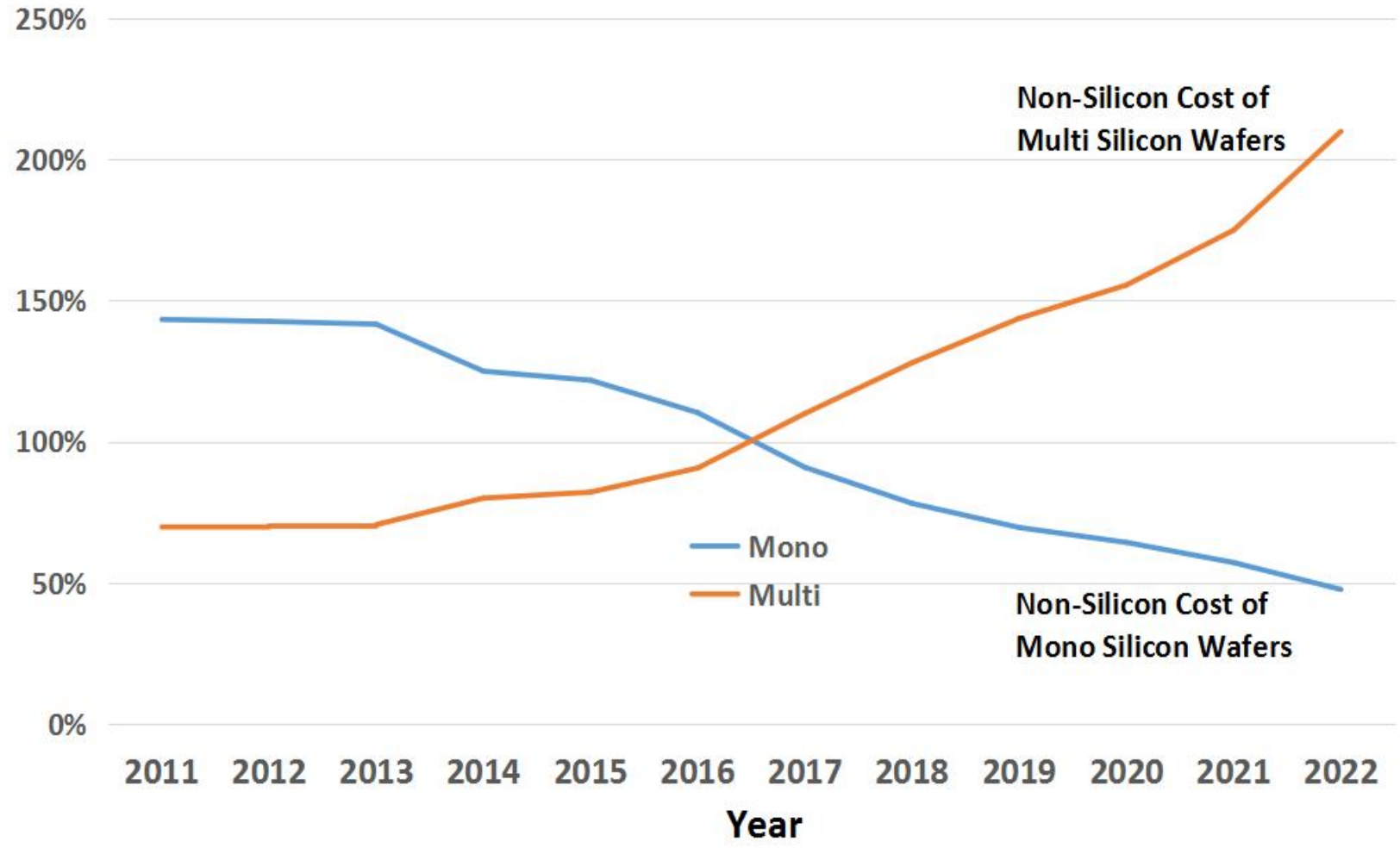


金刚线切割线速变化趋势
DW Linear Speed of Slicer During Cutting




Monthly Output Per Slicer, M10 Equivalent Mono-Crystal Silicon Wafer
10K Wafer
160
140
120
100
80
60
40
20
0
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Year

Trend of Non-Silicon Cost， Mono vs. Multi Silicon Wafers
单晶硅片和多晶硅片非硅成本趋势（相对比例）



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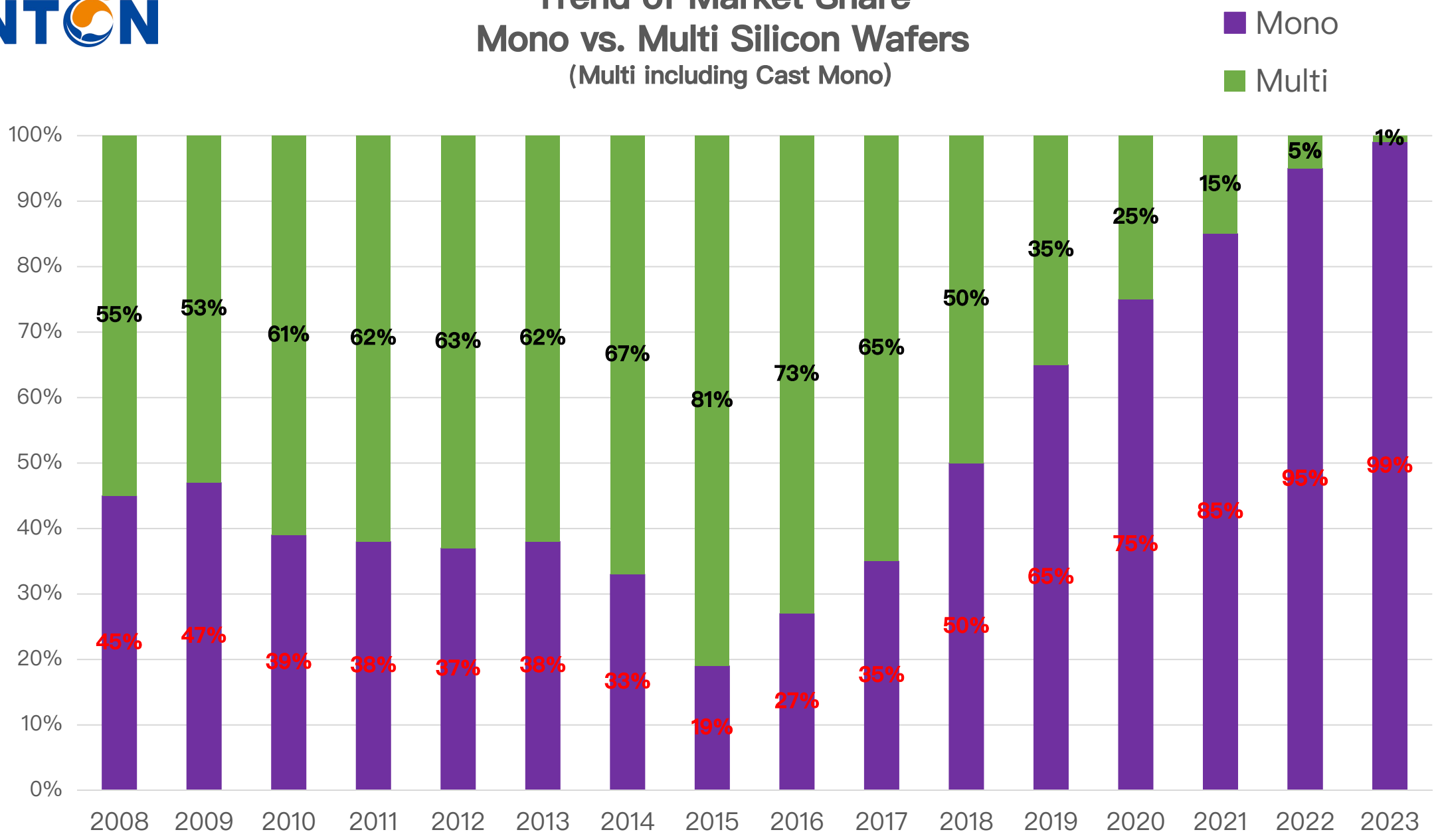
Trend of Market Share
Mono vs. Multi Silicon Wafers
(Multi including Cast Mono)



To become a strong player in PV industry, it is very important to select the right technical path. Linton made 3 critical decisions in the past 15 years:

Third critical decision:

Being the first to promote factory automation of ingot/wafer production lines while most people in PV industry believed automation is too expensive and not necessary

Crystal Growth Process Automation

Current status:

- From seed dipping to tailing: fully automated

Pump Down	Stabilizing
Sead dipping	Crowning
Body Growth	Tailing
Cooling	Recharging

- Growth speed and productivity:

9 inch crystal (M6):

Speed >2.0mm/min, Productivity>150kg/day

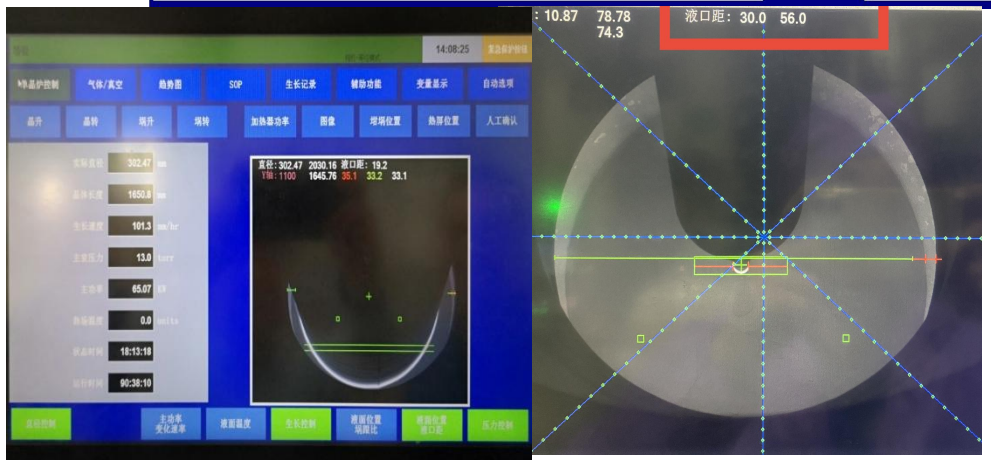
10 inch crystal (M10):

