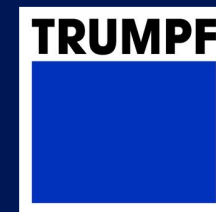




IGBT激光应用中的解决方案

Aaron Wang 2026-08-27-深圳





TRUMPF

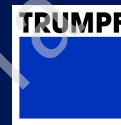


报告内容

1. IGBT中的激光应用

2. 通快激光的解决方案和产品特点

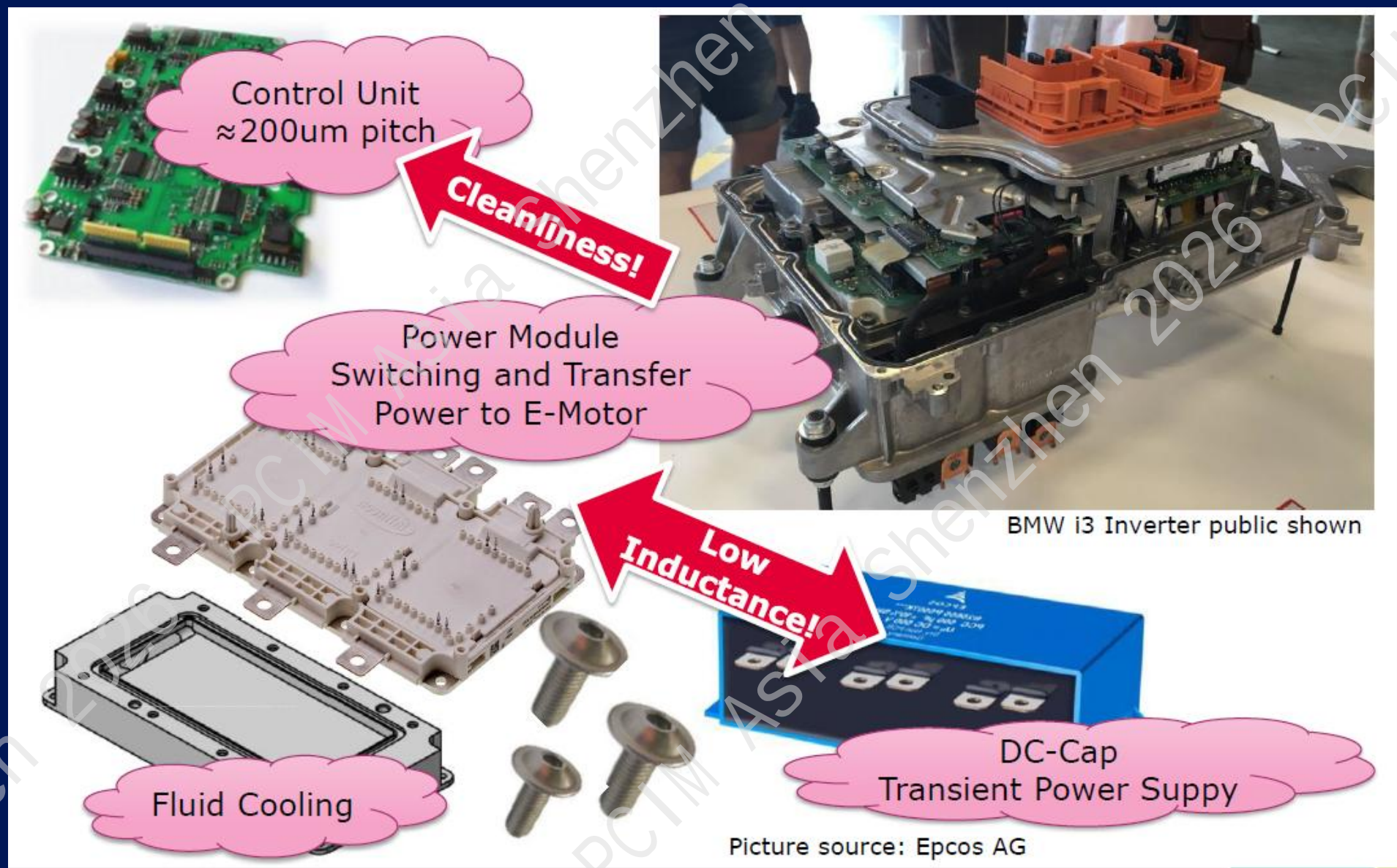
3. 通快激光公司简介



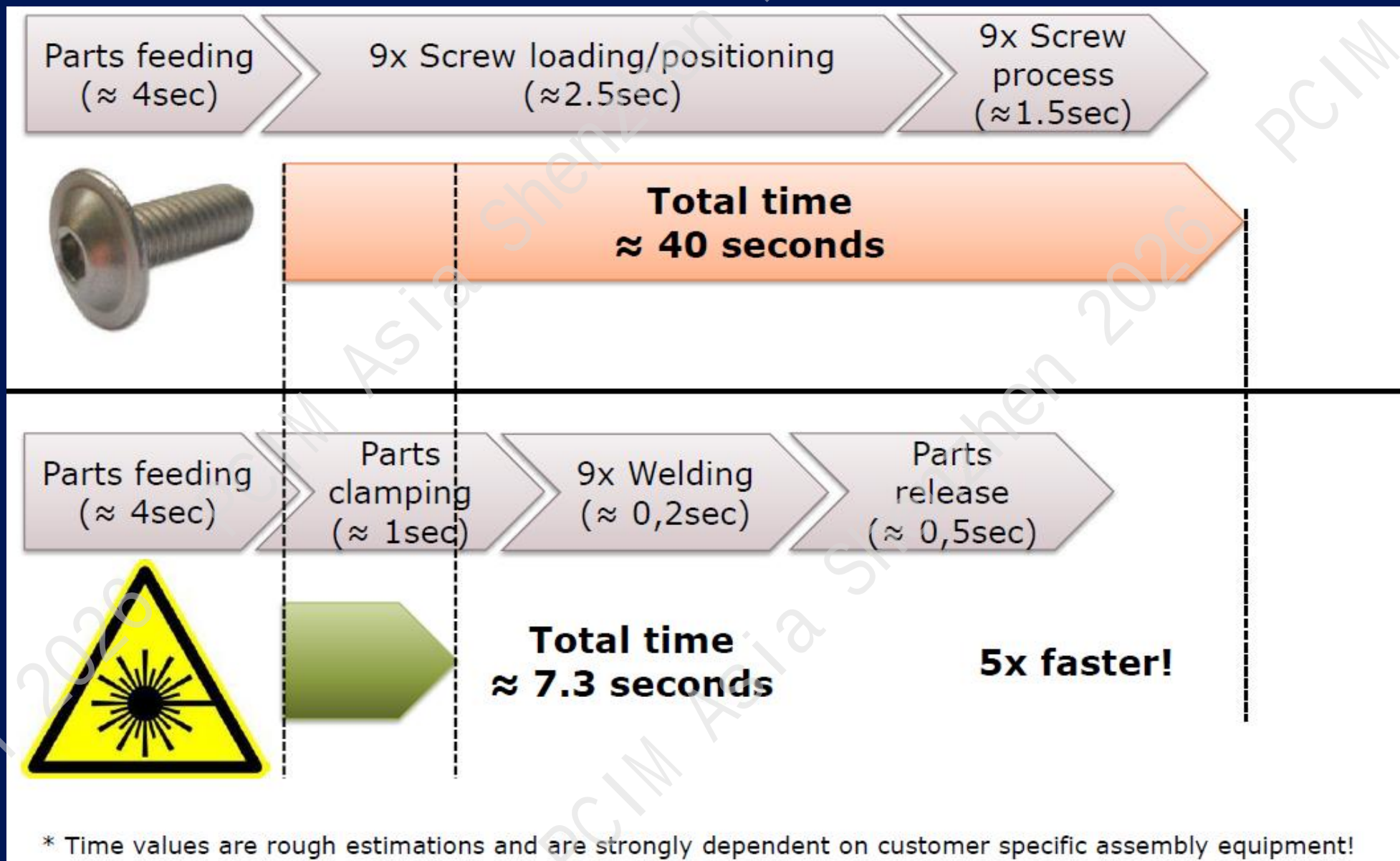
IGBT中的激光应用

IGBT中的激光应用

功率模块的连接架构



IGBT中的激光应用-1-导流铜排的激光清洗/焊接 价值-节拍



IGBT中的激光应用-1-导流铜排的激光清洗/焊接

价值—减少尺寸

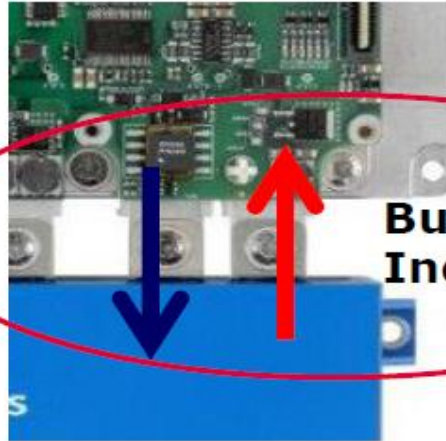


IGBT中的激光应用-1-导流铜排的激光清洗/焊接

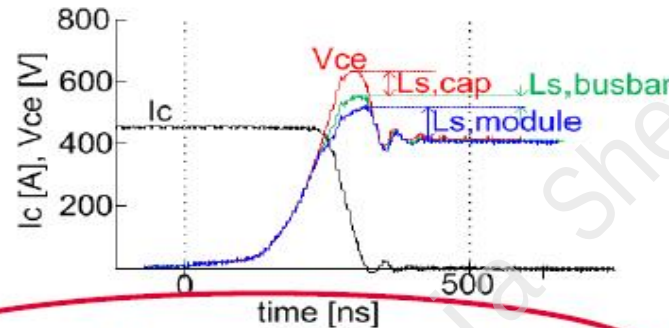
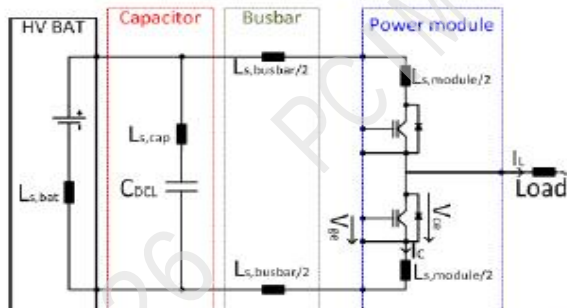
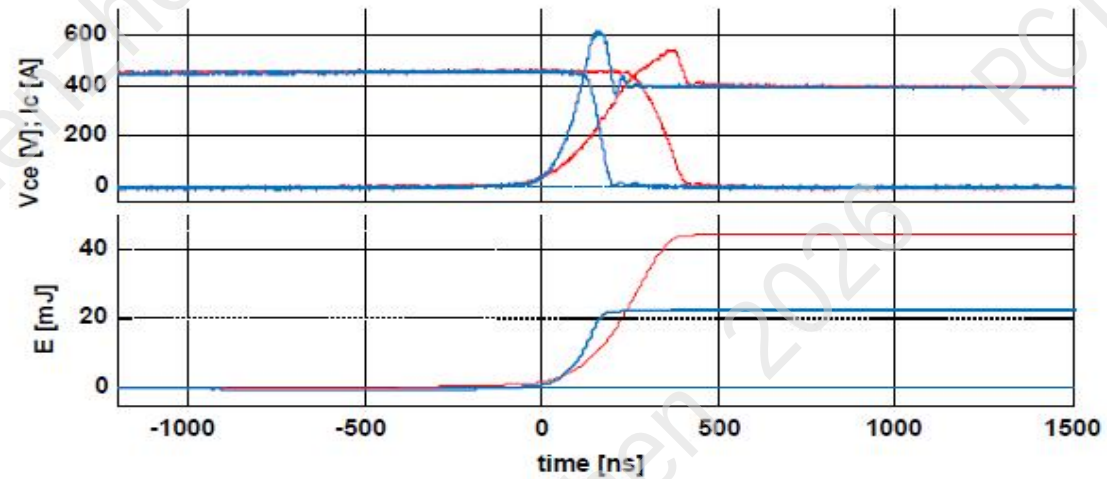
价值—更低的寄生电感，更低的关断过电压，更快的开关速度



