silicon products
RESEARCH ENGINEERING PRODUCTION

Post-processing

for high quality solar grade and semiconductor grade silicon

后处理工艺

用于高纯太阳能级和半导体级硅生产

Silicon Products Engineering GmbH (SPE)

德国硅产品工程有限责任公司（SPE）

Process steps of post-processing
后处理工艺步骤

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- Main steps describe the post-processing technology from CVD reactor to packaged silicon products (ready to ship)
  后处理工艺的主要步骤，从CVD还原炉到完成装箱的硅产品（准备发货）

Top technology worldwide
世界上最先进的技术

Auxiliary technology
辅助技术

Harvesting
收割
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Pre-crushing
预破碎
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Comminution
粉碎
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Sorting
筛分
(Page页 8-9)

Cleaning
清洗
(Page页10-11)

Bagging
装袋
(Page页12)

Packaging
装箱
(Page页 13)

- SPE offers tailor-made solutions for customer for
  SPE为客户提供量身定制的解决方案，用于
  - High purity solar grade and 高纯太阳能级和
  - Semiconductor grade silicon 半导体级硅

Benefits for our customers
为我们的客户创造的利益

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- Contamination-free from harvesting to packaging 从收割到装箱，无污染
- Desired Particle Size Distribution (PSD) 期望的颗粒尺寸分布
- Low investment 低投资
- Long lifetime of equipment 设备使用寿命长
- Reliable and proven equipment 可靠的、经验证的设备
- Qualified tools and materials 合格的工具及材料
- Tests can be done in our tech-center 可在我们的技术中心进行测试

Harvesting
收割

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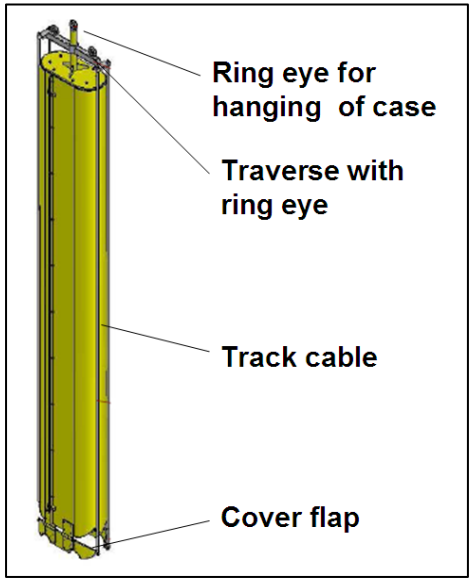
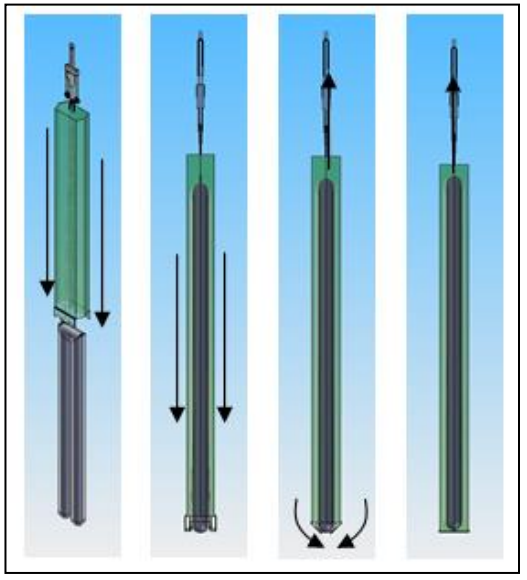
- Clean, safe and easy harvesting process of the silicon rods
  洁净、安全、简便的硅棒收割工艺
- Metal case, polymeric coated (internal and externally), reusable
  金属材质箱体，聚合物涂层（内外部），重复使用
- Remote control
  远程控制