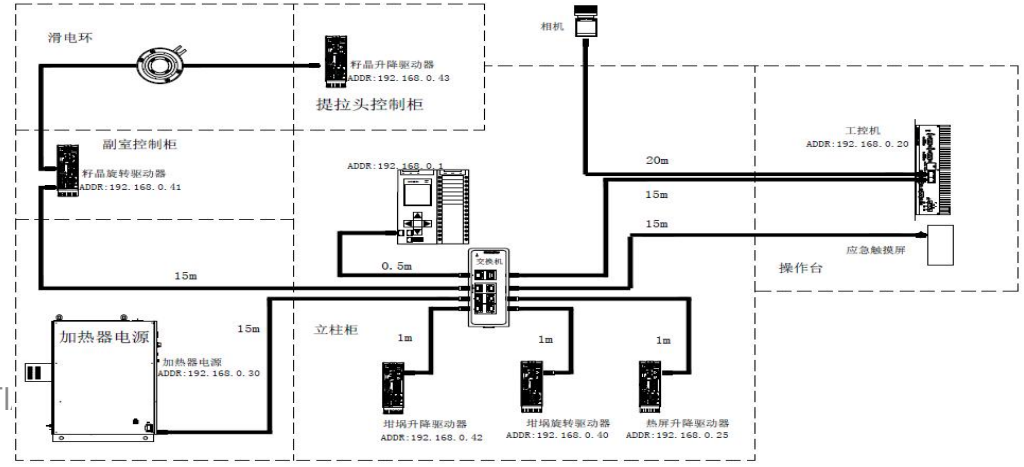
Speed >1.9mm/min, Productivity>150kg/day

12 inch crystal (G12):

Speed >1.7mm/min, Productivity>170kg/day

- Loss of structure less than 25 per 100 pulls



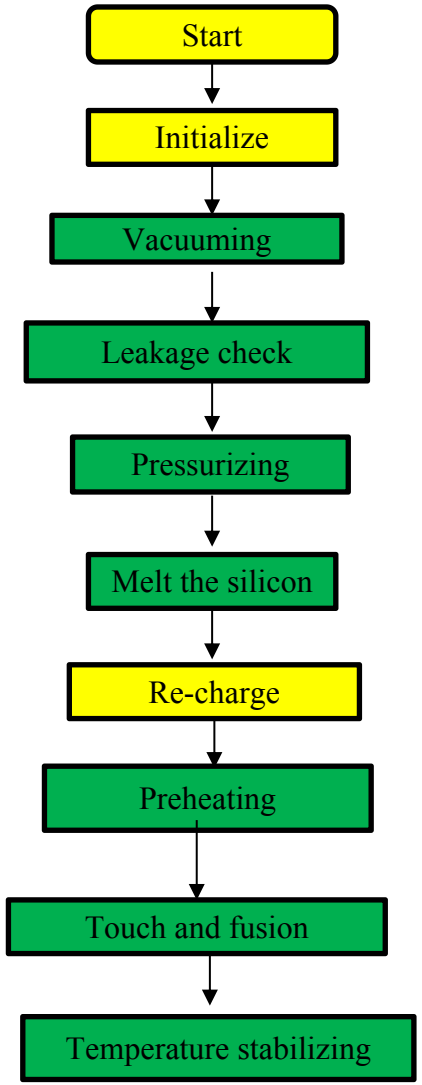


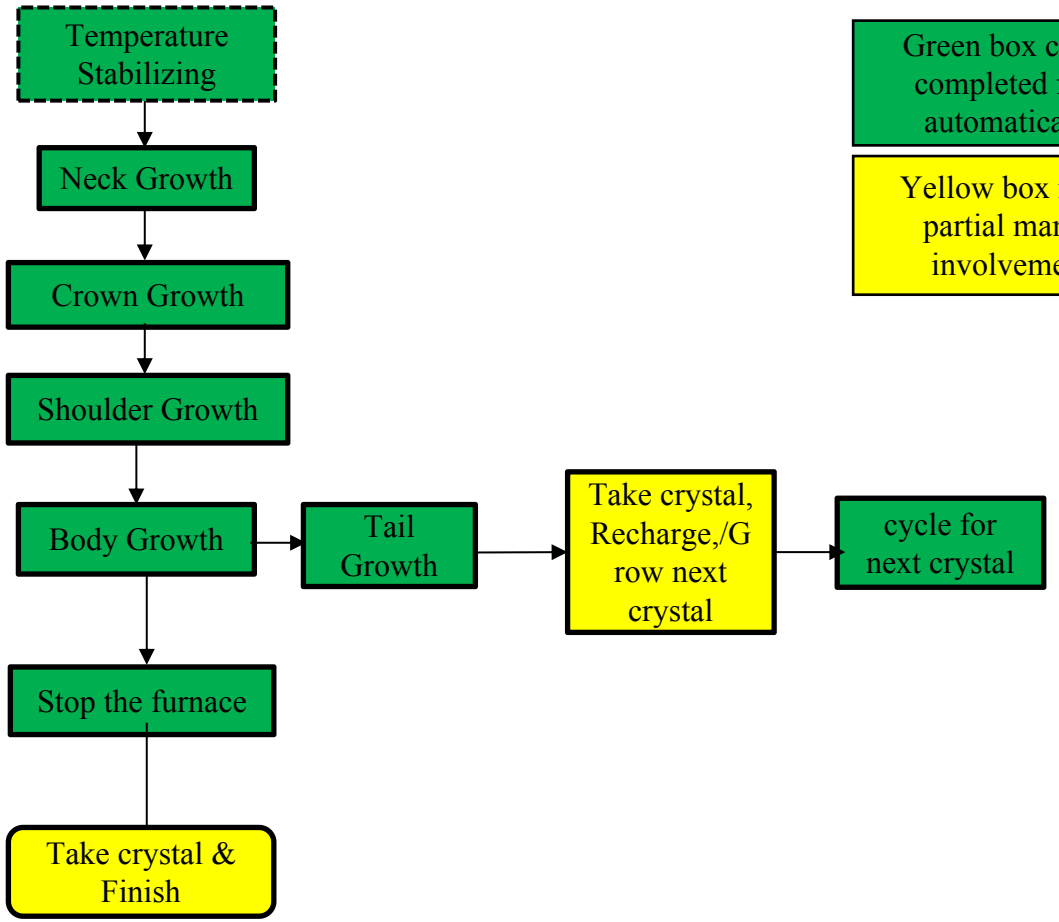
LINTON KAYEX

"One-click crystal growth"- Procedure

Full process automation from vacuuming to tail

Monocrystal Production Intelligentization





Green box can be completed fully automatically.

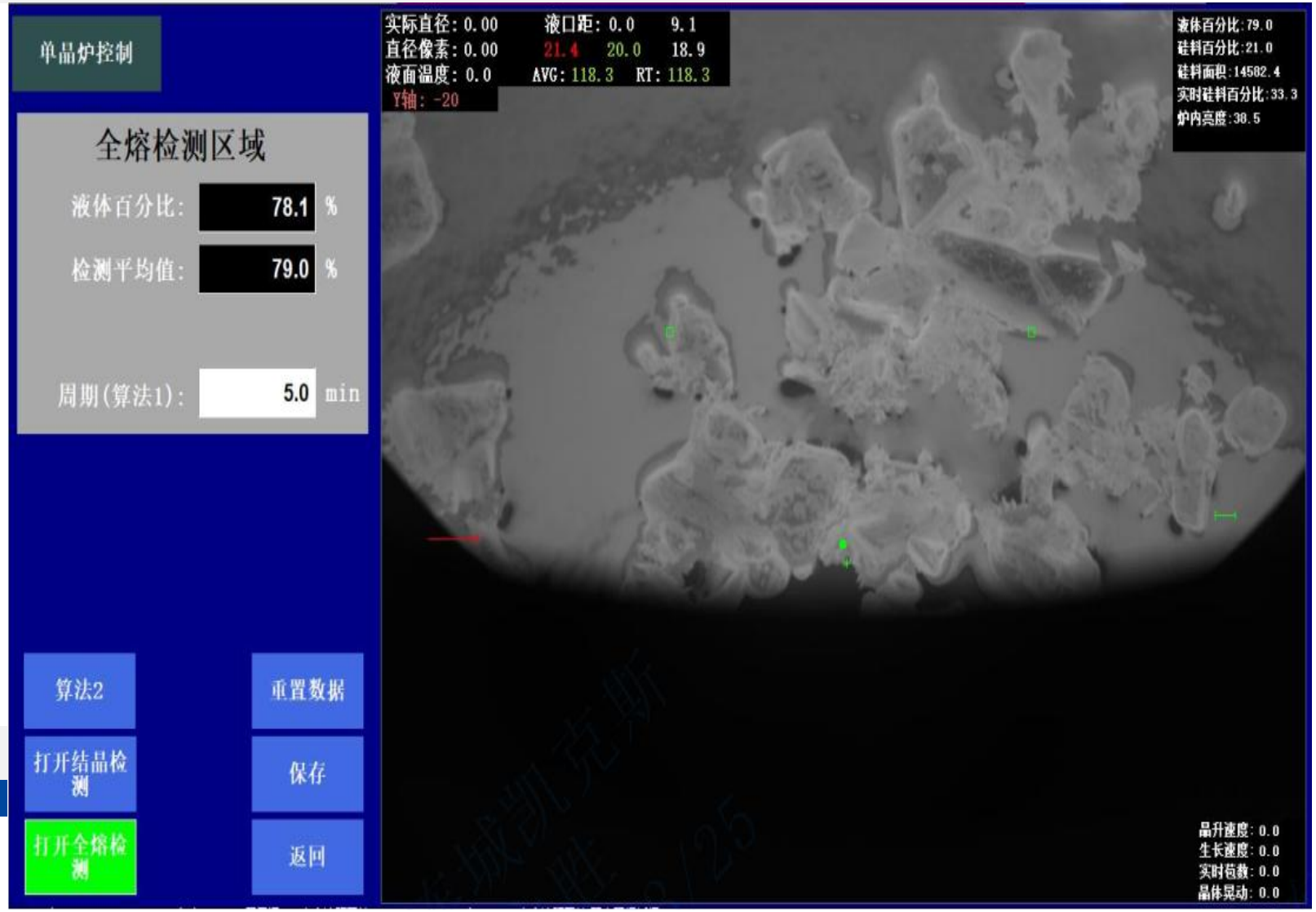
Yellow box needs partial manual involvement.