Parasitic Inductances lead to turn-off over voltages



Busbar Inductance

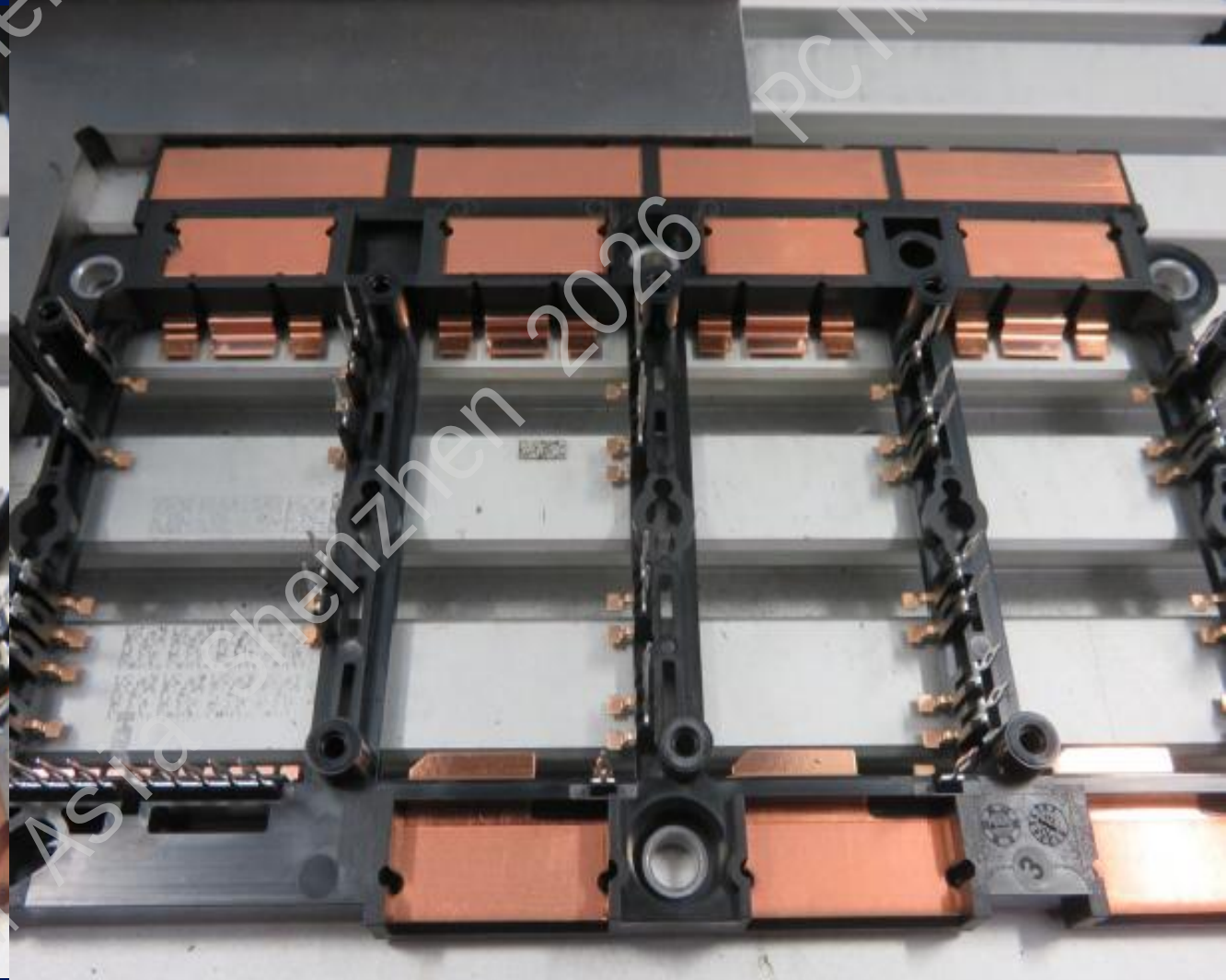
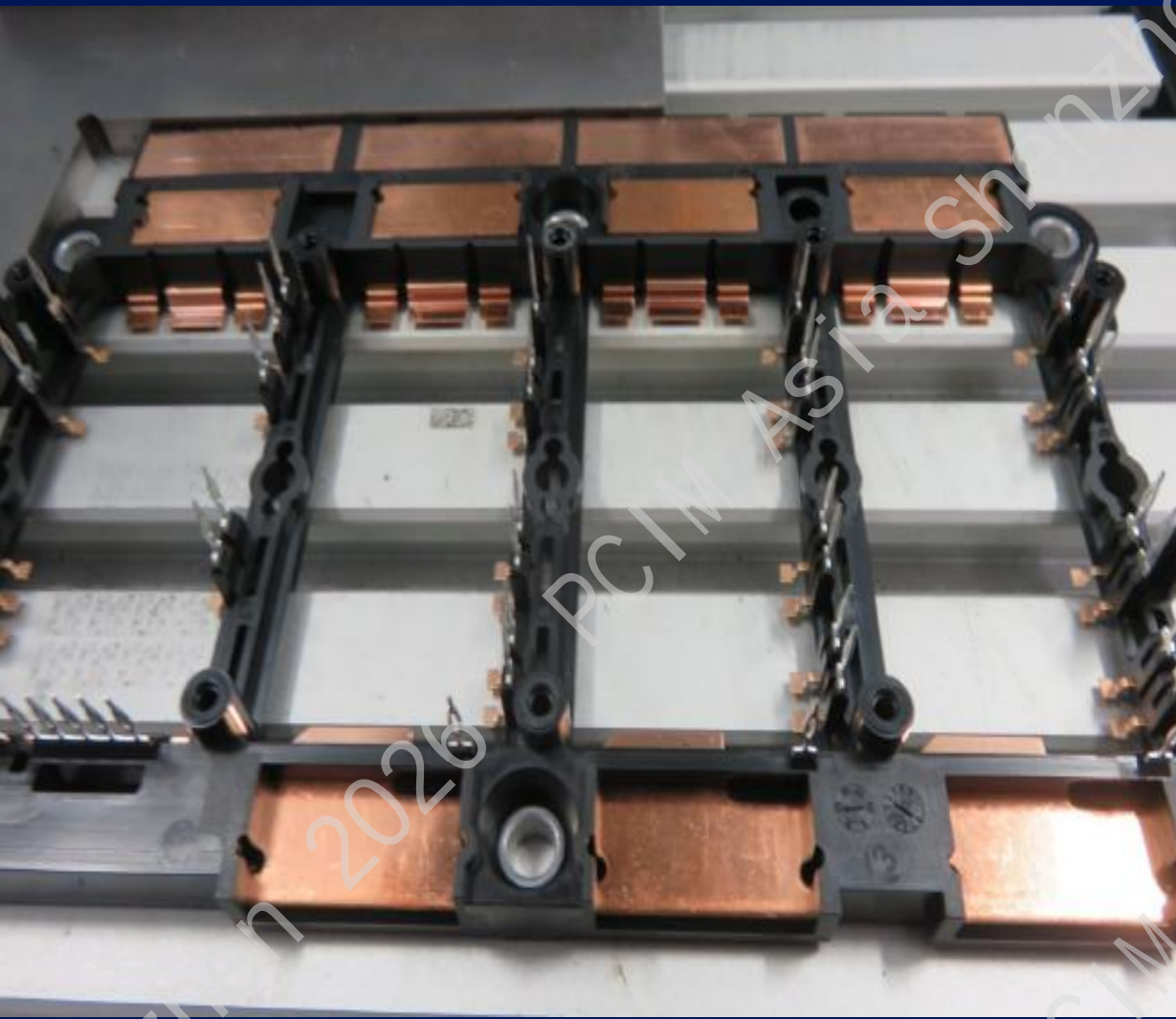


L_s Module $\approx 8\text{nH}$; Screw Connection $\approx 5\text{nH}$; Capacitor $\approx 8\text{nH}$

Laser Welding with single side mounting
can reduce overvoltage up to 20%.
Faster and more efficient switching possible.

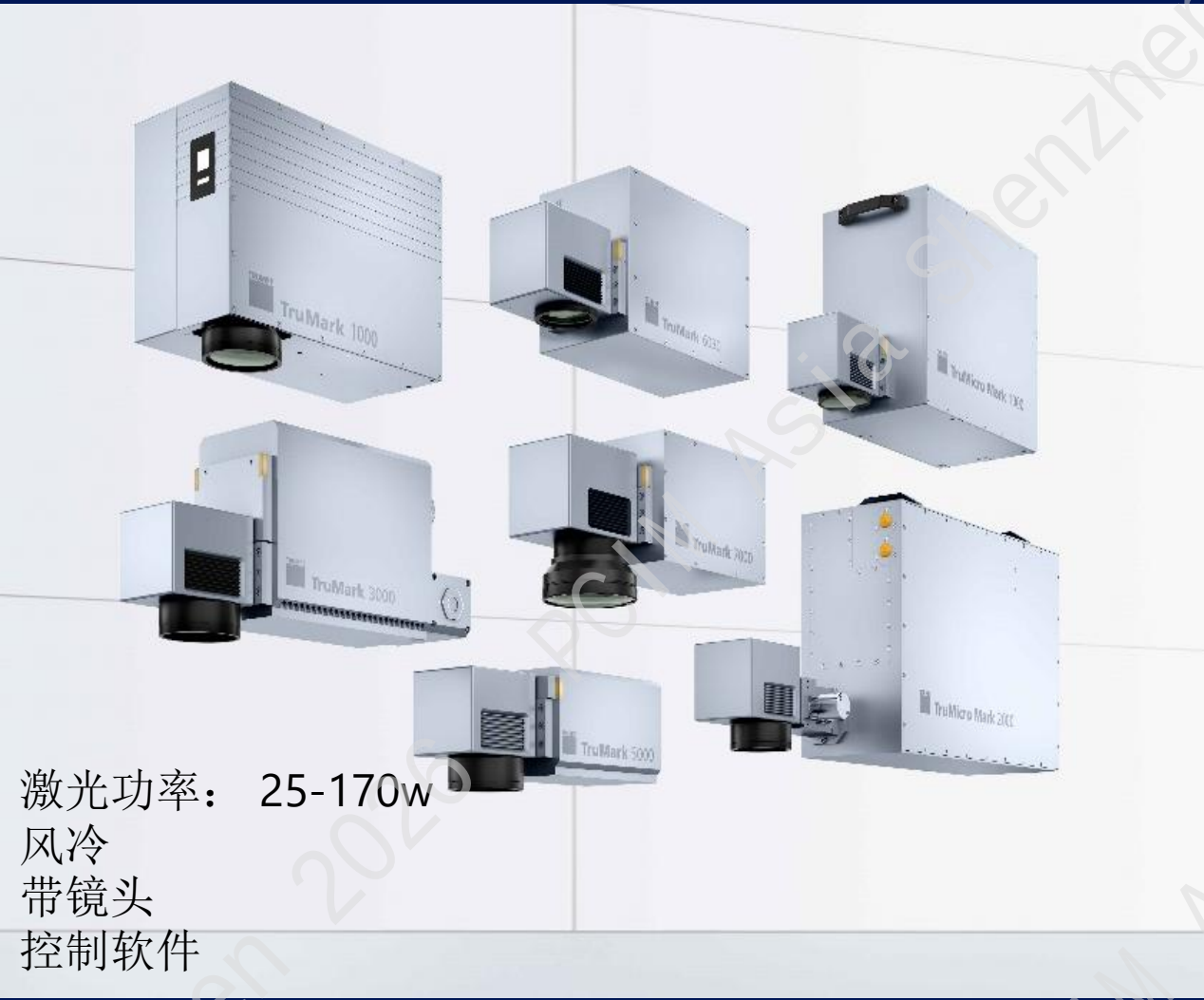
IGBT中的激光应用-1-导流铜排的激光清洗

解决方案—TruMark series/TruPulse Nano



IGBT中的激光应用-1-导流铜排的激光清洗

解决方案—TruMark Series/TruPulse Nano



激光功率: 25-170w
风冷
带镜头
控制软件



激光功率: 20-600w
单脉冲能量: 最大5mJ
脉冲重复频率: 1 to 4MHz
输出脉冲宽度: 8-2020 ns

Labels in diagram: From laser, IP54 cable, Isolator, Collimator, Divergent from ILLK, Collimated, Clamping Screw, Aluminium Body, Cylindrical collimator, Flange.

Item Description	Order Code	Nominal Collimated Beam Diameter (1/e ²)
BEC F30 - with D35 flange	PT-P00577	3mm
BEC F50 - with D35 flange	PT-P00553	5mm
BEC F75 - with D35 flange	PT-P00554	7.5mm
BEC F100 - with D35 flange	PT-P00555	10mm
BEC F30 - no flange	PT-P00614	3mm
BEC F50 - no flange	PT-P00615	5mm
BEC F75 - no flange	PT-P00616	7.5mm
BEC F100 - no flange	PT-P00617	10mm

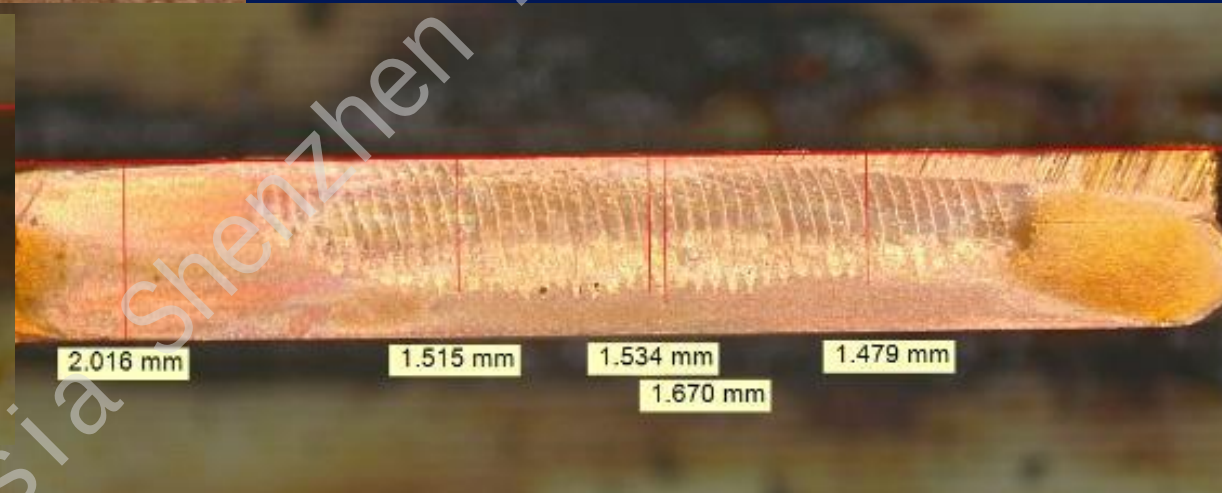
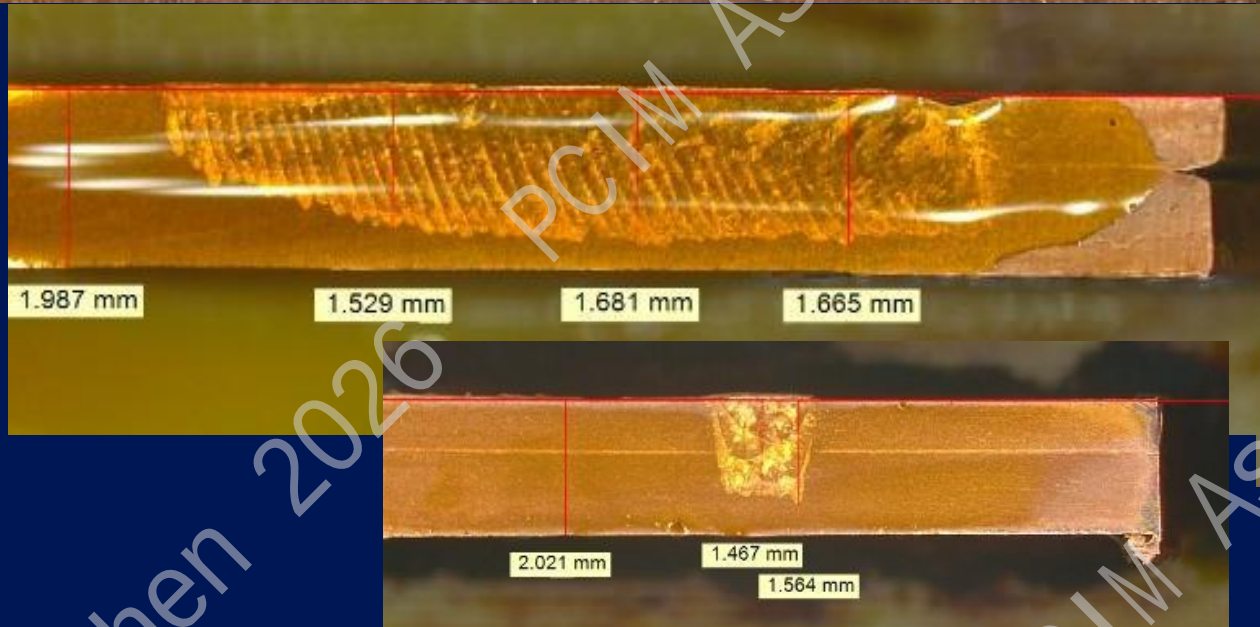