Harvesting box
收割箱



Harvesting process with harvesting box
使用收割箱的收割工艺

Steel frame with 4 intermediate storage and transport boxes
带有4个中间存储和输送箱的钢架

Pre-crushing
预破碎

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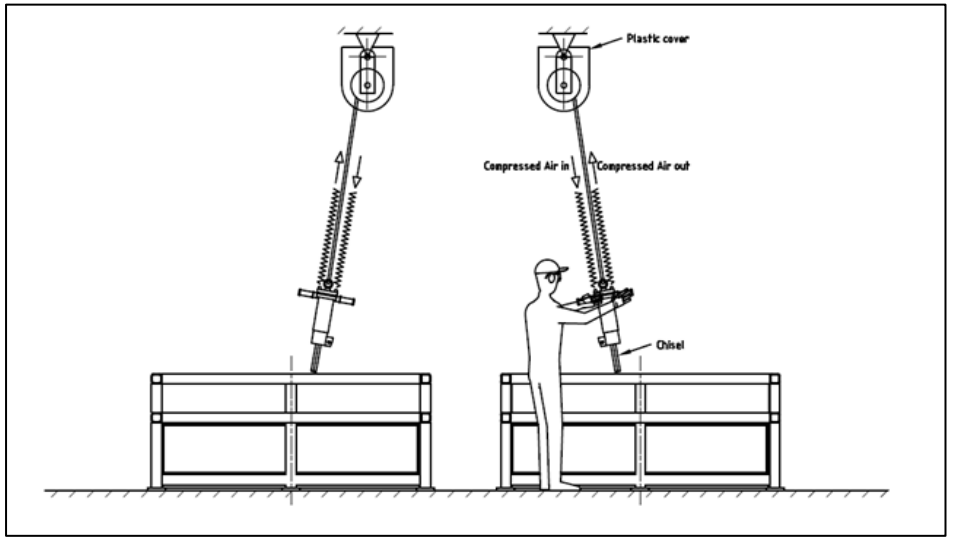
- Special design and special material
  特殊设计，特殊材料
- Defined discharge of compressed air to customer's exhaust system
  压缩气体直接释放到客户的尾气处理系统
- No contact of silicon products with compressed air
  硅产品和压缩气体没有接触



Schematic drawing of pre-crusher and pneumatic chisel
预破碎和风镐示意图

Exemplary picture of pneumatic chisel
(tungsten carbide chisel not shown)
风镐示例图（碳化钨镐没有示出）

Comminution technology of silicon
硅的粉碎工艺

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- Two dry-type comminution technologies are available:
  可提供两种干式粉碎工艺：
  - Jaw crusher and 颚式破碎机和
  - Roller crusher 辊式破碎机
- Innovative wear and protection concept
  创新的内衬和保护方案
  - Unique one-piece tungsten carbide without gaps or connectors
    整块的没有缝隙或连接物的碳化钨
  - Lining made of polyurethane, silicon or tungsten carbide
    内衬由聚氨酯、硅或碳化钨制成
- Proven manufacturers in silicon industry
  经多晶硅行业验证的厂家
- Variable Particle Size Distribution (PSD) according to customer‘s requirements
  根据客户要求，多种颗粒尺寸分布

Crushing equipment
破碎设备

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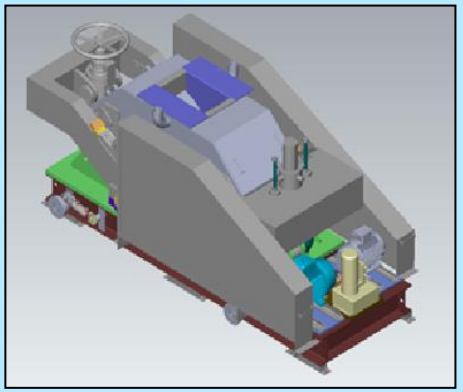
Jaw crusher
颚式破碎机

+ Higher crushing ratio → larger input material possible
  高破碎率 → 可给入较大的物料
+ Reduced crushing ratio → contamination and fines better manageable
  减小的破碎比 → 更好的管理污染和细粉末
+ Lower invest costs
  较低的投入成本

Jaw crusher
颚式破碎机

Roller crusher
辊式破碎机

+ Reduced contact to silicon → lower contamination risk
  减少硅的接触 → 较低的污染风险
+ Proven technology and manufacturer
  经验证的工艺和厂家
+ Low portion of fines
  低细粉末比例