LINTON KAYEX

"One-click crystal growth"- Molten poly silicon percentage detection by CCD

The data from molten poly silicon percentage detection is important for:

1. Deciding the time of poly silicon re-charging;
2. Automatic setting of heater power for melting;
3. Predicting the start point of following processes.



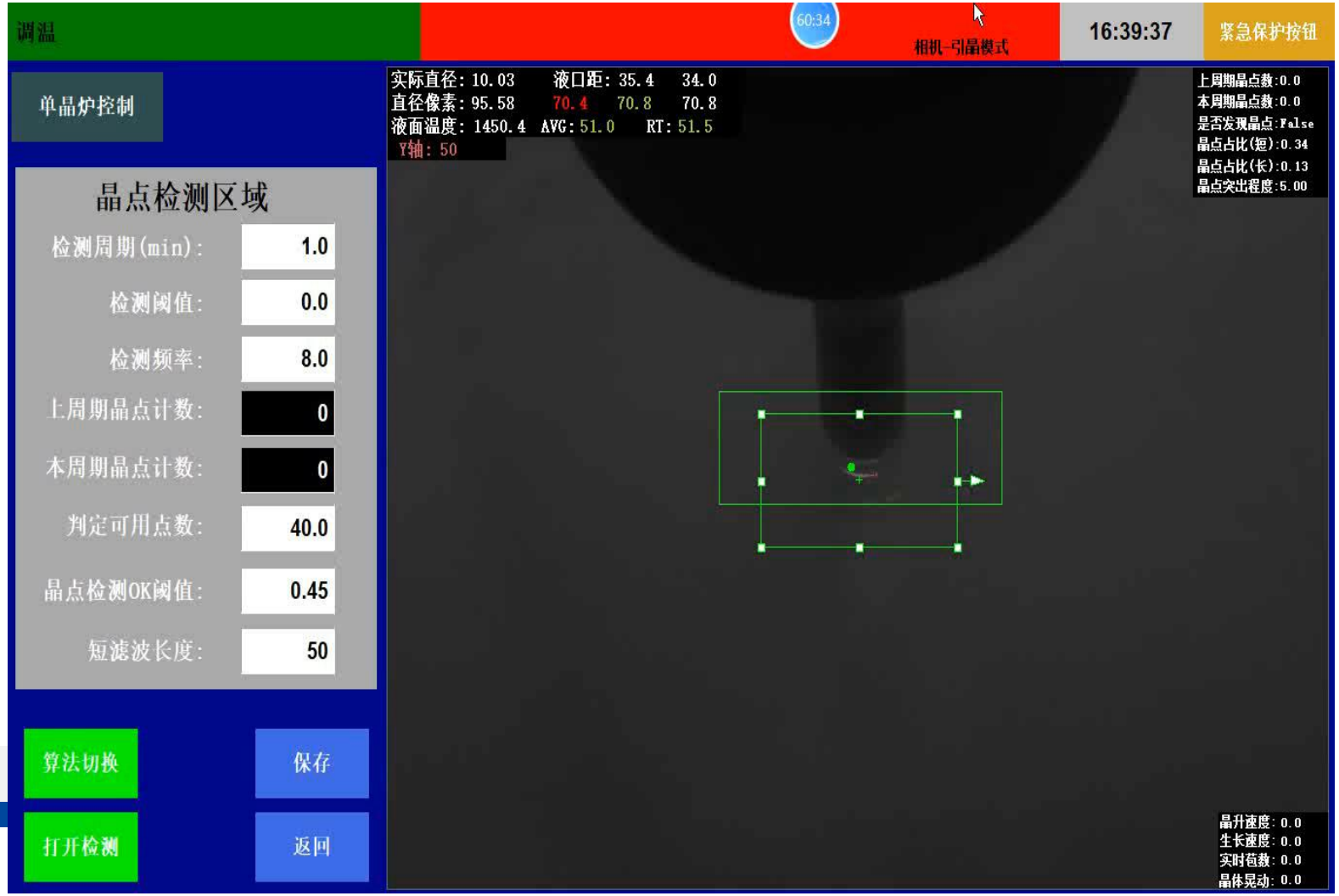
LINTON KAYEX

"One-click crystal growth": Automatic temperature stabilizing

1. Melt surface temperature measurement using CCD camera;

2. Automatic adjustment of heater power;

3. Automatic judgement of completion of temperature stabilizing.



LINTON KAYEX

"One-click crystal growth ": Automatic seed touching and fusion

1. Automatic preheat the seed;
2. Automatic detection of seed position;
3. Automatic adjustment of heater power;
4. Automatic seed touching and fusion completion.

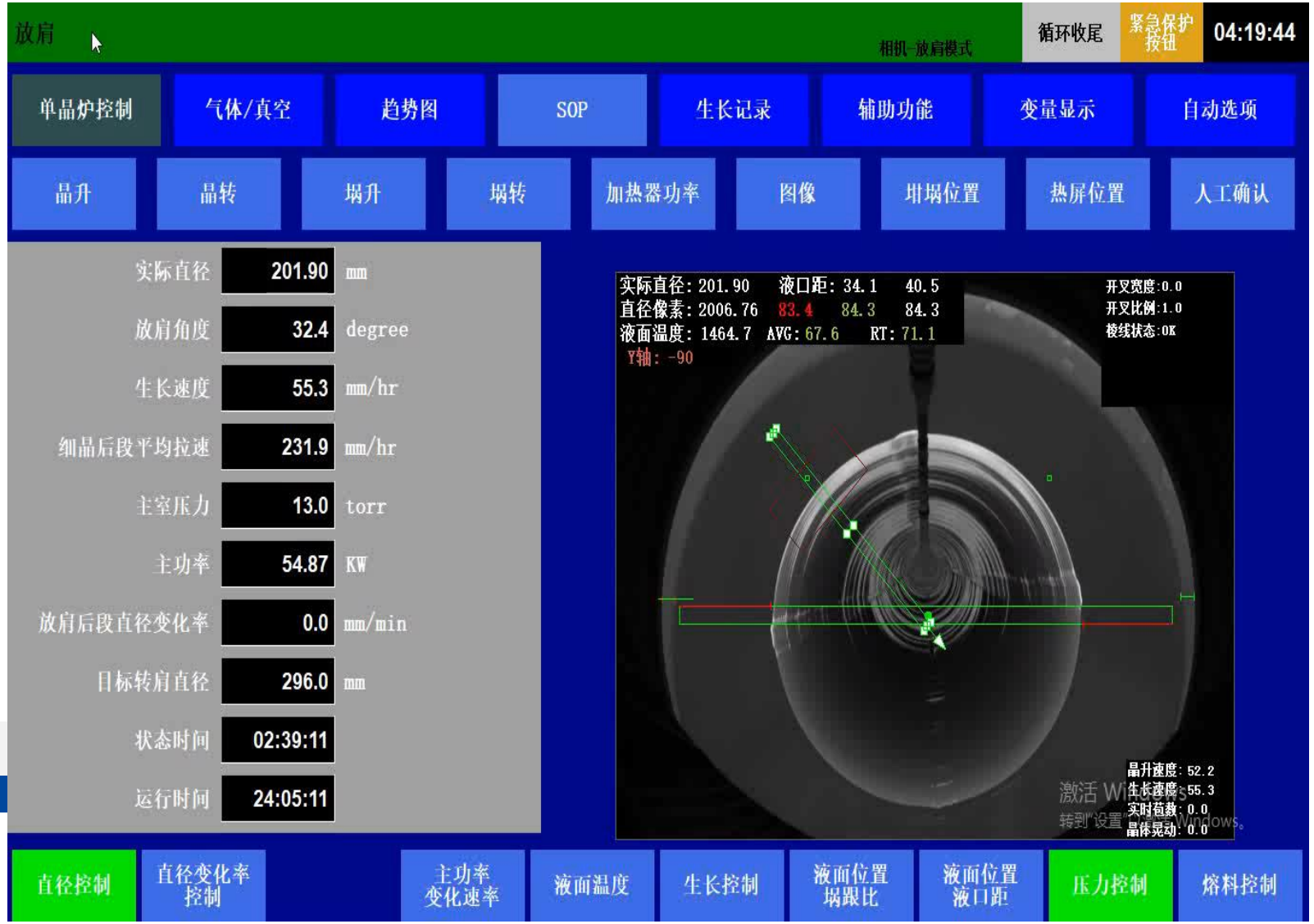
LINTON KAYEX

"One-click crystal growth" : Automatic crown growth

Fully automatic crystal crown growth with preset crown shape curvature.

Has facet examination function to decide whether the crystal is in good condition.