IGBT中的激光应用-2-导流铜排的激光焊接

解决方案-TruFiber 6000P(3+3kw)单模环+PFO33+OCT



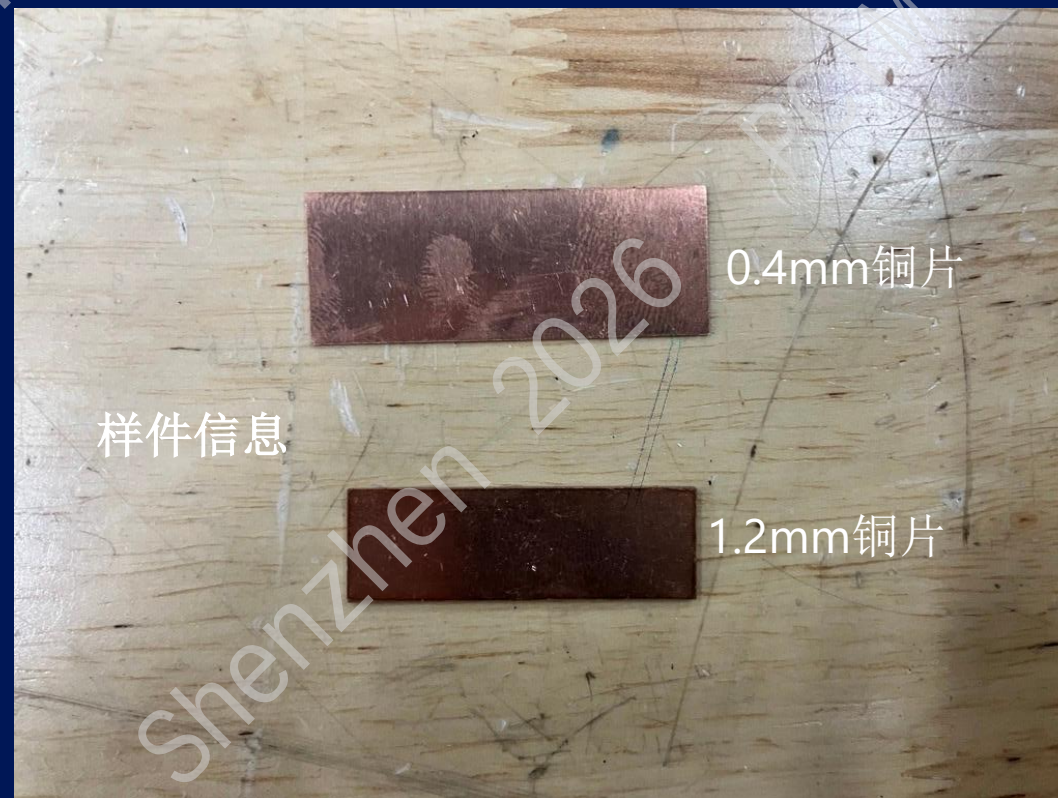
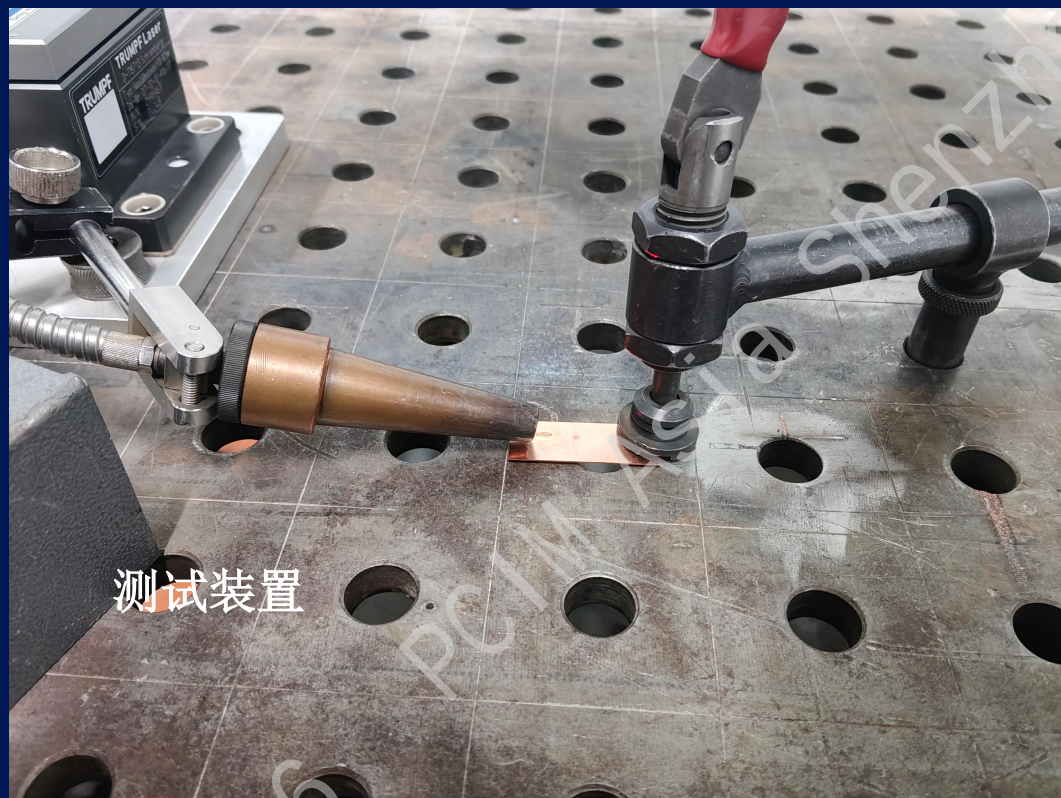
上下叠焊 0.8+1.2mm
Welding depth: 1.5mm
Welding length: 9mm
Welding width: > 1.5mm



CT: 0.3s

IGBT中的激光应用-2-导流铜排的激光焊接

解决方案-TruFiber 6000P(3+3kw)单模环+PFO33+OCT

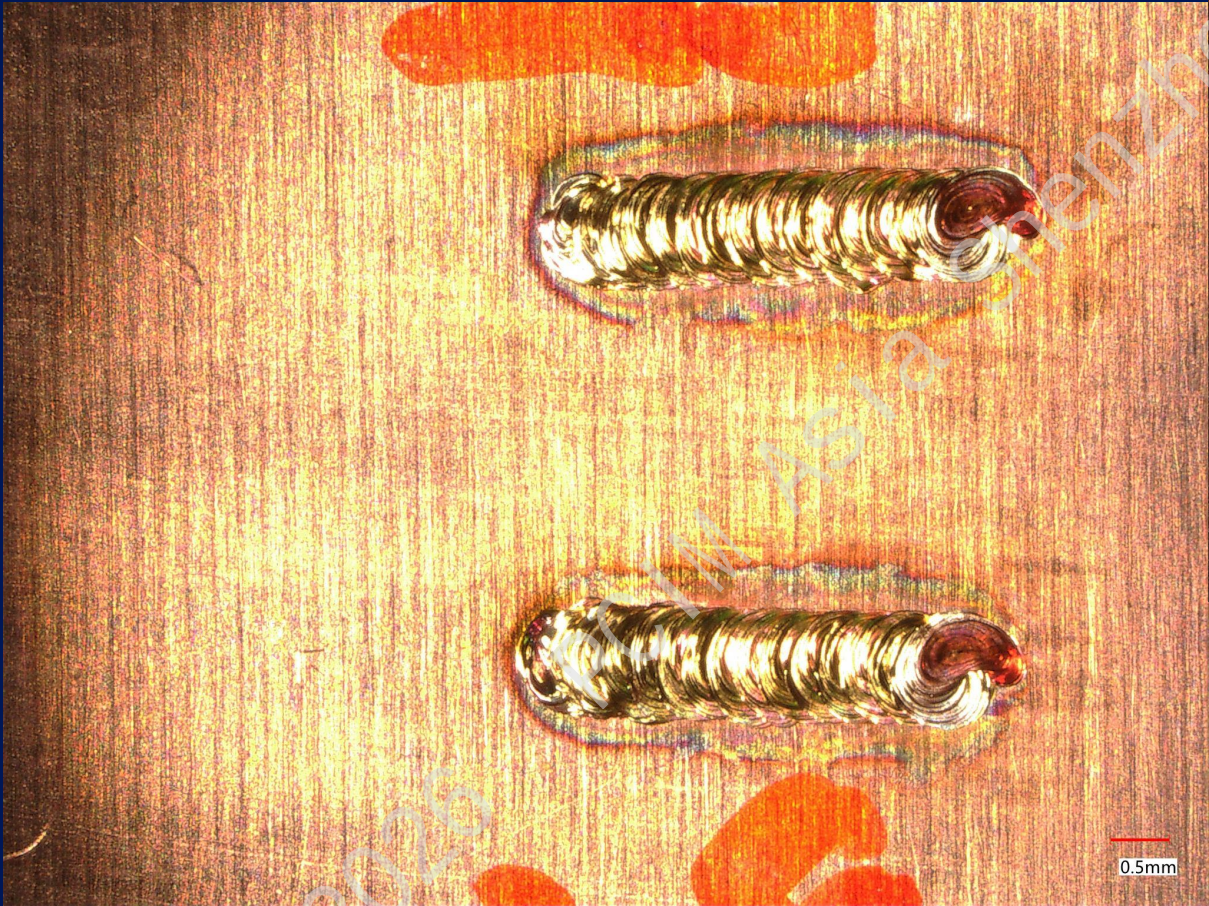


焊接要求:

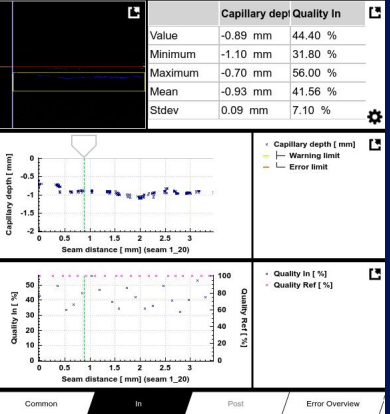
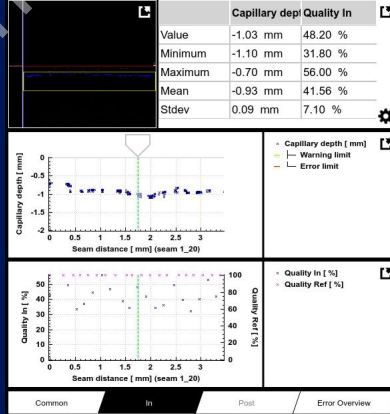
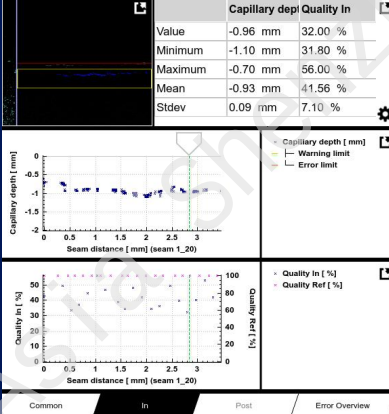
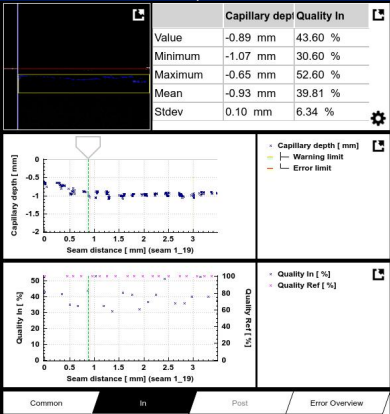
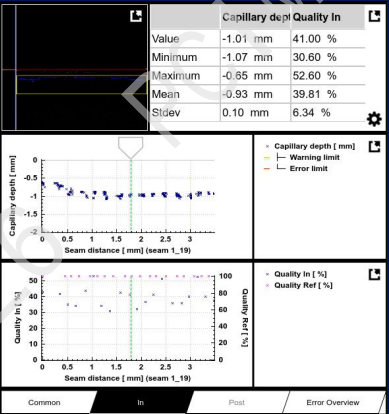
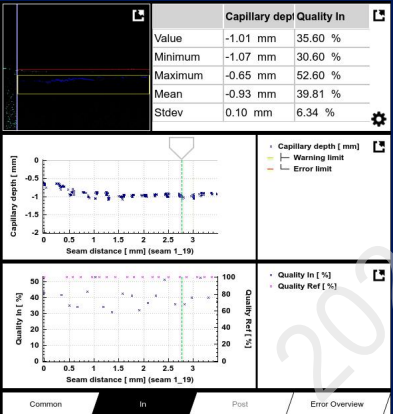
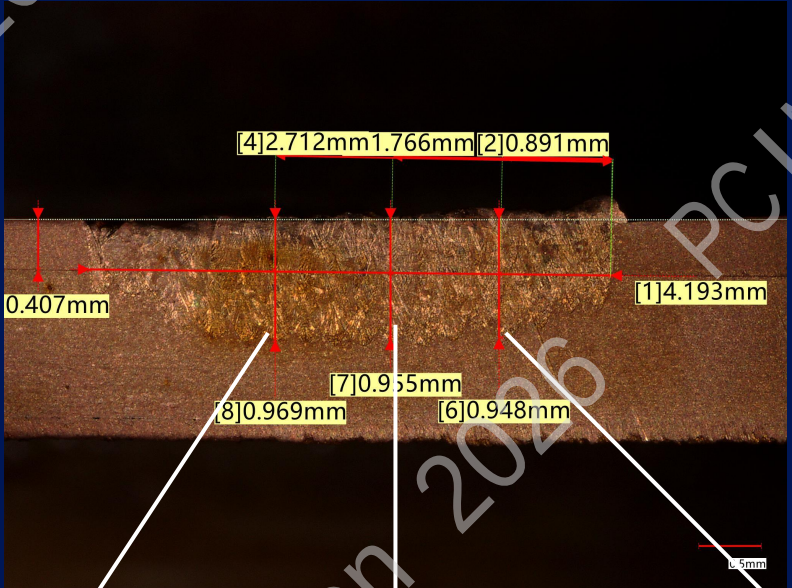
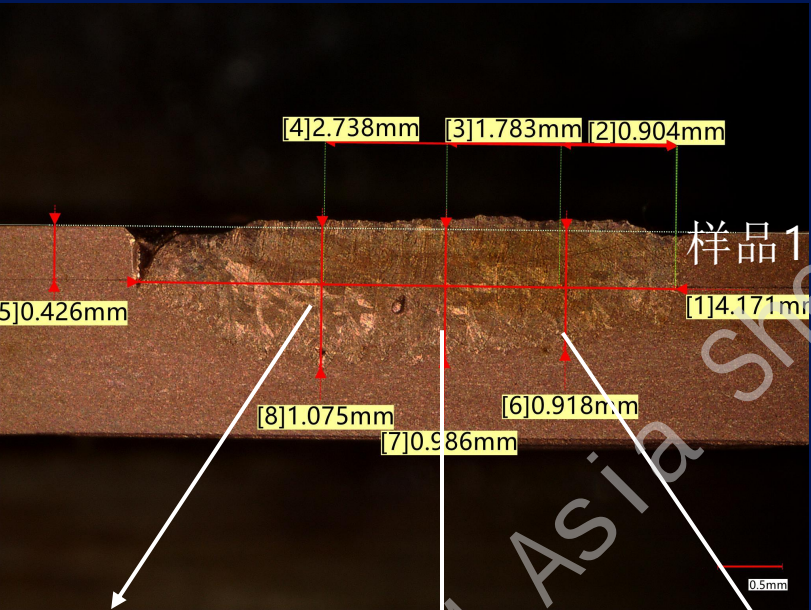
验证单模环焊接稳定性测试和对应的OCT熔深检测精度