3D drawing of Roller crusher
辊式破碎机3维图

Sorting technology of silicon
硅的筛分工艺

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- Two sorting technologies are available:
  可提供两种筛分工艺：
  - Mechanical sorting and 筛分工艺和
  - Opto-pneumatic sorting 光选-气动筛分
- Contact of silicon with equipment minimized
  使硅和设备的接触最小化
- Innovative wear and protection concept
  创新的内衬和保护方案
  - Parts in contact with product covered with polyurethane, silicon or tungsten carbide 与产品接触地方覆盖有聚氨酯、硅或碳化钨
  - Screen plates made of polyurethane or silicon 筛板由聚氨酯或硅制成
- Proven manufacturers in silicon industry
  经多晶硅行业验证的厂家
- Variable cut sizes according to customer requirements
  根据客户需要，多种分割尺寸，筛板替换简便
- Easy maintenance due to exchangeable cover and screen plates
  可替换的内衬及筛板，因此维护简便

Sorting equipment
筛选设备

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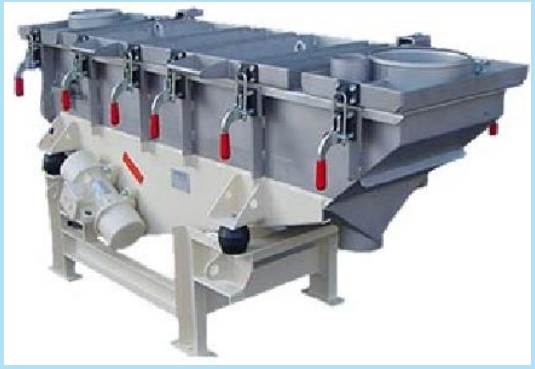
Mechanical sorting
机械筛分

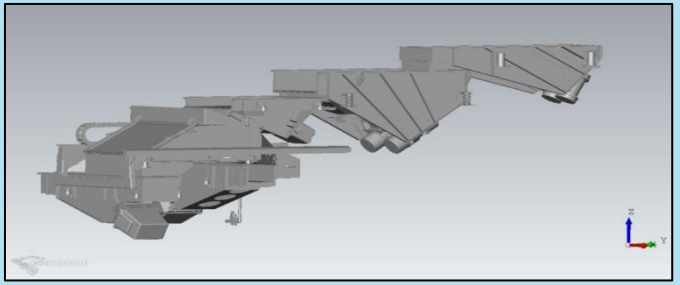
+ Simple and robust technology
  简单稳健的工艺
+ Low invest costs
  低投资成本
+ Standard and high purity solar applications
  标准和高纯太阳能级应用



Mechanical sorting equipment
机械筛分设备

Opto-pneumatic sorting
光选-气动筛分

+ High-technology solution for higher sorting accuracy: up to 99.99 %
  高科技解决方案高筛分精确度：达到99.99 %
+ Reduced contact of equipment with product – avoidance of contamination
  降低产品和设备的接触 – 避免污染
+ Data recording of particles – exact knowledge of geometric data and particle size distribution
  颗粒数据采集–准确了解几何数据/颗粒尺寸分布
+ Mainly semiconductor application
  主要是半导体级应用



3D drawing of opto-pneumatic sorting equipment
光选-气动筛分设备3维图

Etching
刻蚀

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- Tailor-made unit to fulfill customer's demand 量身定制单元，满足客户要求
  - Products on the market: "acid etched" "light etched" "washed"
    市场上产品："酸刻蚀"、"光亮酸刻蚀"、"清洗"
  - What are your clients' requirements in terms of surface conditions?
    在表面整理方面，您的客户的需求是什么？
- Modular design system 模块设计系统
  - Key components 关键组成部分
    - Detergent treatment 洗涤液处理
    - Combination of different etching methods 不同的刻蚀方法组合
    - Surface conditioning 表面修整
  - Final design depending on requirements 最终设计取决于需要
  - Stable, corrosion-proof construction with fluoropolymers and polypropylene as key materials 具有关键材料如含氟聚合物和聚丙烯的稳定的、抗腐蚀的结构
  - Cleanroom requirements 洁净室需求
    - ISO 6 in preparation area 准备区ISO 6
    - ISO 5 in packaging area 装箱区ISO 5