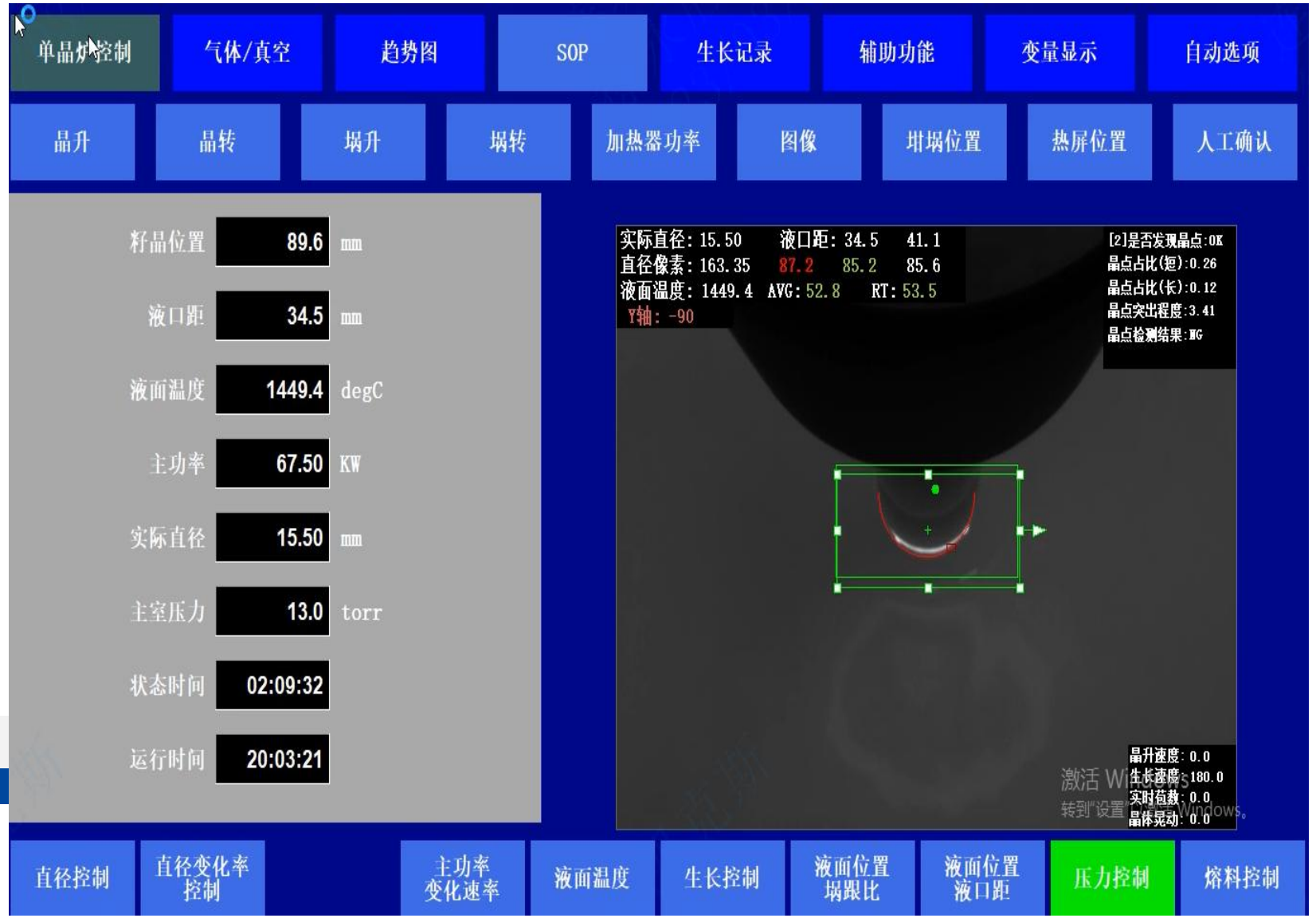
Self-learning AI algorithm to gradually improve success rate.



LINTON KAYEX

"One-click crystal growth": Facet detection by CCD at start point of growth

During temperature stabilizing, using CCD to check the size and condition of facet points at the seed/melt interface to decide whether the temperature of the melt is proper for starting the neck growth.
Because the facet points are very small, highly accurate CCD system and sophisticated algorithms are needed for this step.



Curve fitting method for diameter calculation

Coordinate positions of multiple points along the meniscus are measured and commercial algorithms are used to calculate the diameter

Again, because CCD is doing measurement atan angle, the value of R is dependent onmelt surface position. Accurate melt surface position measurement is needed for a high accuracy crystal diameter measurement

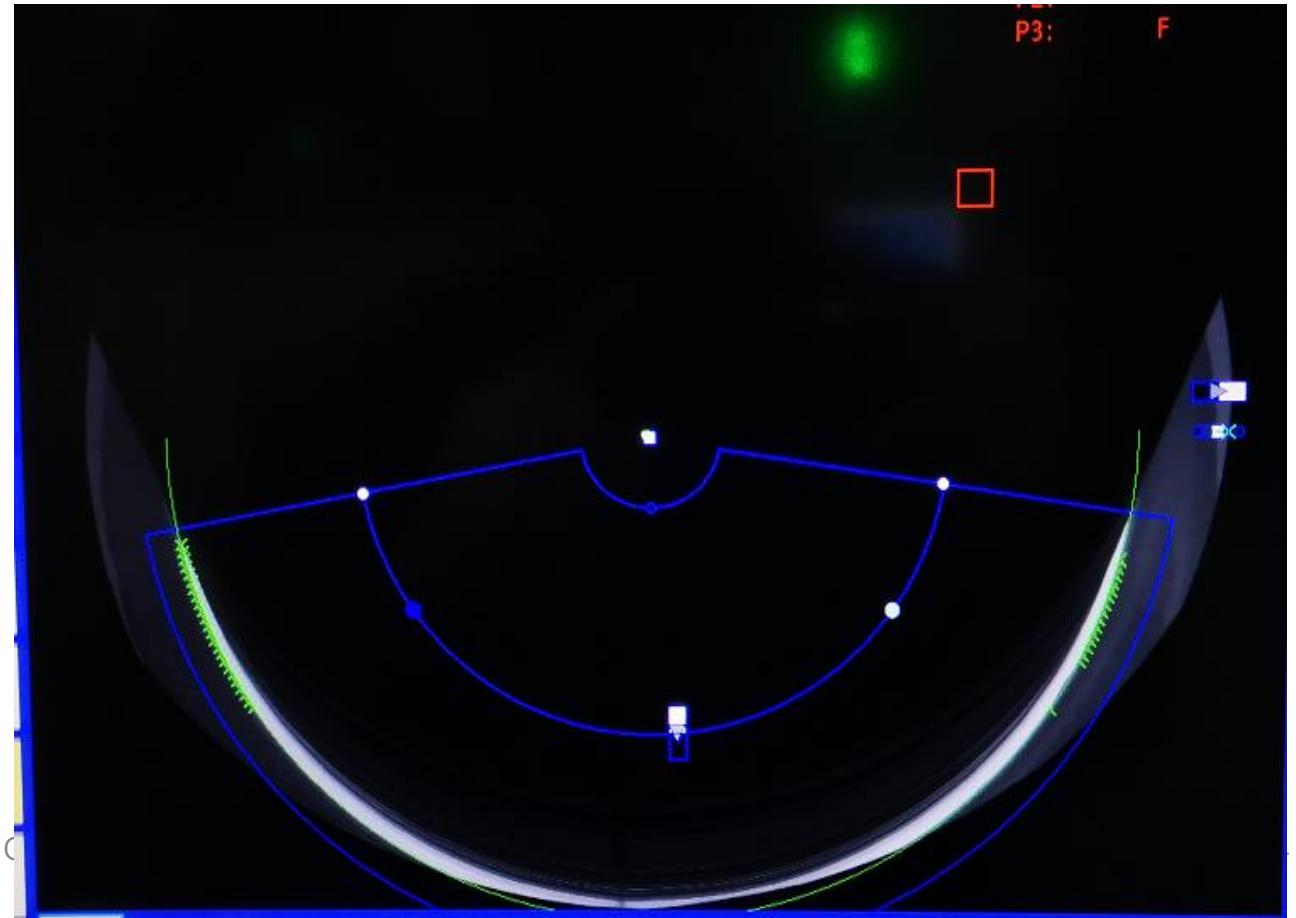
Disturbances such as crystal movement and melt surface wave affects diameter measurement accuracy

Question:

How to accurately measure the melt surface position ?

Melt surface position is also

called Melt Level

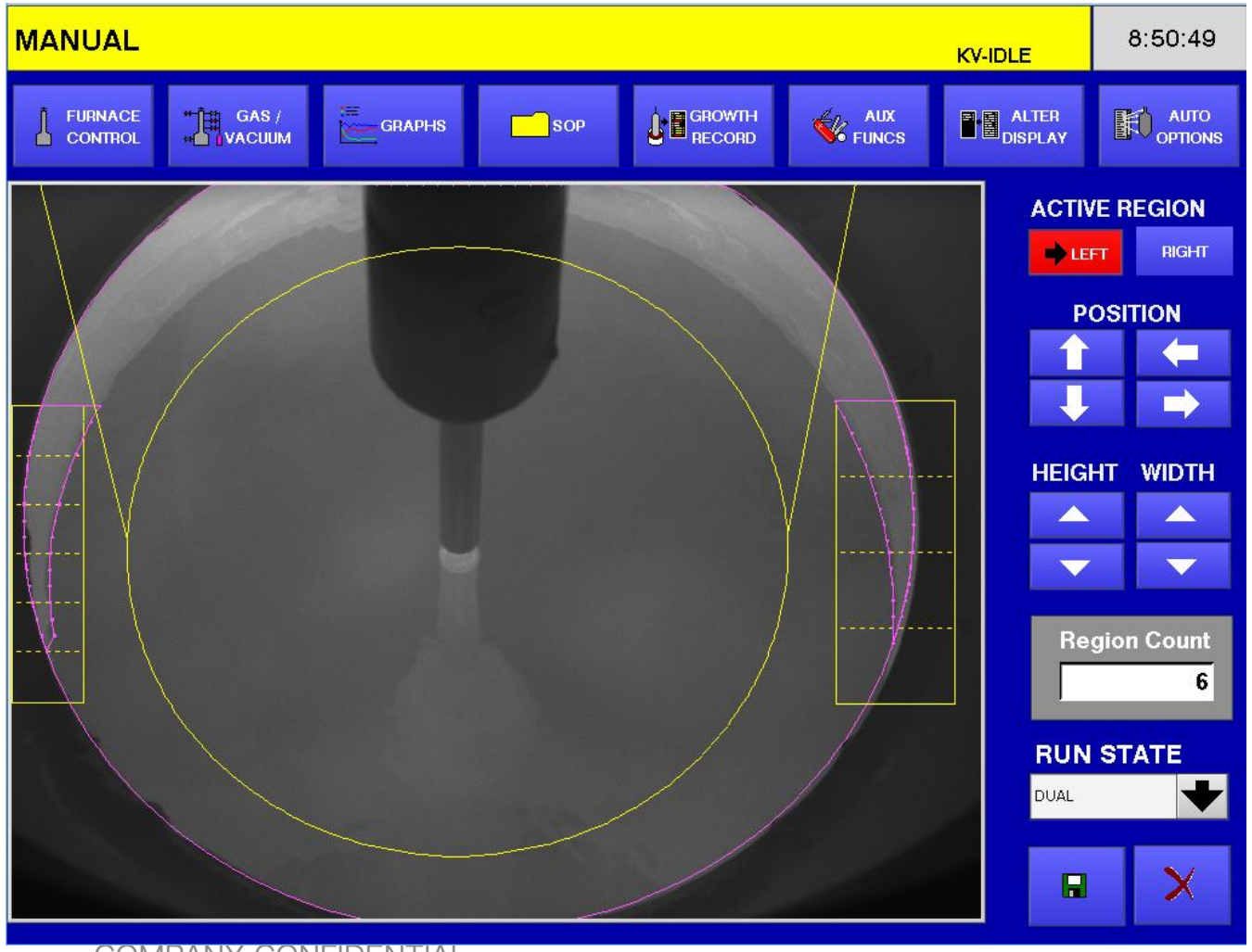


"One-click crystal growth " : Melt Gap measurement

Using CCD camera to capture the image of heat shield bottom edge and its reflection inside the melt, then calculate Melt Gap through Geometric relationship.