验证物料: 样片下铜排1.2mm, 0.4mm上铜排。验证32pcs样片熔深稳定性与32pcs OCT熔深偏差。

焊接参数与表面效果



金相熔深与OCT数据



备注：数据采集于焊缝位置1/4 2/4 3/4处

金相熔深与OCT数据

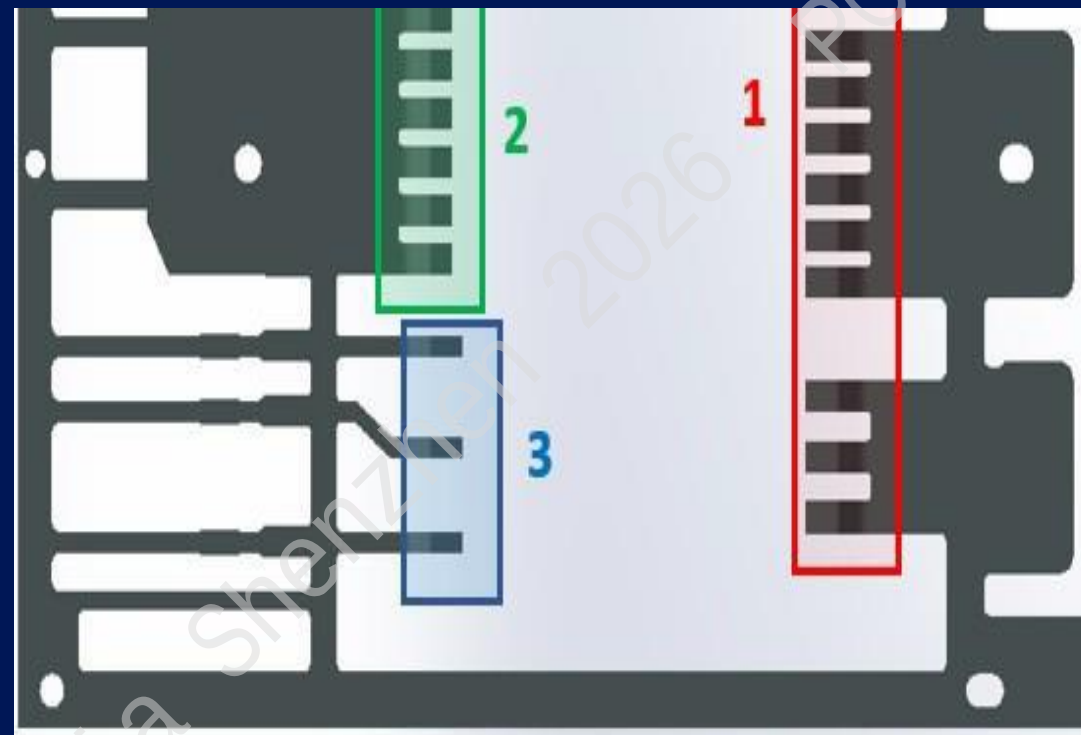
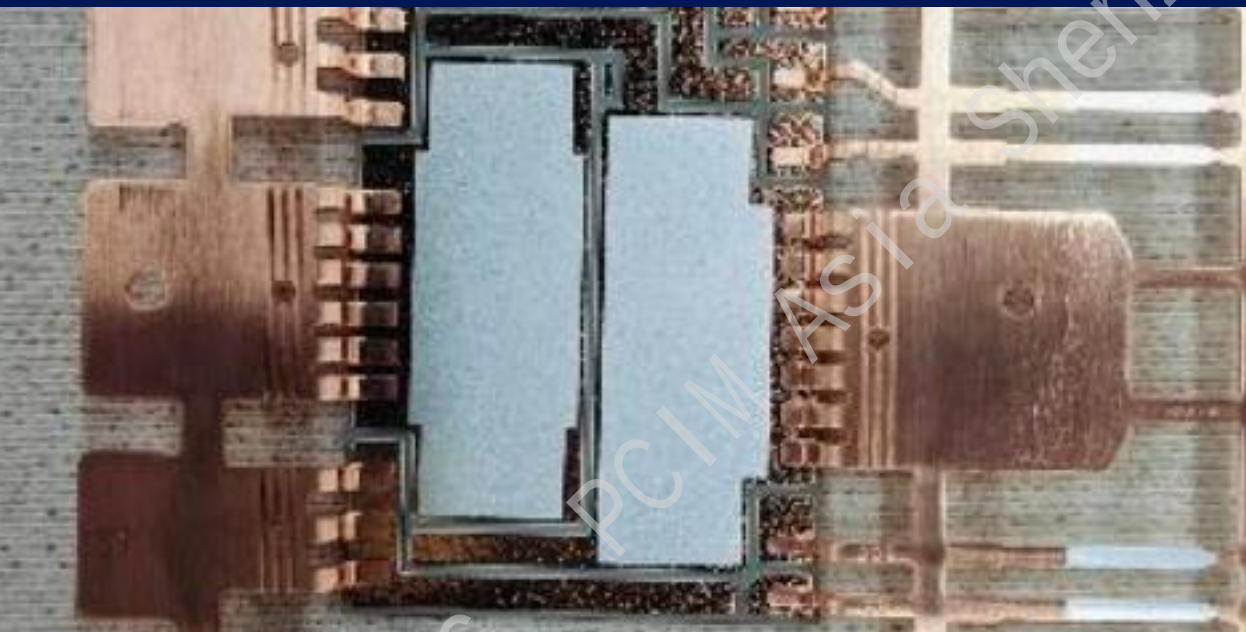


序号	金相数据 (mm)	OCT数据 (mm)	误差%
样品一	0.918	0.89	0.028 (3%)
	0.986	1.01	0.024 (2.5%)
	1.075	1.01	0.065 (6%)
样品二	0.948	0.89	0.058 (6%)
	0.955	1.03	0.075 (7.8%)
	0.969	0.96	0.009 (1%)
样品三	0.91	0.9	0.01 (1.2%)
	0.921	0.98	0.059 (6%)
	1	0.98	0.02 (2%)
样品四	0.913	0.91	0.003 (0.3%)
	1.028	1	0.028 (2.7%)
	0.937	0.91	0.026 (2.7%)
样品五	0.91	0.89	0.02 (3.1%)
	0.946	0.95	0.004 (04%)
	0.931	0.91	0.021 (2.2%)
样品六	0.92	0.9	0.02 (2.1%)
	0.94	0.96	0.02 (2.1%)
	1.019	1.01	0.009 (1%)

小结：实际熔深与OCT测试熔深
误差均小于百分之十满足客户的
实际需求

IGBT中的激光应用- 3-IGBT引脚+陶瓷覆铜板激光焊接

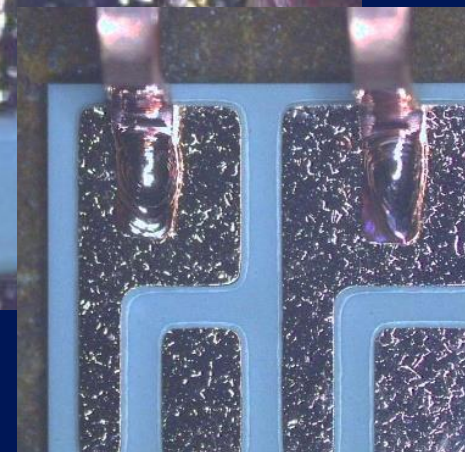
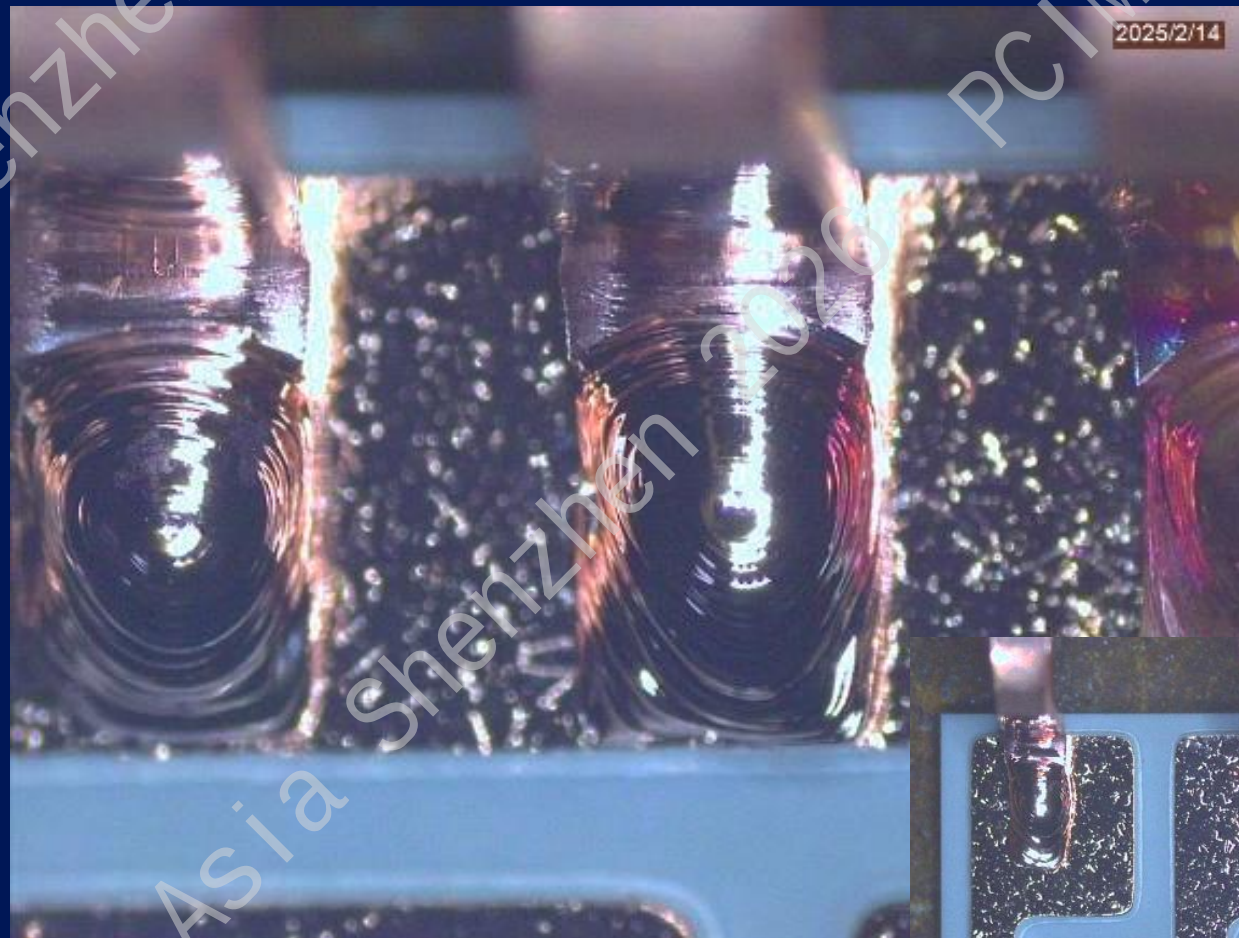
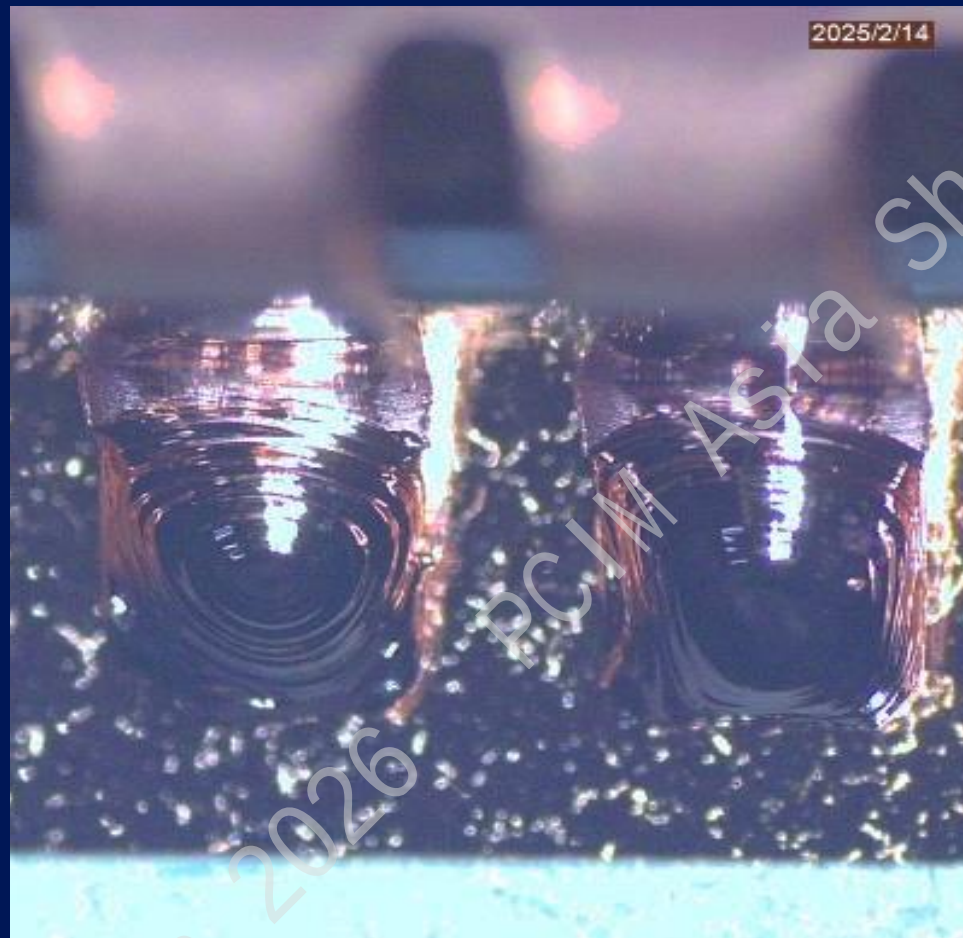
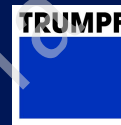
解决方案—TruDisk Green Laser/TruFiber 6000P BLM 单模环