Etching – Process (Semiconductor Application)
蚀刻–工艺（应用于半导体）

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Detergent (organics) 洗涤液 (有机物)	Rinse 冲洗	Pickling 酸洗	Rinse 冲洗	Abrasive etch 磨蚀	Shiny etch 光亮酸蚀刻	Rinse 冲洗	Surface conditioning 表面修整	Rinse 冲洗	Drying 干燥

- Detergent: removal of organics
  洗涤液：去除有机物
- Rinse: follows each chemical step to avoid carry-over
  冲洗：在每个化学步骤后，避免遗留
- Pickling: mobilization / removal of persistent contaminants
  酸洗：活化/去除持久性杂质
- Abrasive etch: removal of all surface metals
  磨蚀：去除所有的表面金属
- Shiny etch：removal of etching stains, surface correction for a shiny appearance
  光亮酸蚀刻：去除蚀刻污渍，表面校正，实现光亮的表面形态
- Surface conditioning: hydrophilic or hydrophobic
  表面修整：亲水或疏水
- Drying: 2 steps optional (convection, vacuum)
  干燥：2个步骤可选（对流，真空）

Automated bagging and high precision dosing
自动装袋及高精确定量进料

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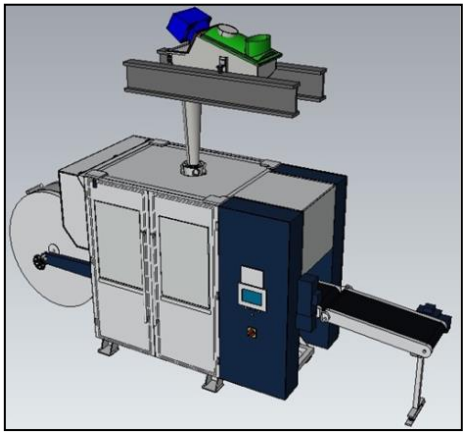
- Single or double polyethylene bags 单层或双层聚乙烯袋子
- Foil thickness up to 300 µm 膜厚度可达到300微米
- Various bag types (pillow, gusseted, …), made of tubular foil
  不同的袋子型号（平放的枕头形式，竖放 的M形式，…），由管式的膜制成
  - Reduced contamination and reduced Opex compared to ready-for-use bags
    与成品袋子相比，降低污染，降低操作成本
- Parts in contact with product covered with special materials: polyurethane, silicon
  与产品接触部件覆盖有特殊材料：聚氨酯或硅
- Up to 10 kg with high-precision dosing up to ±1% weight tolerance (± 100 g)
  可达到10 公斤，带有高精确定量进料，称重偏差±1% (± 100 克)
- Proven manufacturer
  经验证的厂家
- Compact and robust design
  设计紧密精巧、稳健
- Cleanroom compatible labeling on each bag
  每个袋子上带有适用于洁净室的标签



3D drawing of bagging machine with dosing system
带有定量进料系统的装袋机3维图

Automated packaging
自动装箱

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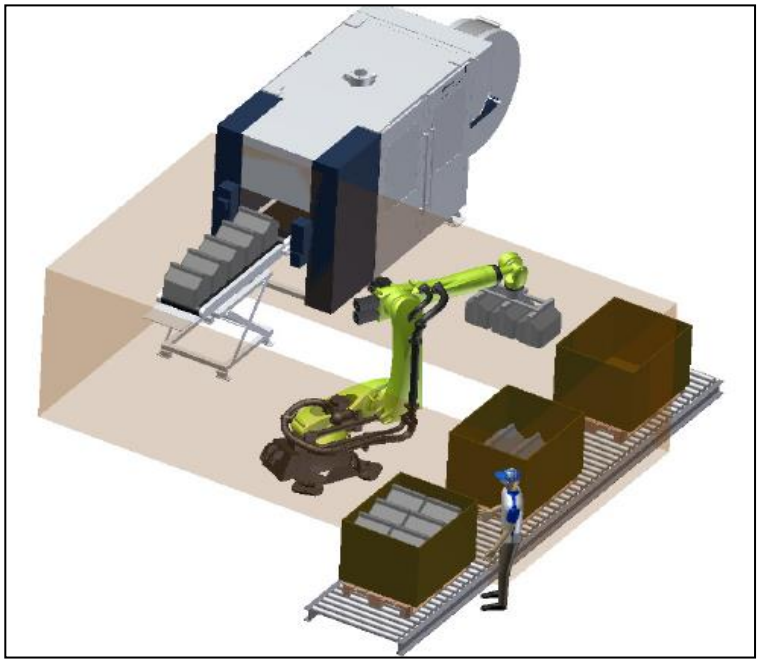
- Variable cardboard box and pallet sizes
  纸箱和托盘尺寸可变化
- Different cardboard box types
  不同纸箱型号
- Handling of bags of several types and weight
  处理多种型号和重量的袋子
- Automated packaging and palletizing
  自动装箱码垛