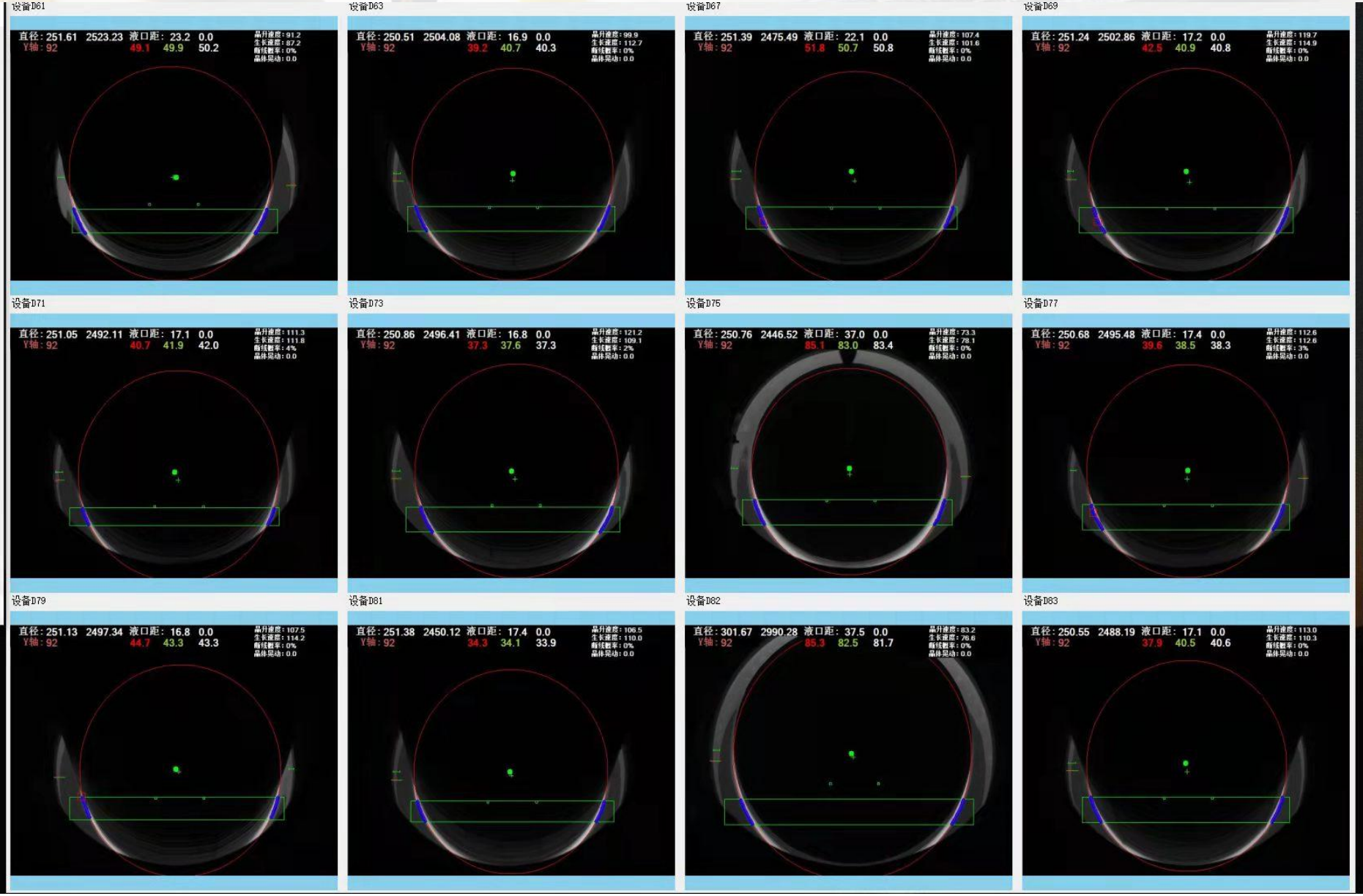
Accurate measurement of melt gap is critical in determining automated growth speed of the crystal.

Melt surface waves, color change of melt, dimensional accuracy of components, etc. , affect measurement accuracy of MG. Thus Advanced tech is needed



Centralized control system - classified display

Classified display



New Directions:

1. *Using Artificial Intelligence in crystal growth, wafer slicing & ingot/wafer factory;*
2. *Achieving lower oxygen, lower cost; higher productivity, higher quality;*
3. *Full ingot/wafer production line integration and automation.*

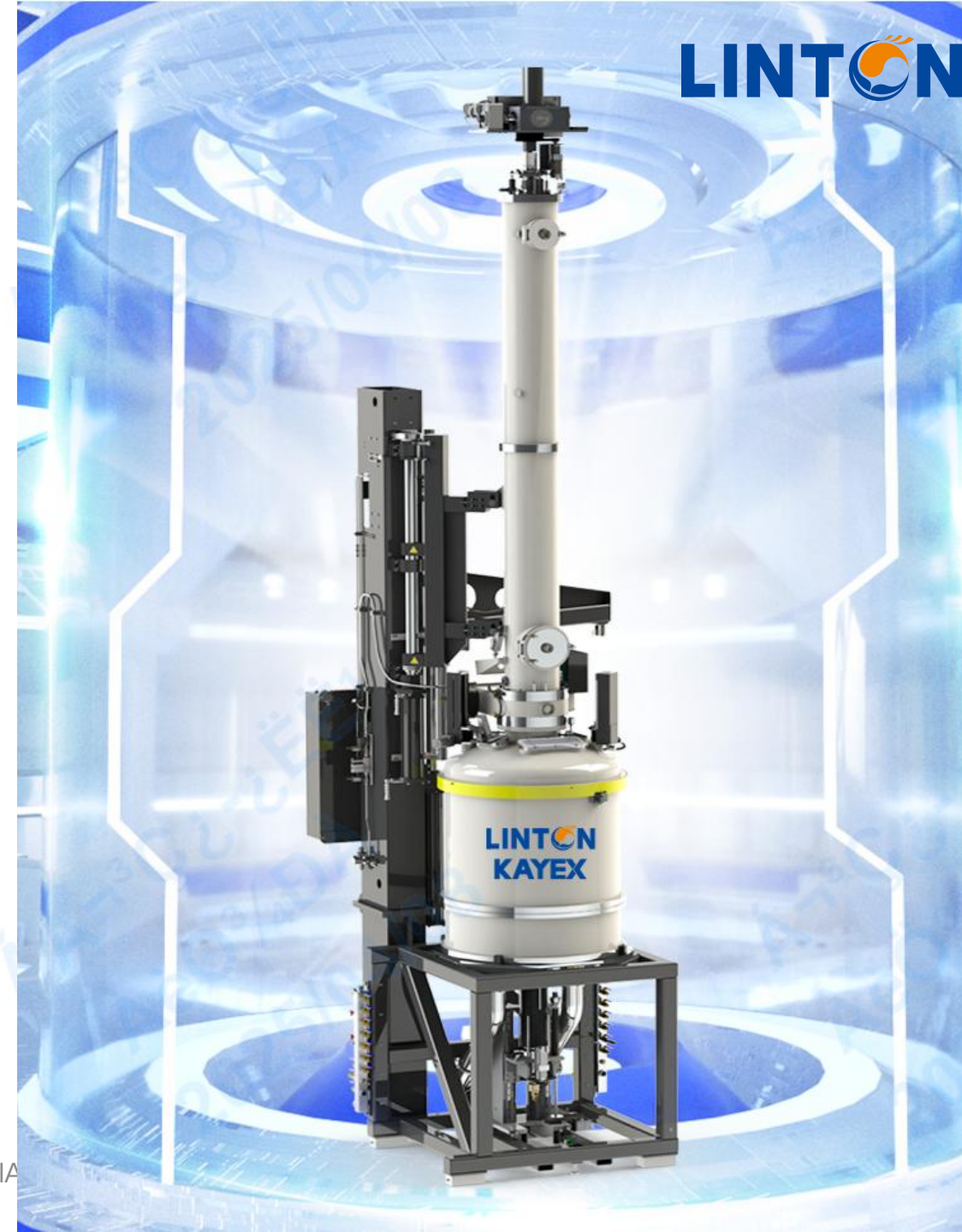
New Generation
Advanced N-Type Smart Crystal Puller
KX420 Series

1. **Lower Cost, Higher Yield**
   - Up to 200+kg/day per puller yield.
   - Lower hot zone power consumption, body growth power can be as low as 42 kW.
   - Lower water consumption, cooling water flow rate per puller can be as low as 20m^3 /h.

2. **Higher Quality**
   - Multiple oxygen control schemes and configurations, ingot oxygen concentration can be as low as 6 PPM.
   - More uniform resistivity and higher minority carrier lifetime.

3. **Broader Compatibility**
   - Hot zone diameter up to 42 inches, ingot diameter up to 16 inches.
   - Compatible with CCz and magnetic field.

4. **Smart Ingot Growth**
   - Integrated BI and AI based on big data of equipment and optimized whole process flow.