上下叠焊 0.8+0.4mm
Welding depth: >0.3mm
Joint width: > 1.2mm

IGBT中的激光应用- 3-IGBT引脚+陶瓷覆铜板激光焊接

解决方案—TruDisk Green Laser



CT: 0.04S/pin

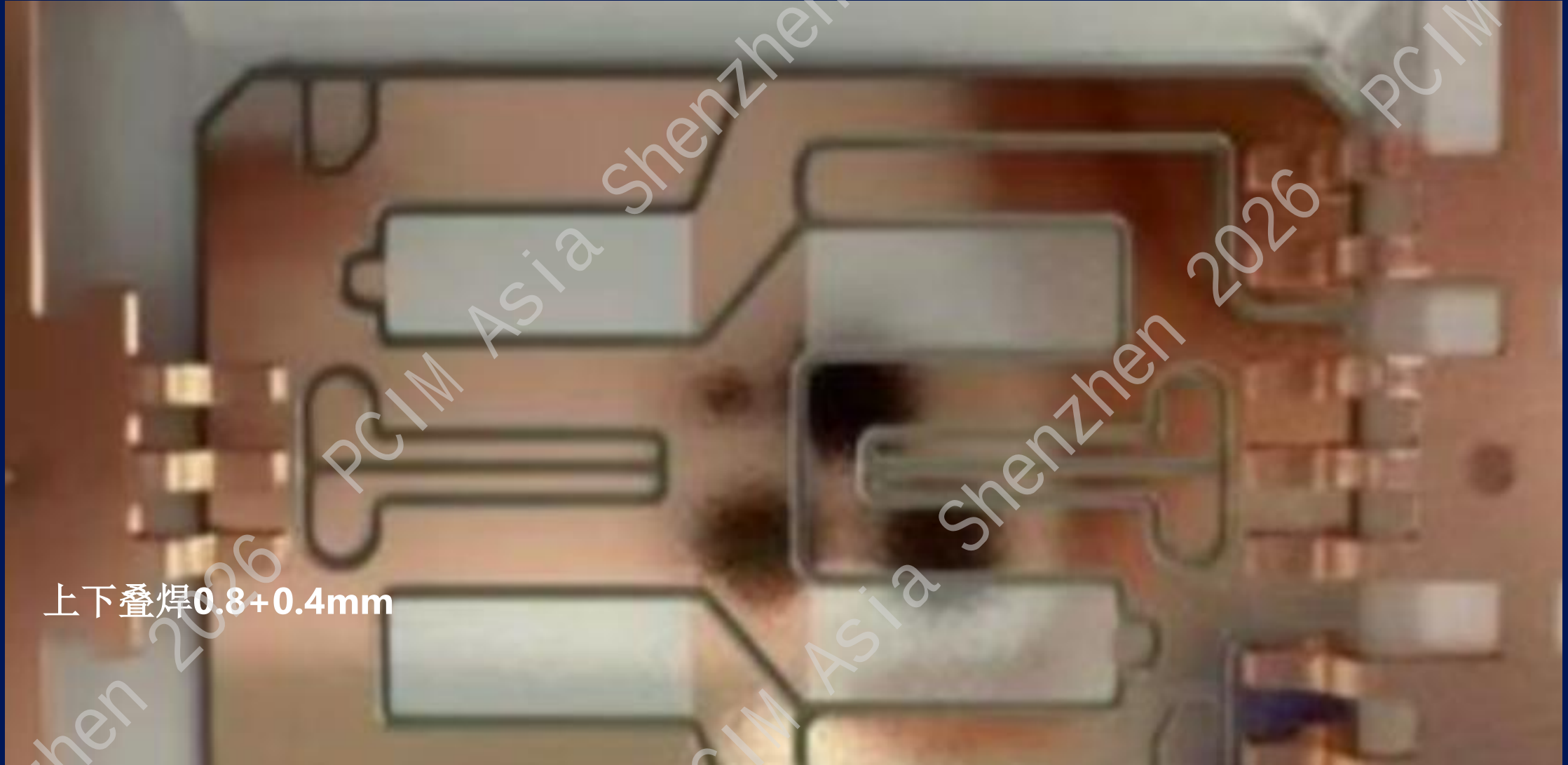
IGBT中的激光应用-3-IGBT引脚+陶瓷覆铜板激光焊接

解决方案—TruDisk Green Laser



IGBT中的激光应用-3-IGBT引脚+陶瓷覆铜板激光焊接

解决方案—TruFiber 6000P BLM 单模环



上下叠焊0.8+0.4mm

IGBT中的激光应用

2. IGBT引脚+陶瓷覆铜板激光焊接-解决方案—TruFiber 6000P 3+3 单模环

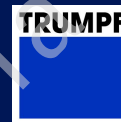


Fig. 5: Macro view1(BLM)



Fig. 6: Macro view1(BLM)



2

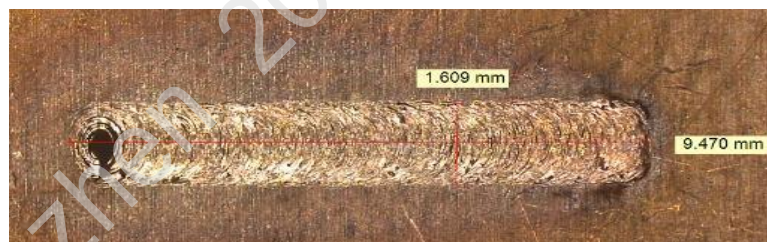
通快激光的解决方案和产品特点

通快激光的解决方案



IGBT导流铜排激光焊接(0.8/1mm+1.5/2mm)

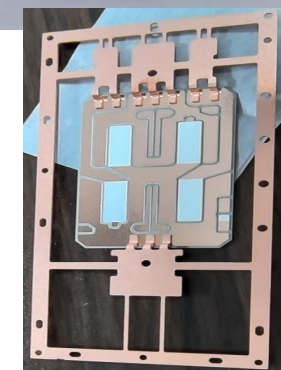
TruFiber 6000P 3+3kw 单模环+PFO+OCT



IGBT引脚+陶瓷覆铜板激光焊接

TruDisk Green Laser

TruFiber 6000P 3+3kw 单模环



IGBT导流铜排激光焊接

TruFiber P 3+3kw 单模环激光器+PFO振镜+OCT

内芯: 25 μm (BPP: 0.38mm.mrad)

外环: 100μm (BPP: 4mm.mrad)

环形光斑: 2+2kw, 2+4kW, 3+3kw, 3+6kw

功率稳定性: max ±0.5 % (闭环功率控制)

光纤长度: 10-15m-20m(BLM)

支持通快和第三方加工头

现场总线: (Profibus, Profinet, DeviceNet, Ethernet/IP) and OPC UA

远程服务支持

工艺支持

FD 45	Laser Power	VisionLine Cam, Basic, Detect, Project	VisionLine OCT Detect, Check	CalibrationLine Focus, Power
S	3 kW	✓	✓	✓
	4 kW	✓	✓	✓
	6 kW	✓	✓	✓
	9 kW	✓	✓	✓
	12 kW	✓	✓	✓
P	3 kW	✓	✓	✓
	4 kW	✓	✓	✓
	6 kW	✓	✓	✓



最高工艺稳定性的关键

TruFiber P 提供一流的功率稳定性



在正确的深度进行加工

用于焊接、切割、表面处理应用等



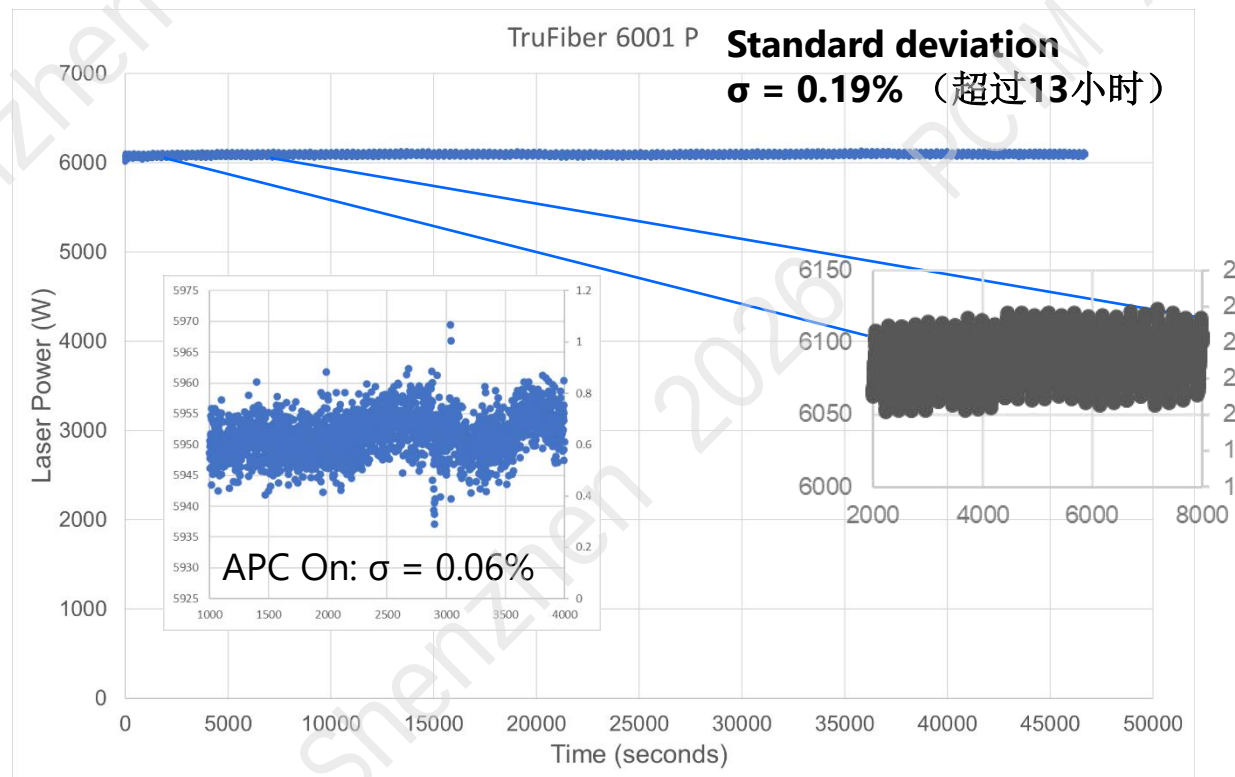
抗外部干扰能力强

坚固的机柜设计和固有的光学引擎稳定性



脉冲形状精度

精确按照设定要求进行调制和坡度输出



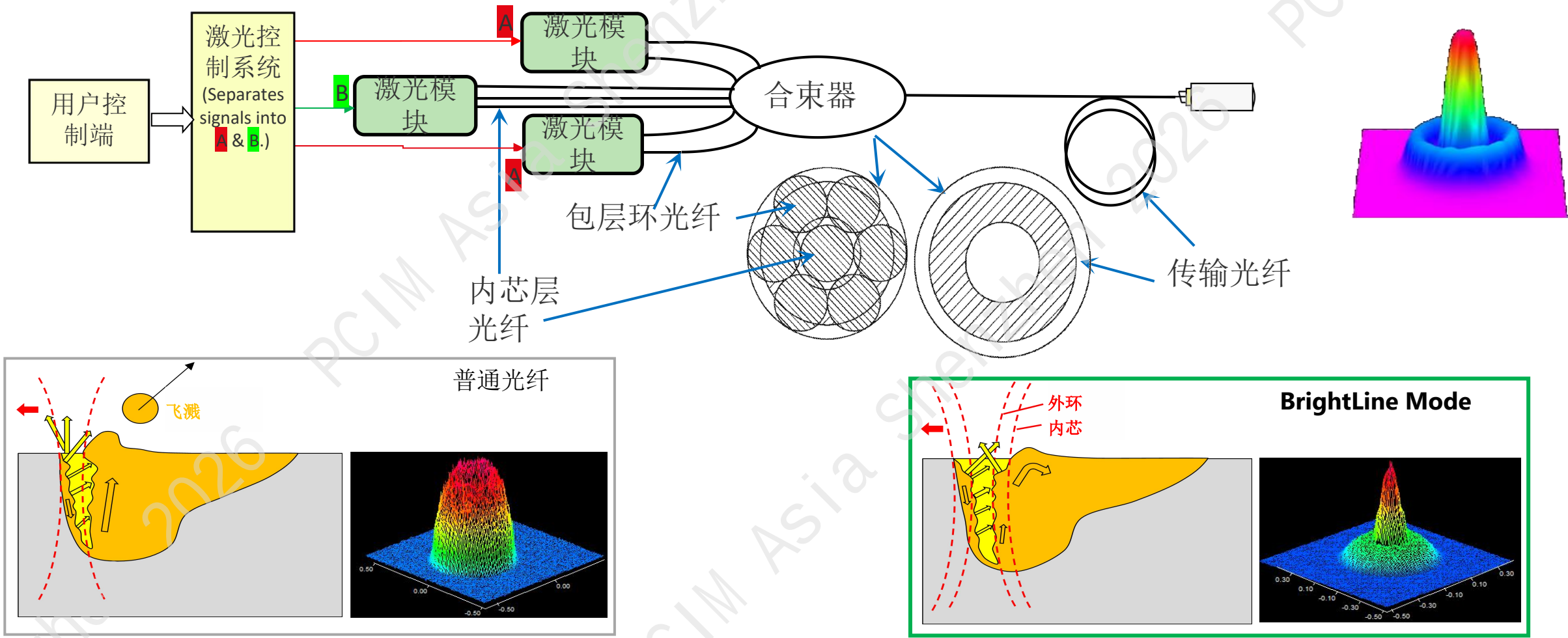
	闭环控制	关闭闭环
典型功率稳定性 >8小时，峰值-峰值稳定性，在恒定环境温度时	$\pm 0.5\%$	$\pm 1\%$