Exemplary drawing of outer bagging machine and automatic packaging to cardboard boxes
外包装机及自动装箱的示例图

SPE – customized engineering
SPE – 为客户特制的工程

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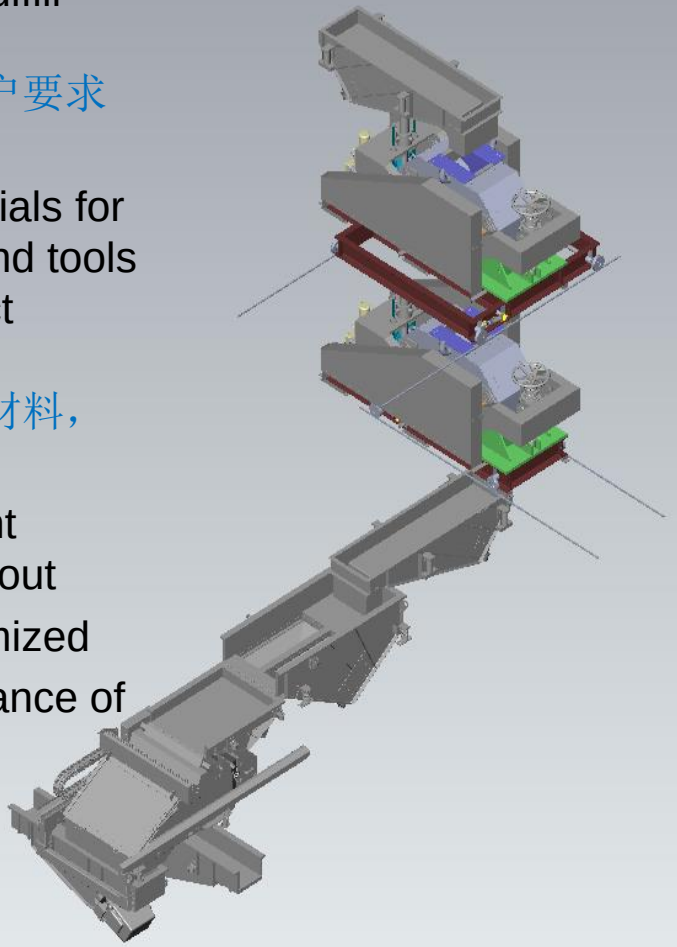
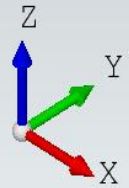
- Customized solutions to fulfill customer requirements
  为客户量身定制，满足客户要求的解决方案
- Selection of special materials for covering machine parts and tools regarding required product quality
  根据产品质量，选择特殊材料，用于覆盖机械部件和工具
- Arrangement of equipment according to customer layout
  – 2 story solution for optimized transport ways and avoidance of contamination
  根据客户布置图安置设备 - 2层解决方案，优化输送路线，避免污染
- 3D modeling 3维模型



Process design 工艺设计

- Equipment selection and design according to customer requirements: type of sorting, crushing
  根据客户要求选择设计设备：破碎、筛分类型，
- Selection of required process steps in close collaboration with customer
  同客户紧密合作，选择工艺步骤



Thank you very much for your attention