Puller

Type	Model	Chamber (mm)	Throat (mm)	Receiving chamber (mm)	Upper bearing load (Kg)	Lower bearing load (Kg)	Total equipment weight	Crucible loading capacity	Crucible diameter				
									33 in.	37 in.	40 in.	42 in.	44 in.
1600+	KX380PV	⌀1600*2050	⌀410	⌀410*5500	1500	2000	≈16 tons	Loading capacity	700kg	1000kg	1200kg	/	/
1700	KX420PV	⌀1700*2100	⌀450	⌀450*5500	1500	2000	≈17 tons		700kg	1000kg	1200kg	1400kg	/
1800	KX460PV	⌀1800*2100	⌀450	⌀450*5500	1500	2000	≈17 tons		700kg	1000kg	1200kg	1400kg	1450kg

Type	Delivery	Max hot zone compatibility	Puller type dimension compatibility	Product description
1600+	The first in the industry to develop and deliver **over 8,000 units** in bulk.	40 in.	Compatible with 1700 equipment factory layout.	Meets the demand for larger feeding capacity and larger-spec crystal rod growth, with multiple upgradeable modules reserved for cost-effective technological upgrades. The 1700 and 1800 models can meet the growth requirements for 16-inch crystal rods.
1700	The first in the industry to develop and deliver **over 2,000 units** in bulk.	42 in.	Compatible with 1600+ equipment factory layout.	
1800	/	44 in.	/	

Standard Configuration	Optional Configuration
1.One-click Crystal Pulling Module 2.Centralized Control System 3.Low Oxygen Crystal Pulling 4.High-efficiency Heating Power Supply 5.High-speed Vacuum Pump 6.High-efficiency Filtration Tank;	1.Data Center & Big Data Analysis System Vision Server 2.Monocrystalline Production MES System 3.Low Oxygen Crystal Pulling Module 2.0 4.Extension Chamber 5.CCz Process Equipment 6.MCz/MCCz Magnetic Field Solution 7.High-efficiency Thermal Field Process Package 8.Production Auxiliary Tools

Technological Leadership:

1.Equipped with the next-generation digital intelligence platform, daily output increased by 10kg+/day, leading the industry.

2.Lower hot zone power consumption, with isothermal power reduction exceeding 10%, leading the industry.

3.Reduced water usage, with cooling water flow as low as 20m³/h.

4.Multiple oxygen control solutions and configurations available, as low as 6PPM, ensuring more uniform resistivity and longer minority carrier lifetime.

5.Maximum thermal field size of 44 inches, with a maximum silicon rod diameter of 16 inches, compatible with CCz and magnetic fields.

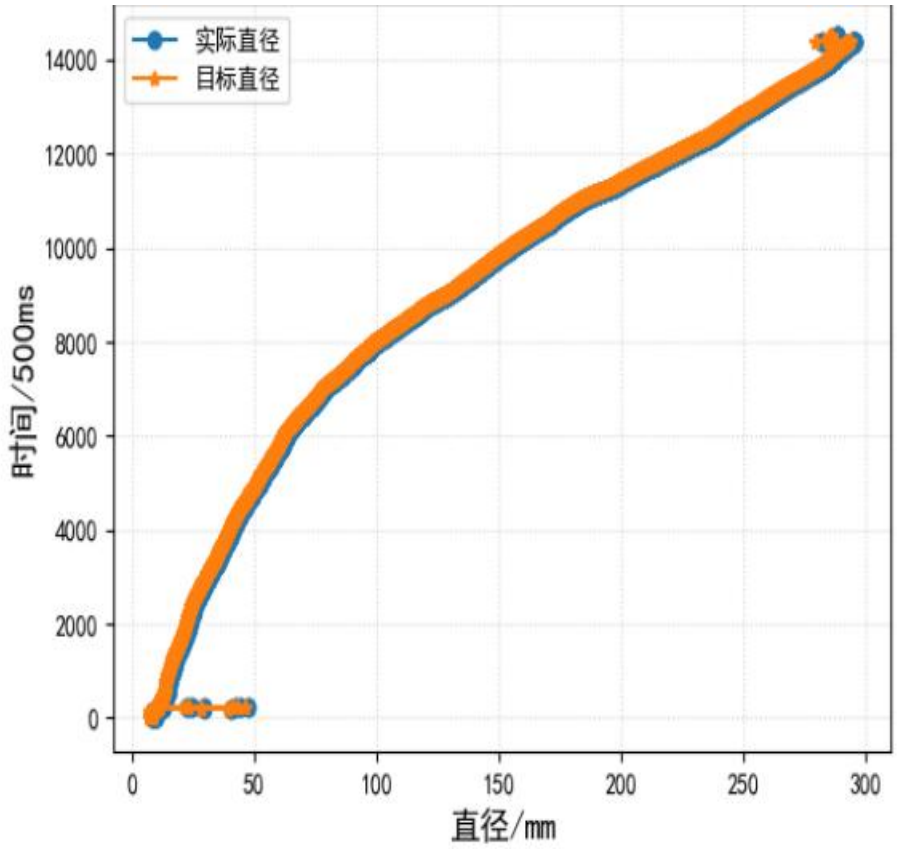
Intelligent Crystal Pulling:

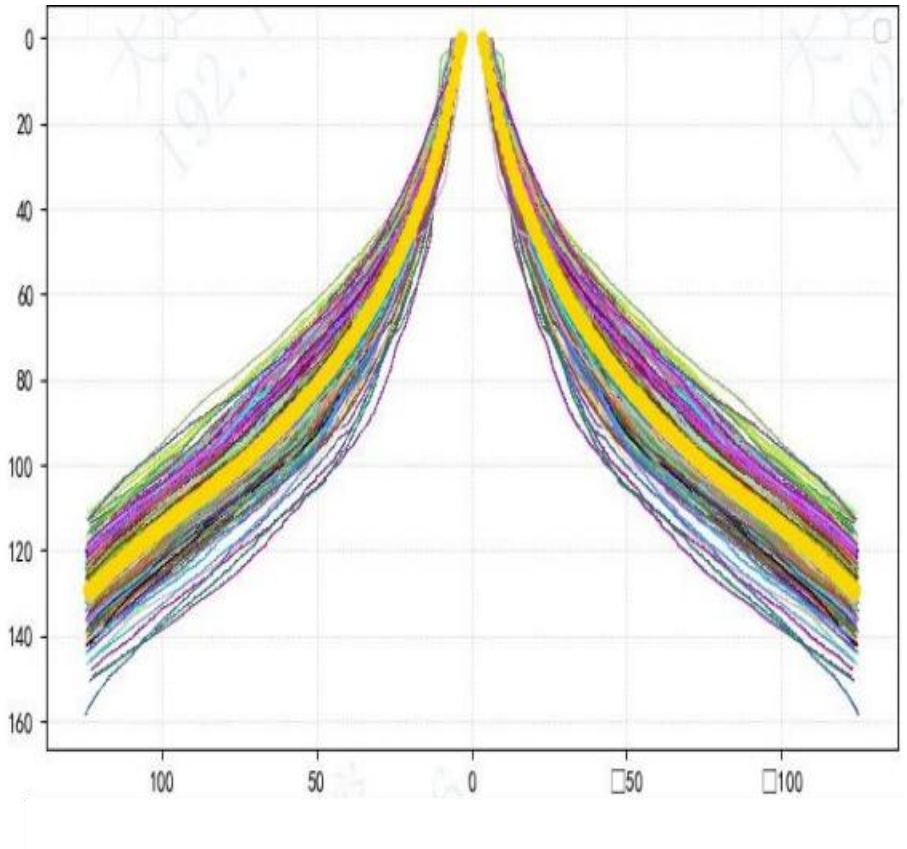
1.Integration of BI and AI based on equipment big data to optimize the entire process flow.

2.Intelligent crystal pulling with full process automation, automatically recommending pulling power and achieving an automatic pulling and releasing accuracy rate of ⩾99%.

3.AI-based visual inspection and automatic crucible release modules with improved accuracy, stability, and safety, offering customers higher automation rates and unmanned operation efficiency.

" One-Click Crystal Pulling" : AI intelligent shoulder growing





Intelligent prediction of growth trends, automatic intervention in crystal growth
Crystal success rate increased > 7%, Production yield increased > 3%

LINTON 连城数控

New: Linton Advanced N-Type Ultra-Thin Wafer Slicer

Comprehensive advantages:

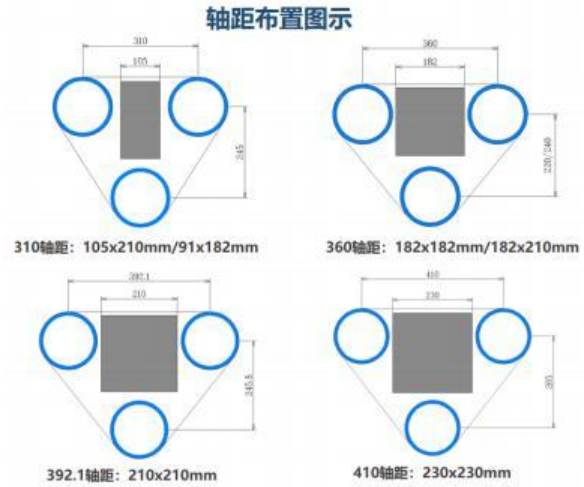
- Ultra-thin wires, 16-18μm
- Ultra-thin wafer, 45-50μm
- Large loading capacity, up to 1000mm brick length
- Higher yield, > 96.5%
- Lower wire consumption, save 20-30%
- High wire speed, 45m/sec
- User-friendly operation
- Compatible with wafers of all different sizes: 182/210/Half
- Automatic operation features
- Process improvement with AI

Progress in Slicing Technology - QP950 Slicer for Ultra-thin N-Type Silicon Wafers: M10/G12 Half-Wafer & Full-Wafer Capable

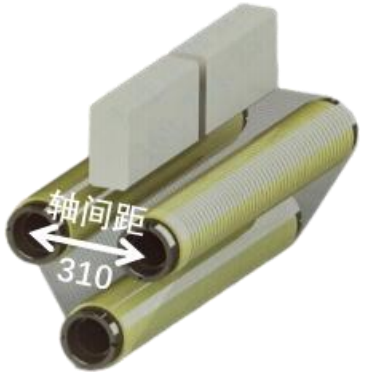
Adjustable wheelbase for optimal slicing condition. Ideal for fine wire and ultra-thin wafer.