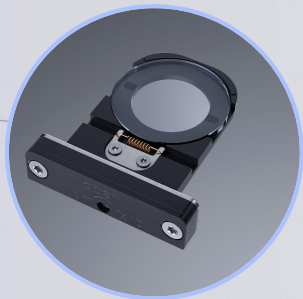
TruFiber P BrightLine Mode激光器设计结构



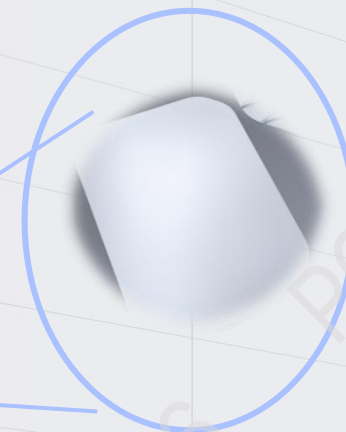
使用带有芯层和包环层的特殊输送光纤结构实现激光能量的灵活分布



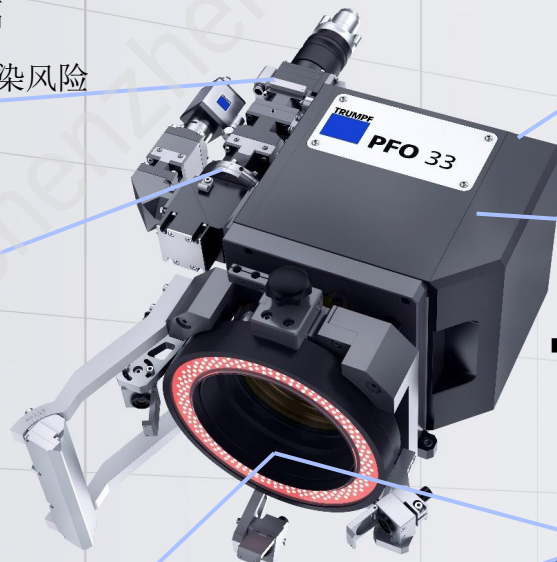
OCT技术基于--第三代可编程扫描振镜 PFO 33 Kf023



- 新增准直镜保护玻璃
 - 减少更换光纤造成的污染风险

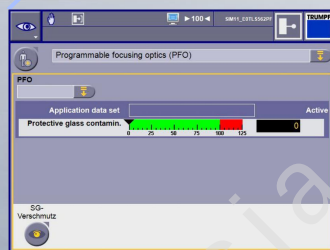


- 轻量化的镜片
 - 更快的扫描速度，提高高频摆动焊接以及清洗应用的稳定性
 - 实时轨迹监测，运动轨迹精度超差报警



- 新增光纤端散射光传感器
 - 监测光纤输出端的散射光数值及状态
- 新增温度熔断器 + 光电二极管
 - 检测设备的温度以及是否有透射光，保证安全
- 新增石英光圈
 - 冷却处理杂散光以及背反光

- 可承受最高激光功率为**12 kW， +50%**
- 快速的数据传输
 - 小于**10微秒**内进行设定，更精准的数据传输
- 改善振镜控制板卡设计，依然集成在激光器控制器中
- 纯数字式驱动，精度更高温漂更低

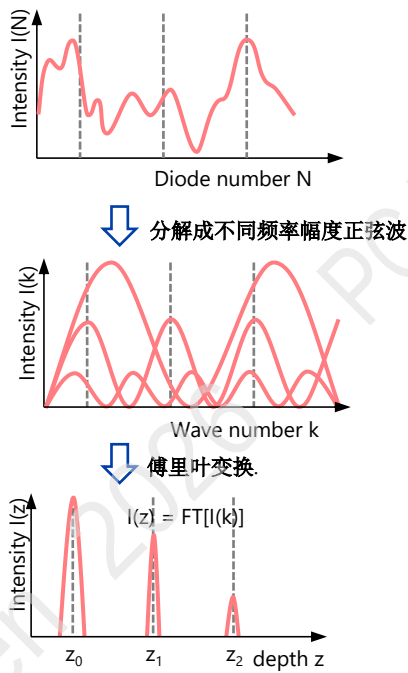


- 新增保护玻璃监控(选项)，提高稳定性和生产良率
 - 检测保护玻璃是否存在以及镀膜是否与激光器匹配
 - 保护玻璃污染监控功能使得玻璃可根据实际的状态进行更换

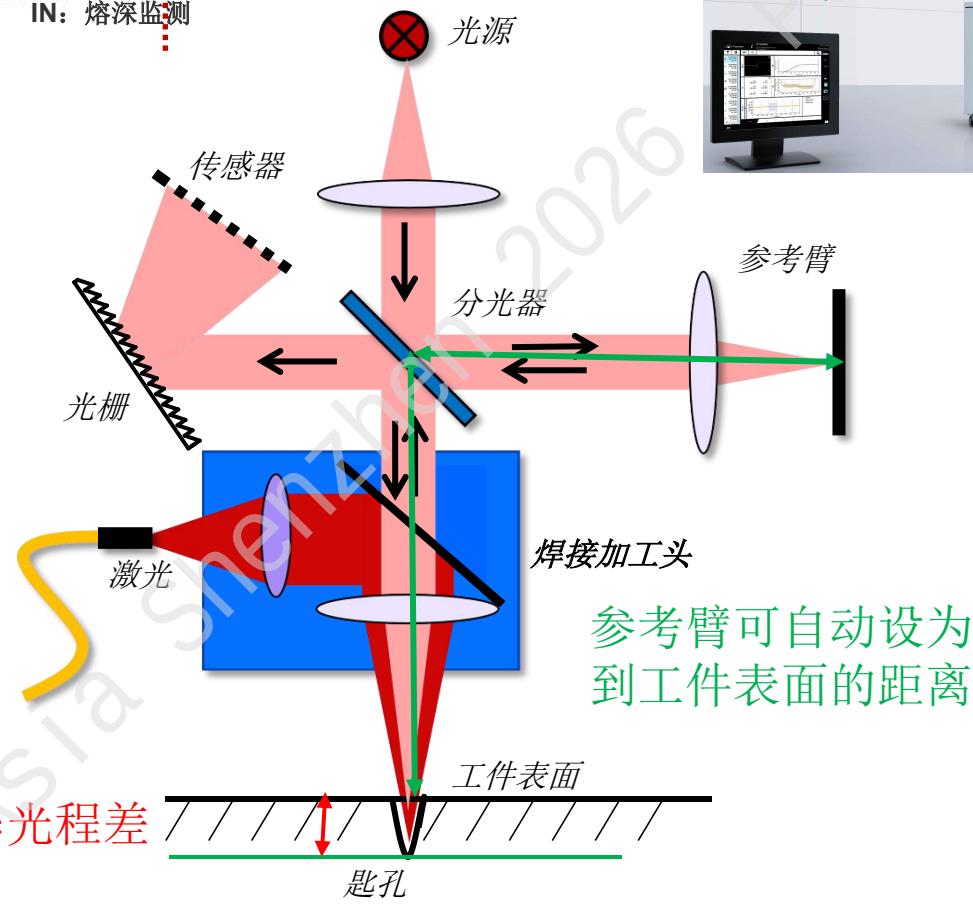
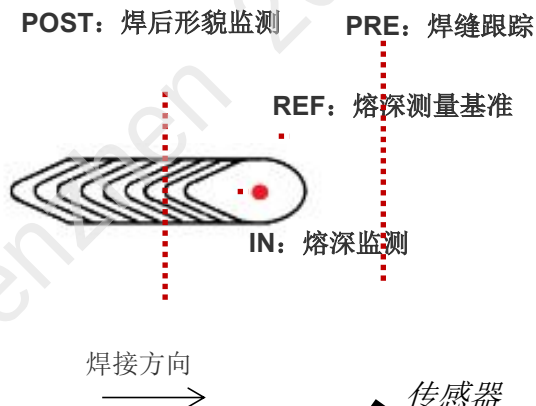
OCT 技术介绍

成熟的光学测量技术

- 成像时间短
- 分辨率高
- 相干原理，不受杂散光影响



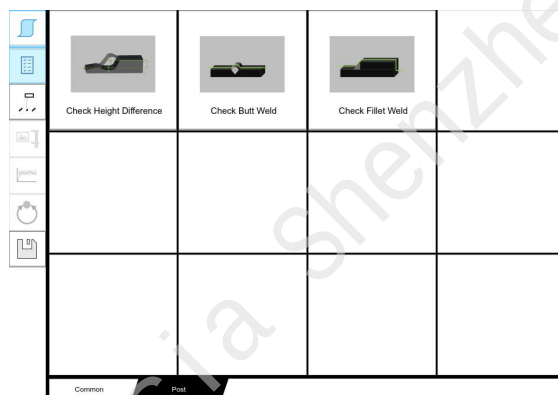
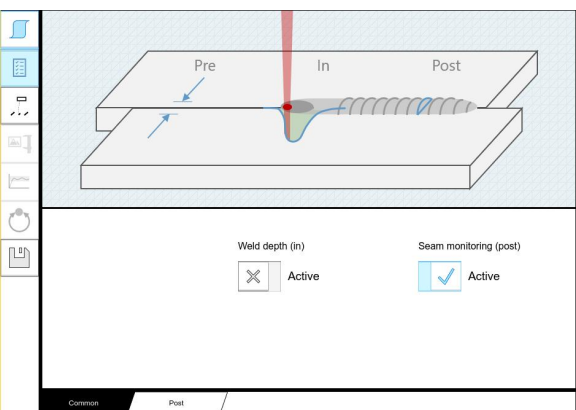
计算过程



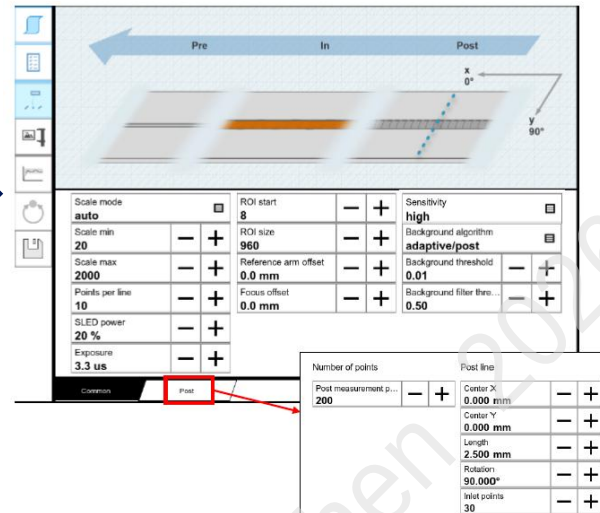
基于PFO的OCT光路结构



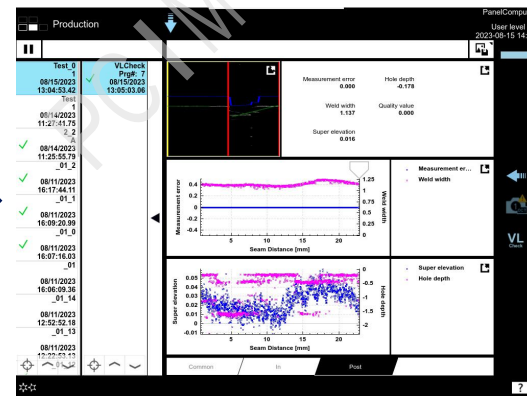
VisionLine OCT –图形化的软件



Select Seam monitoring and Check Fillet Weld



Select related parameters

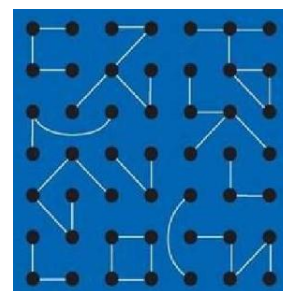


Run the Laser program with Simulation Mode on

通快OCT软件:

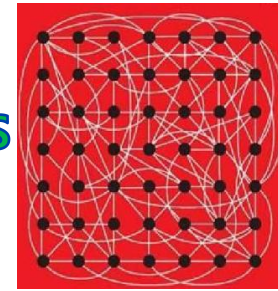
- 图形化的界面，参数的作用更直观更易理解
- 所需设置的参数更少，<15 个
- 用户界面更友好，直观易操作，产品是否合格/熔深曲线等一目了然

通快



<15组调试参数

友商



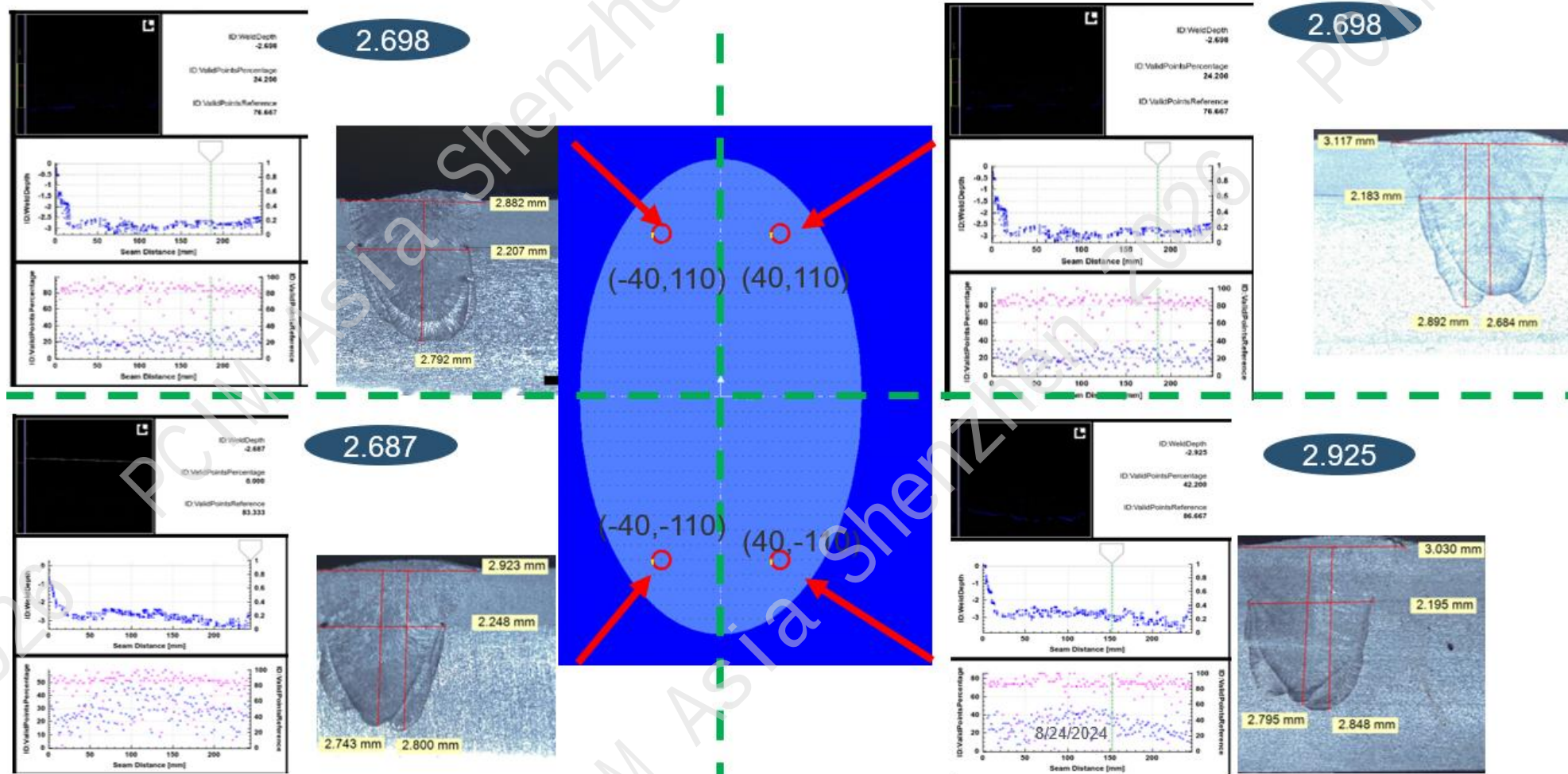
>30组调试参数

VS

VisionLine OCT Check 主要特点



PFO全幅面测量数据与金相测量数值形成准确的对应



2.5D PFO+OCT 在 PFO振镜边缘不同高度下完成准确的焊接和测量

TRUMPF

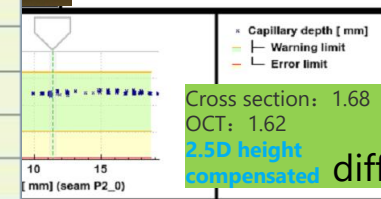
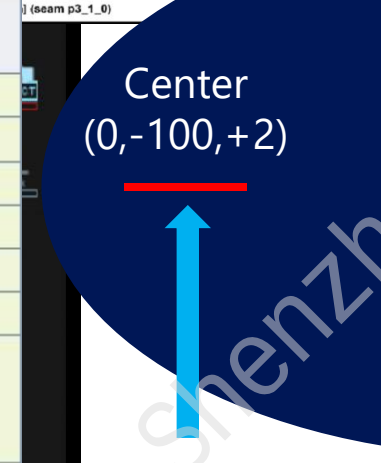
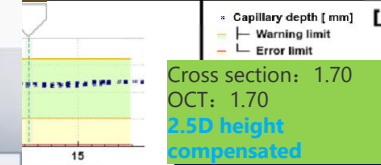
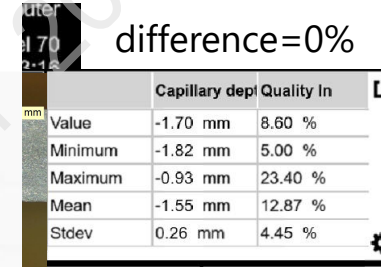