Highly flexible design,
all three axes' wheelbases are adjustable.

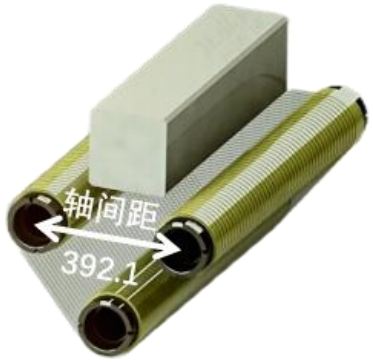
Maintaining optimal horizontal and vertical
axis spacing for different wafer specifications, ensuring
cutting capability

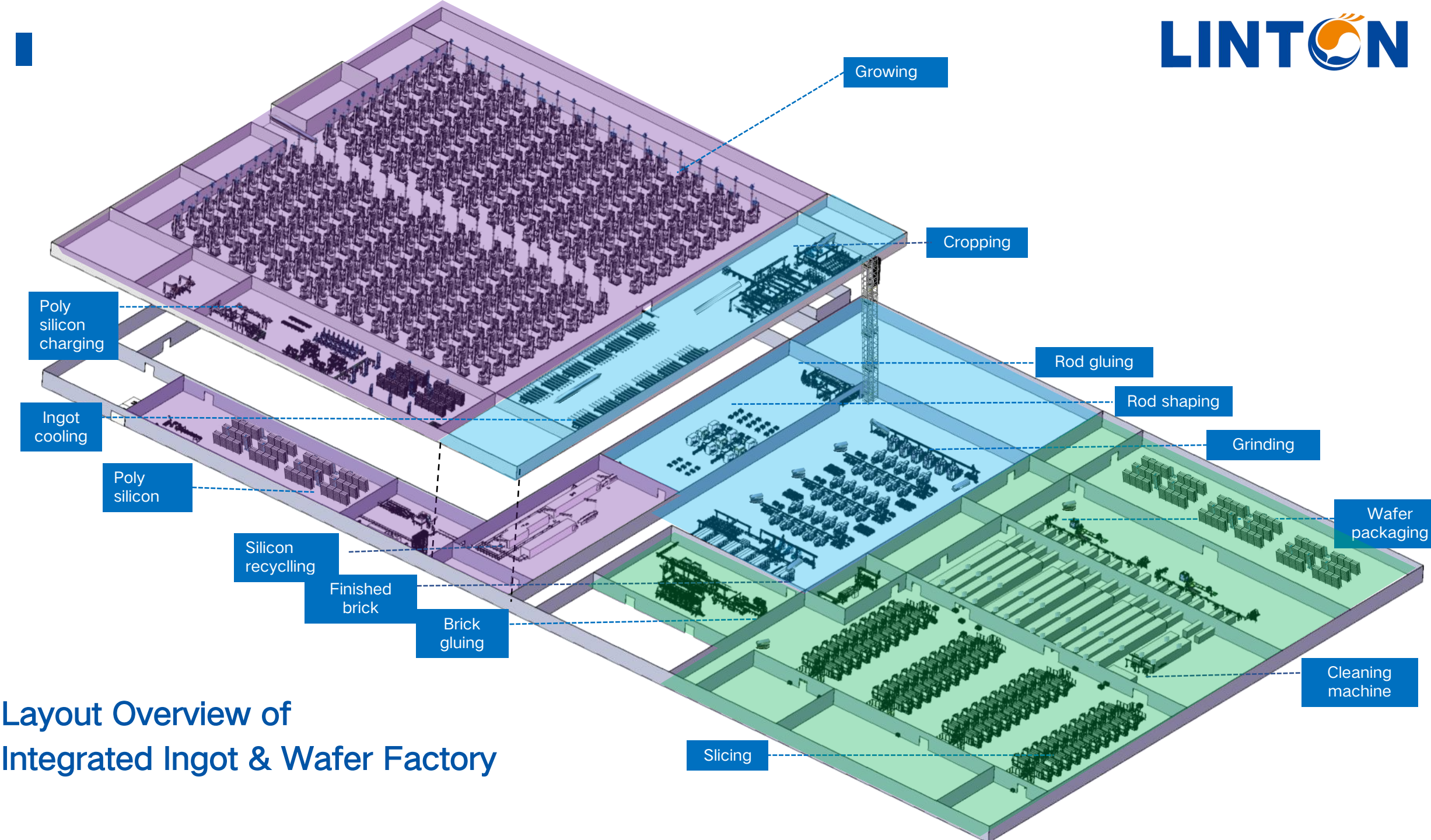


Half-Wafer: finished specifications 210x105mm, axle spacing is 310mm, and finished wafer thickness can be ~ 45µm.



Full-Wafer: finished specifications 210x210mm, axle spacing is 392.1mm, and finished wafer thickness can be ~ 55µm.





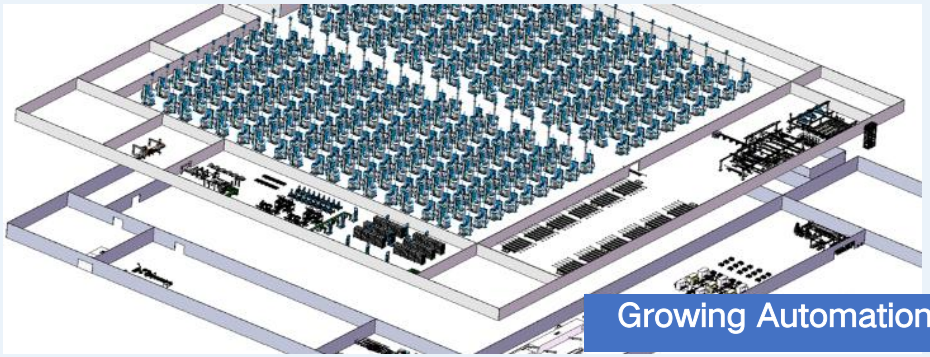
Layout Overview of Integrated Ingot & Wafer Factory