Technical Data



PFO 33 2.5D
(KF023)

Parameter	
Power limit (kW)	12
Aperture (mm)	33
Wavelength (nm)	1030-1085, 515
Laser Mode	SM, MM, BLM SM, BLM MM
Plug type	LLK-D
Weight (total, approx. kg)	35
Collimation	MM & BLM 140 TruMicro 175 SM 150 / 200 / 300
Objective lenses	160HB / 255 / 265HB / 345 / 345HB / 450 / 450HB / 550HB / 700HB
Scan field f265HB @1075nm z=0 (mm ²)	140x102
Scan field f450HB @1075nm z=0 (mm ²)	306x208
Max field @1075nm z=0 (mm ²)	570x370 (f700HB)
Z-travel/Defocus f265HB IR MM (mm)	±5,3
Z-travel/Defocus f450HB IR MM (mm)	±15,4
Z-travel/Defocus fmax IR MM (mm)	±37,5 (f700HB)



difference = 3.6%

difference = 4.7%

difference = 4.0%

VisionLine OCT Check技术参数



VisionLine OCT Check	
激光器	TruDisk (1030 nm, 515 nm), TruFiber (1071 nm)
镜头 ^{1,2}	PFO 33, f = 265 mm, 345 mm; 450 m
相机入射光波长	$\lambda = 625 \text{ nm}$
OCT波长 (激光安全等级)	$\lambda = 820 - 860 \text{ nm}$ (激光安全等级 3B , IEC EN 60825-1:2014)
OCT测量速率	250 kHz
轴向(熔深等)/径向（焊缝宽度等）测量范围	$\pm 5 \text{ mm} / \varnothing 15 - 25 \text{ mm}$ (取决于镜头焦距)
轴向分辨率	12 μm
径向分辨率	$\geq 10 \mu\text{m}$ (取决于测量参数以及镜头光学配置)
典型的熔深测量范围	0,5 mm-12 mm (取决于材料等焊接过程以及光学配置)
电气要求	400 V - 10 % ... 460 V + 10 %, 3 AC+PE 50 ... 60 Hz

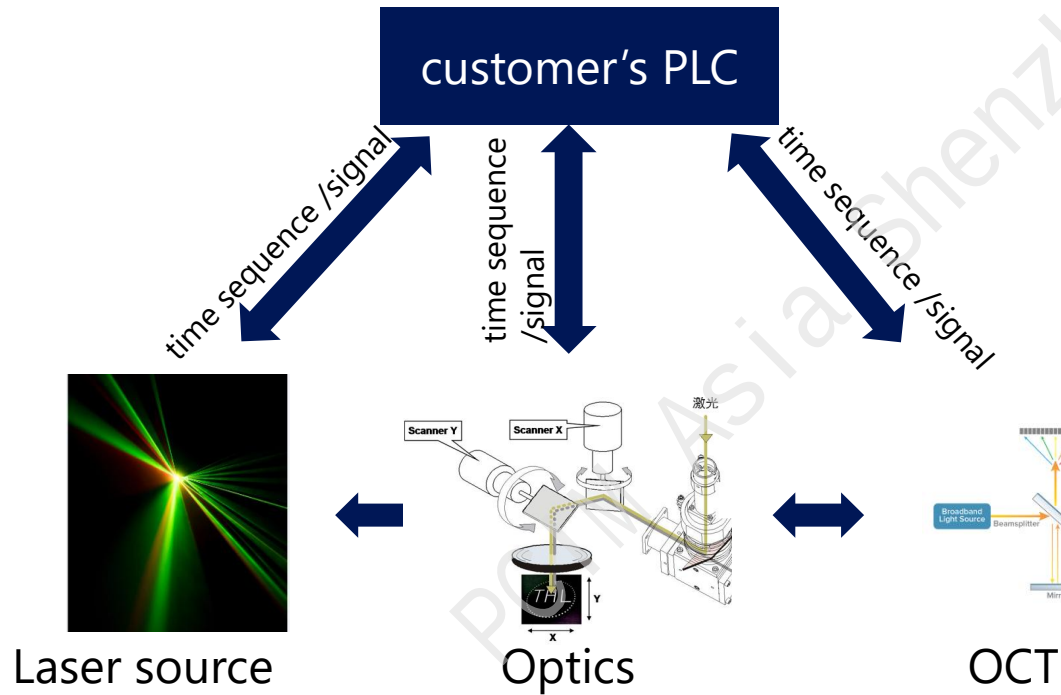
¹ 对于更多可用的光学配置请参考技术参数手册

² 只适用于第三代PFO



Visionline OCT –通讯以及控制架构

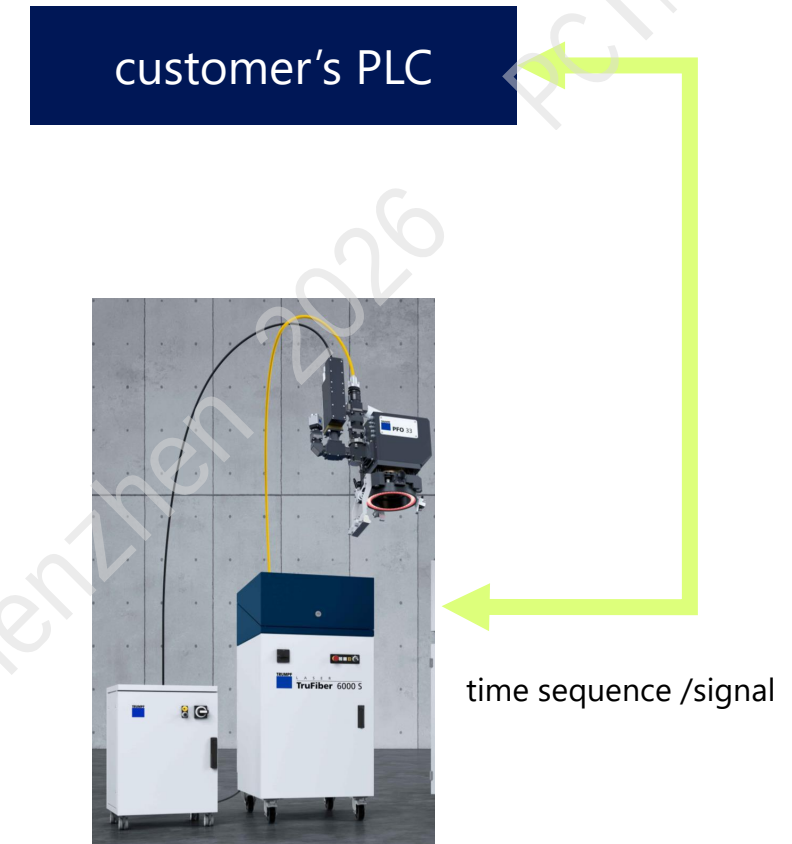
传统方式



一站式解决方案:

- a. 调试工作量更少
- b. 快速部署以及应用
- c. 更容易诊断以及解决问题!