Ingot-wafer Smart Factory Solution – One Station Service by Linton

Silicon cleaning

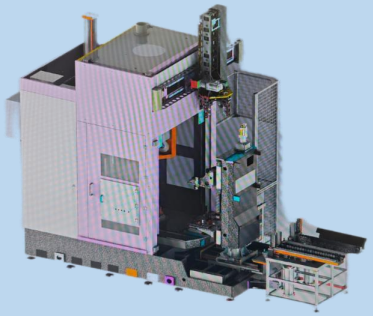
Silicon crushing

Ingot growing

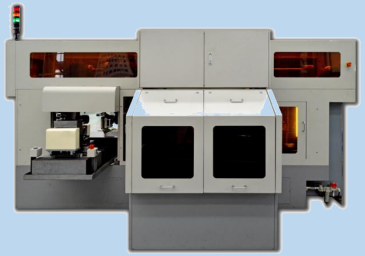


Growing Automation

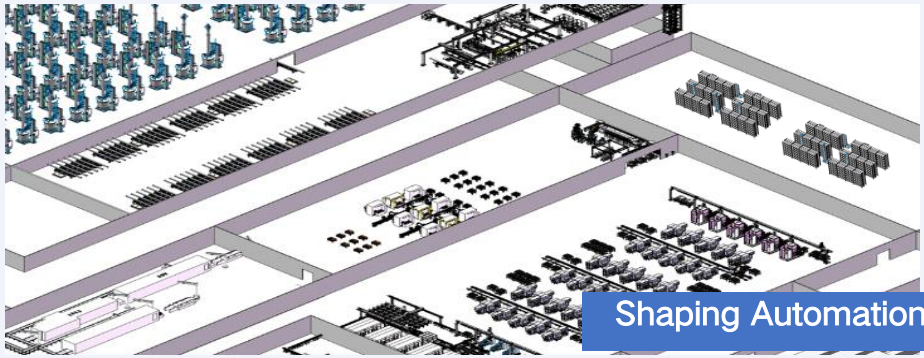
Ingot cropping



Square Cutting



Grinding

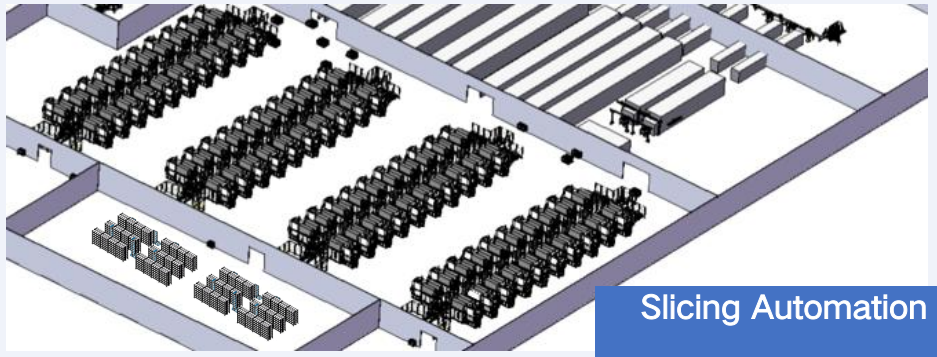


Shaping Automation

Slicing

Wafer degluing

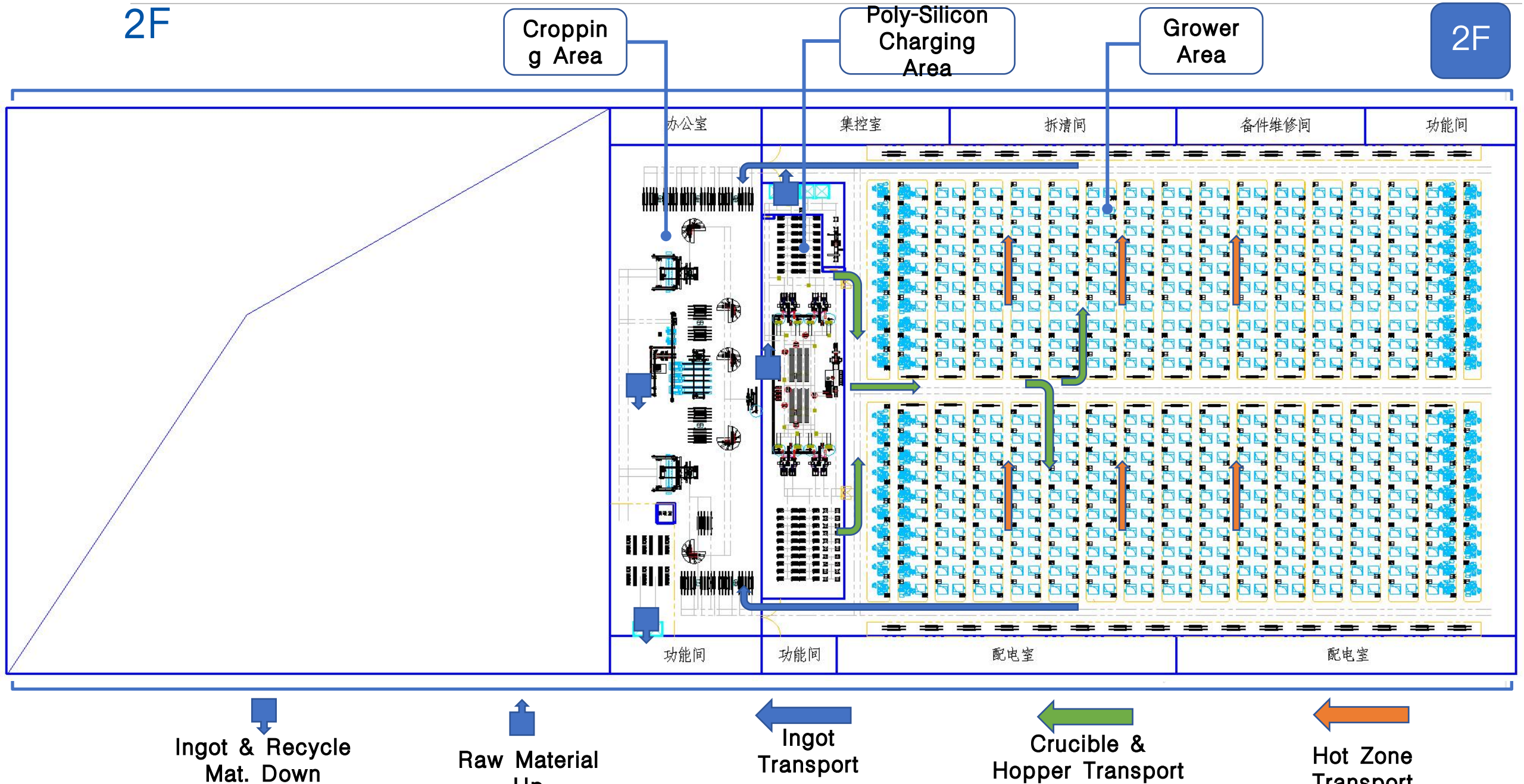
Final cleaning



Slicing Automation

10GW Ingot & Wafer Factory——

2F



10GW Ingot & Wafer Factory——

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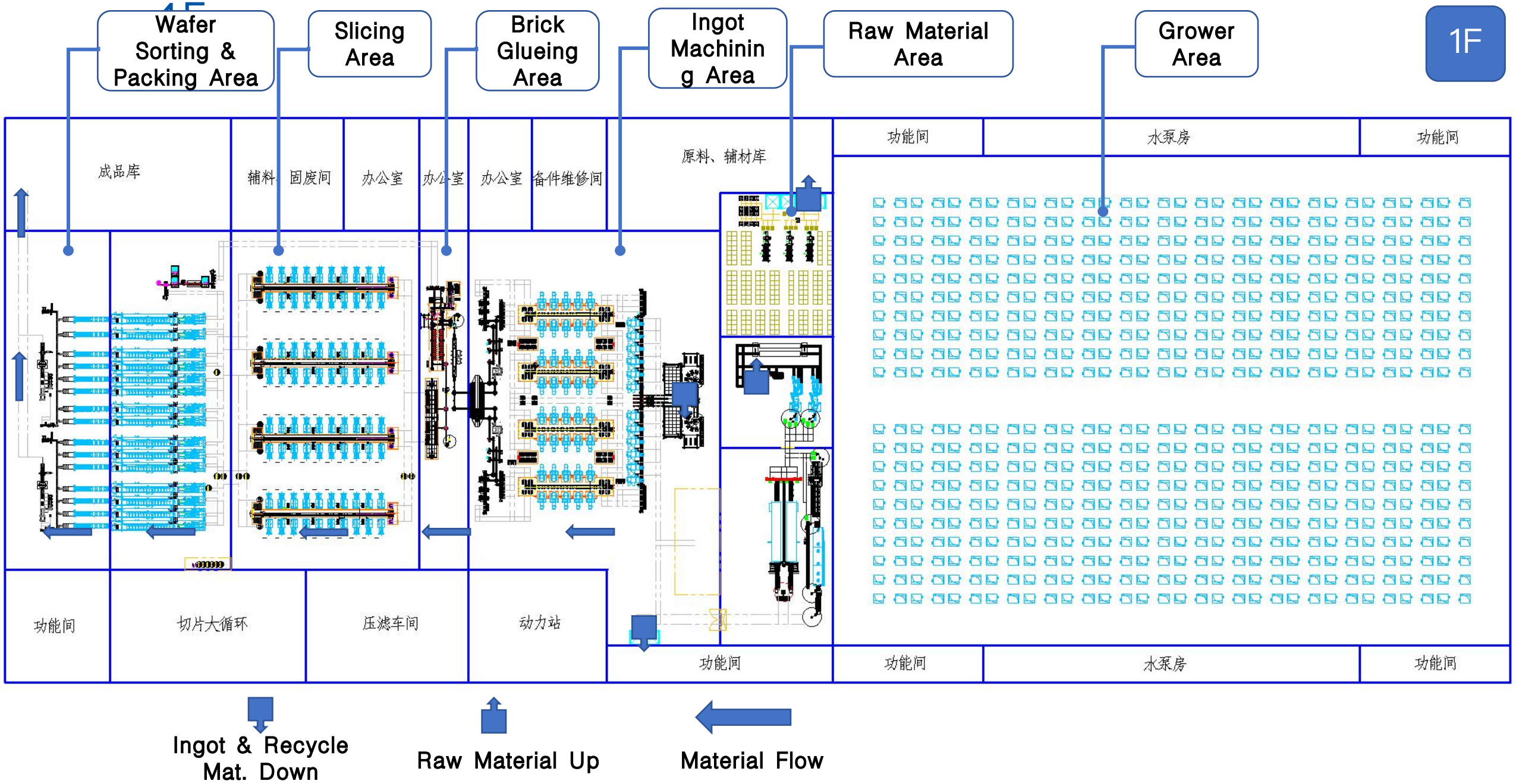
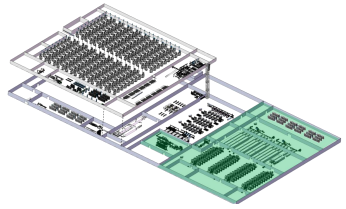
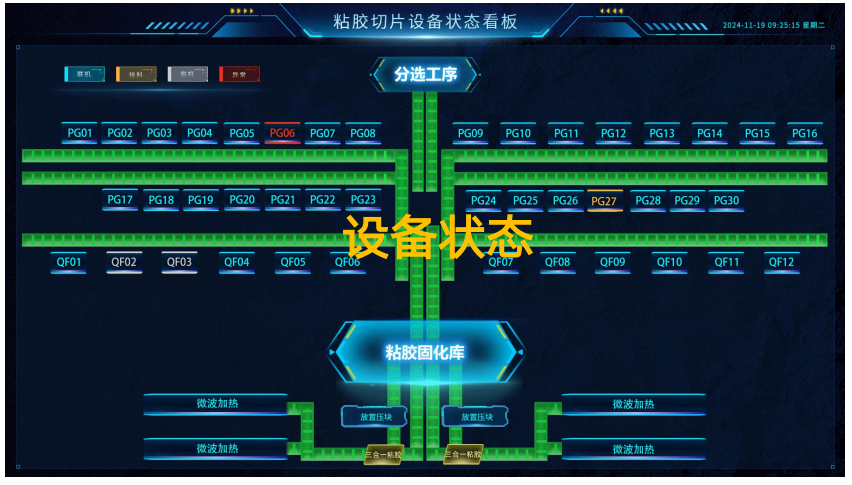
1F



Smart Factory with Digitalized Central Control Platform

Digitization of the slicing workshop





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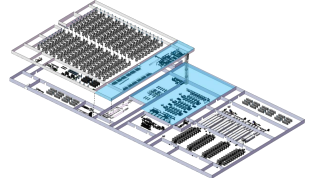
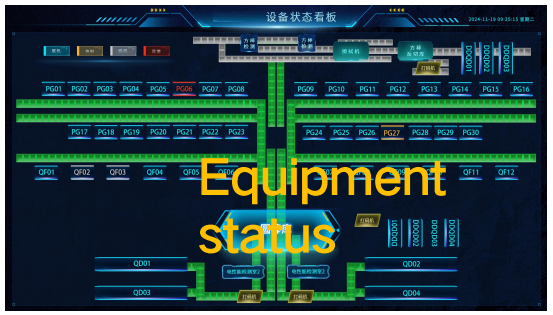
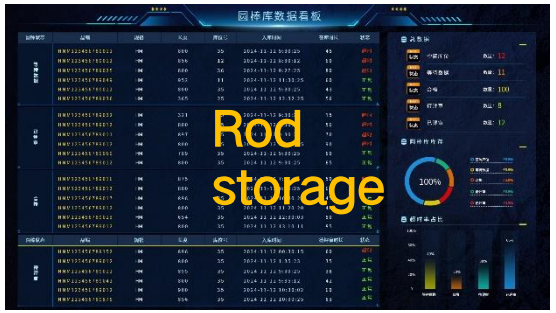
Central Control Room

Digitization of the shaping workshop







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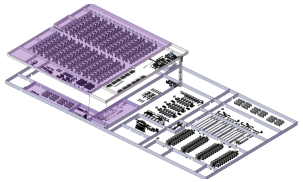
Smart Factory, Digitalized Central Control Platform



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Thank you!

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