通快



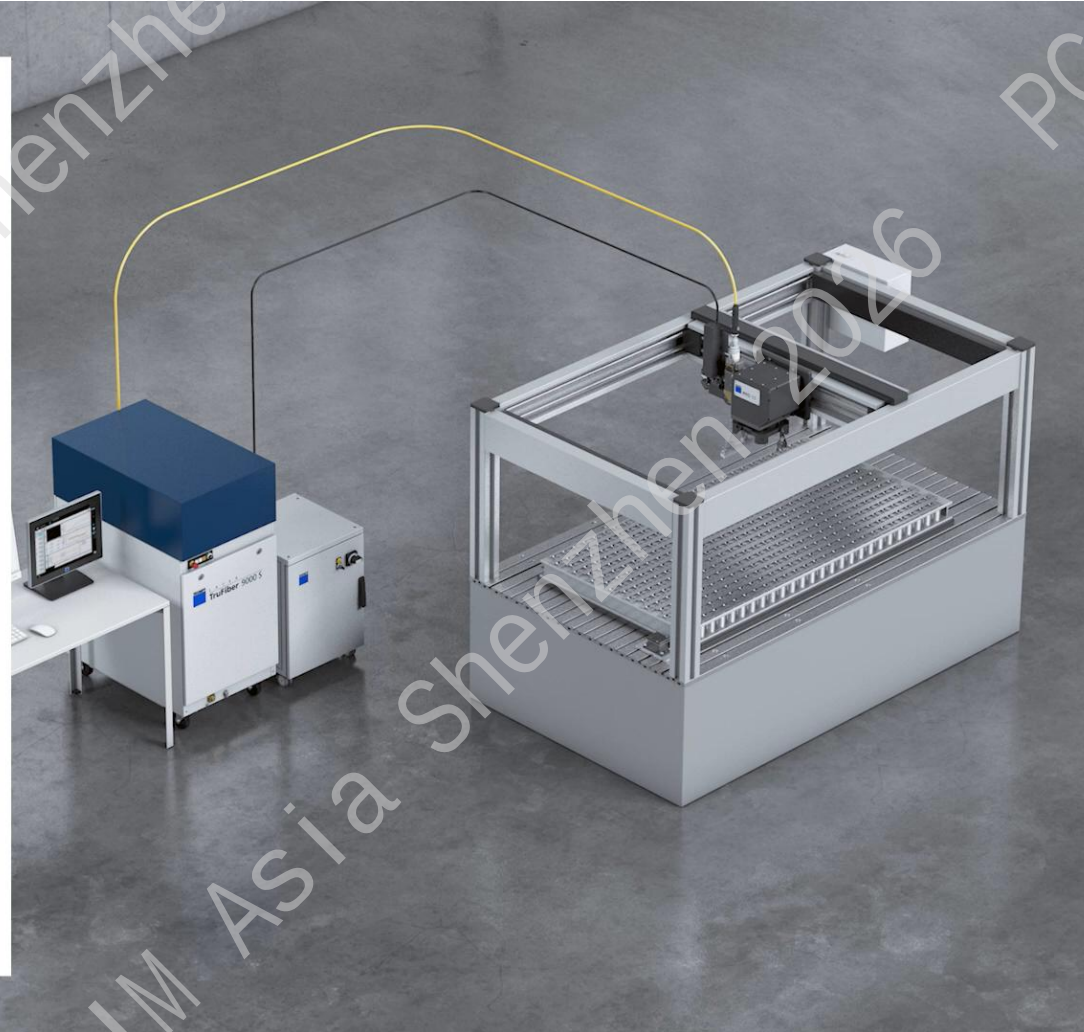
VisionLine OCT Check 主要特点

Busbar焊接模拟视频



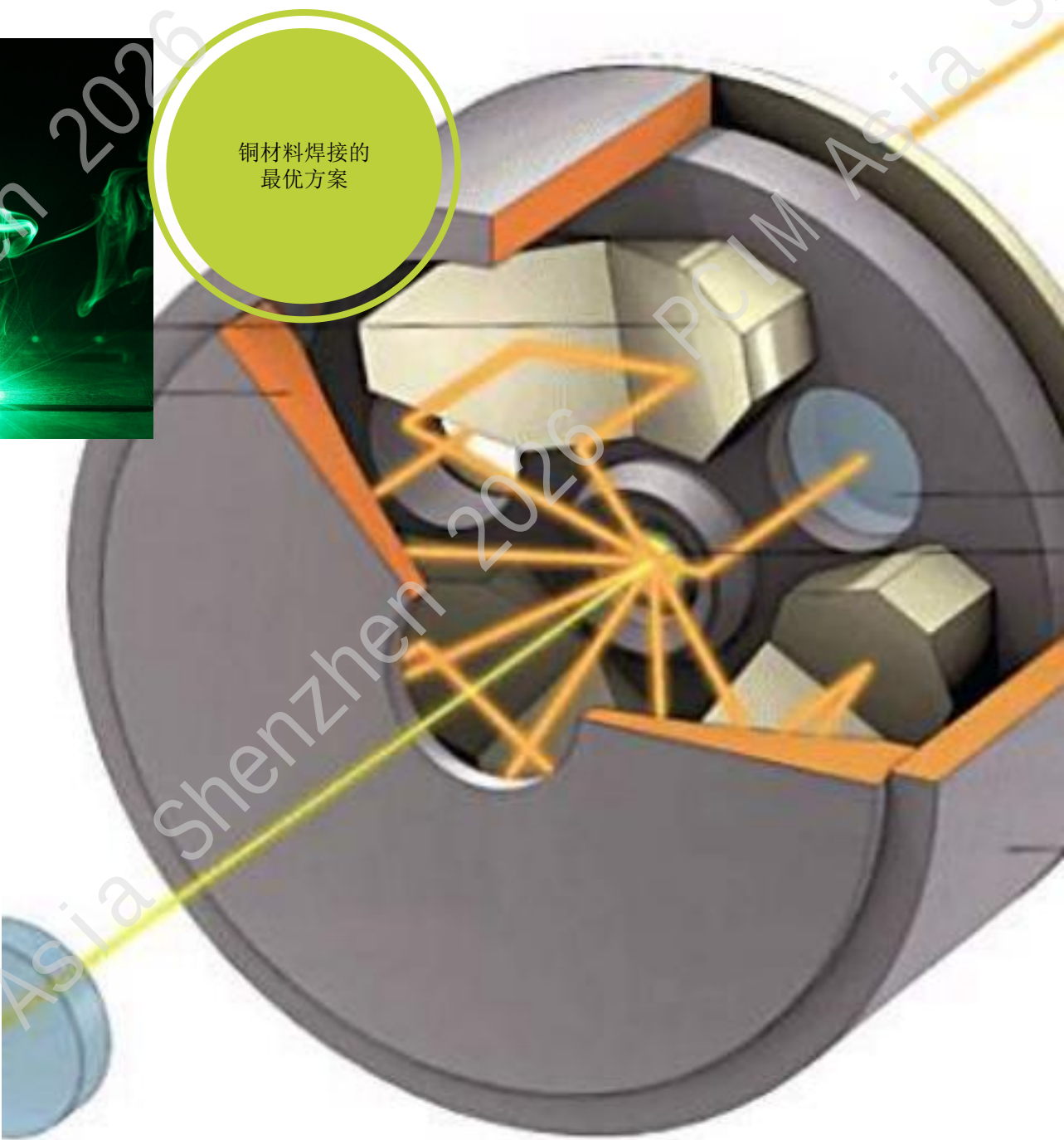
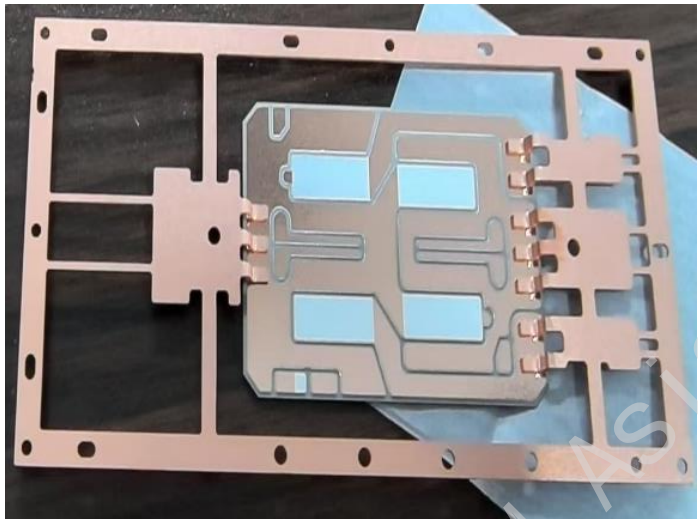
Sensor system
VisionLine OCT Check

Capillary depth monitoring
and seam geometry
measurement - Busbar welding



IGBT引脚+陶瓷覆铜板激光焊接

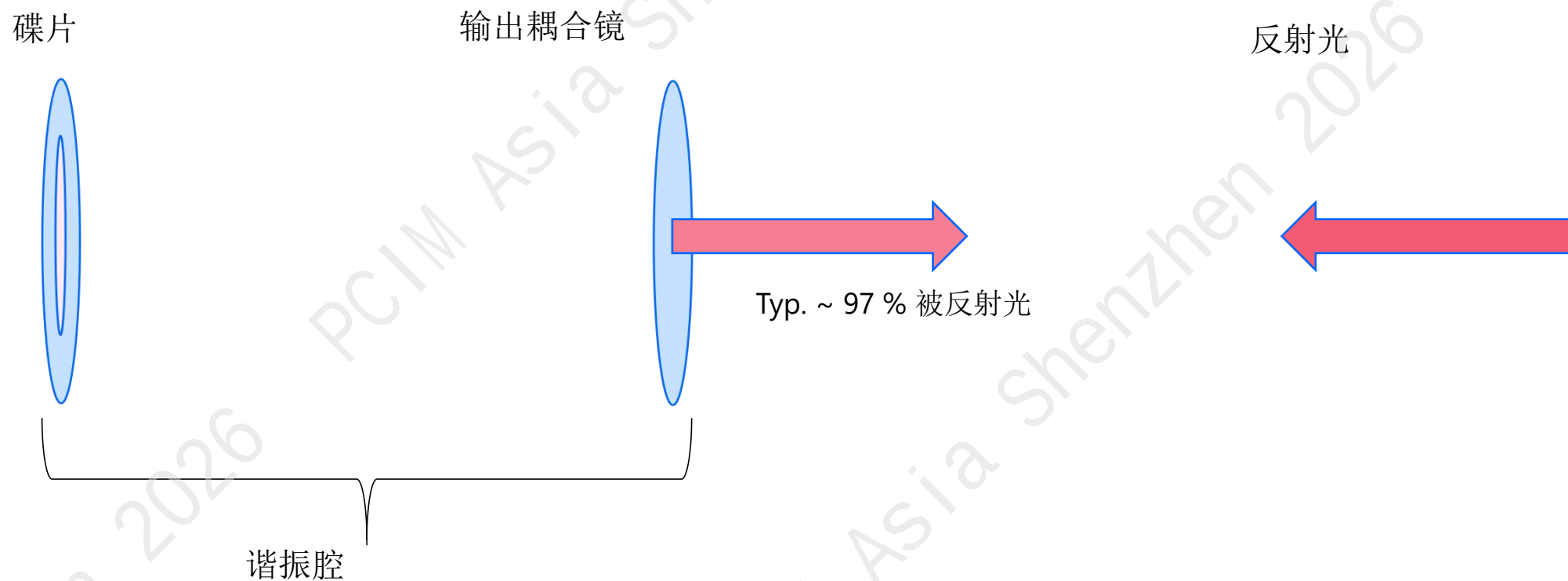
TruDisk 绿光激光器



参数	TruDisk 1020	TruDisk 2021	TruDisk 3022
平均功率	1kw	2kw	3kw
波长	515nm	515nm	515nm
光纤直径	50um	100um	150um
输出光路	支持2路	支持2路	支持2路
光束质量	2mm*mard	4mm*mard	6mm*mard

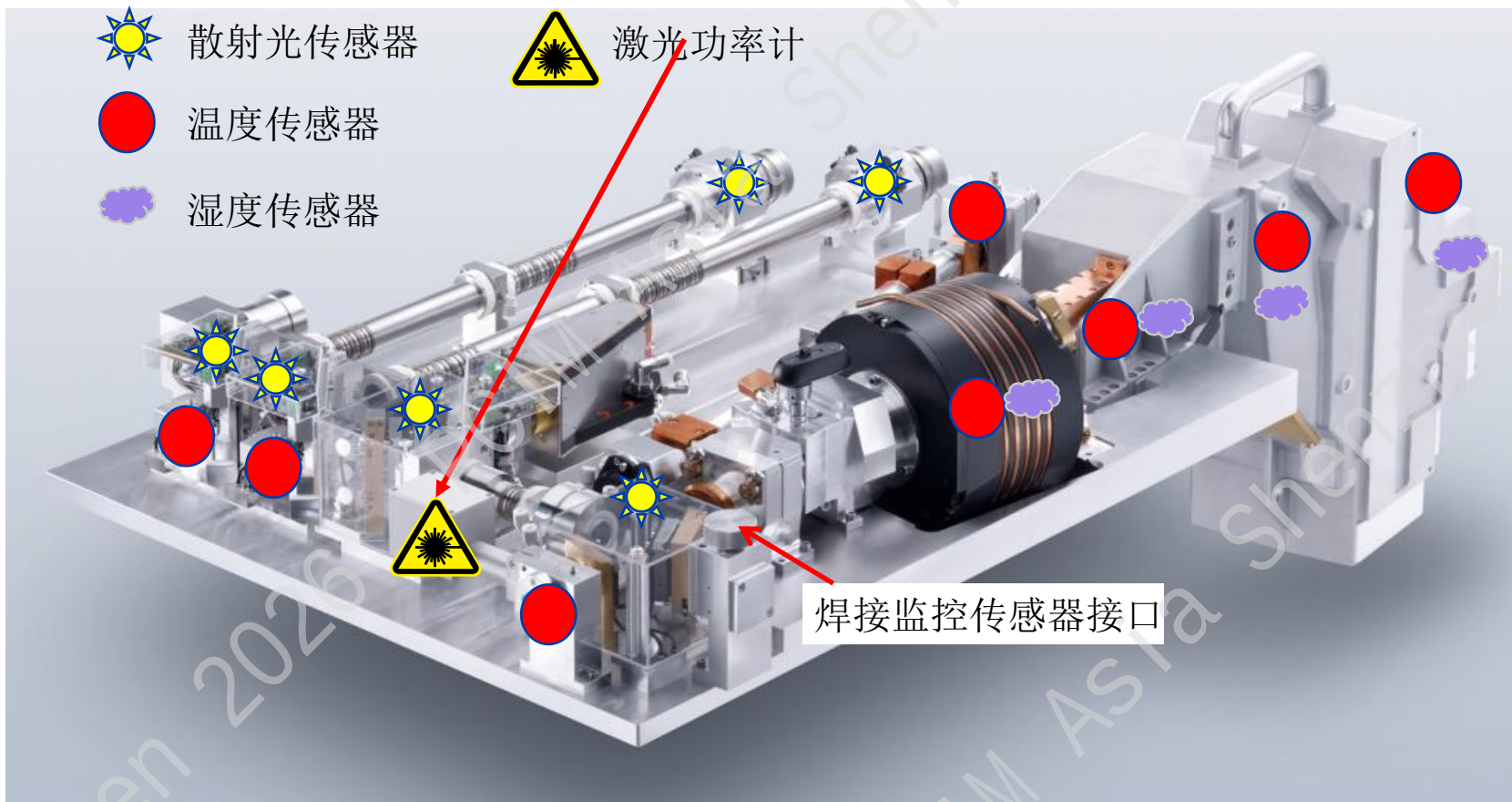
对背反射光不敏感

- 碟片激光器的基本原理和专利性的设计是对背反射光不敏感的巨大优势



TruDisk激光器实现稳定的功率输出

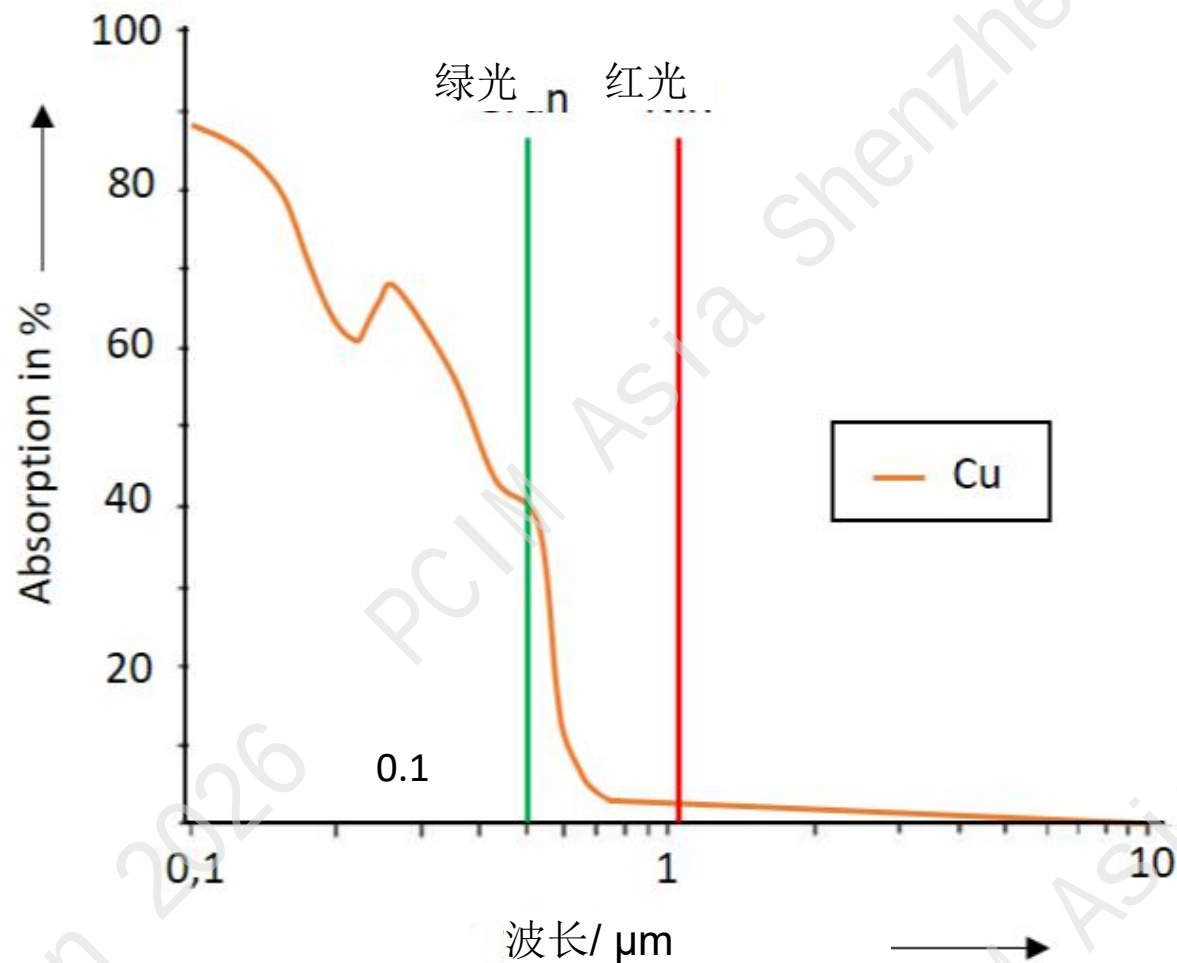
全光路监控：稳定生产的保障！



- ✓ 散射光传感器检测反/散射光信号，判断镜面和其它部件洁净度，保证光束传输中的质量
- ✓ 温度传感器检测和控制部件温度范围，保证激光功率稳定
- ✓ 湿度传感器检测环境湿度范围，防止结露和漏水
- ✓ 功率传感器检测和控制激光功率稳定在 $\pm 1\%$
- ✓ 焊接监控传感器接口可以集成第三方传感器，控制工件焊接质量

绿光在铜材料上的高吸收率

可实现稳定且无飞溅的焊接加工



Nach: Bliedtner, Jens; Müller, Hartmut; Barz, Andrea (2013): Lasermaterialbearbeitung. Grundlagen - Verfahren - Anwendungen - Beispiele. München: Hanser.

红外（近红外）：在室温铜材料仅吸收激光能量的5%

→ 95%因反射而损耗

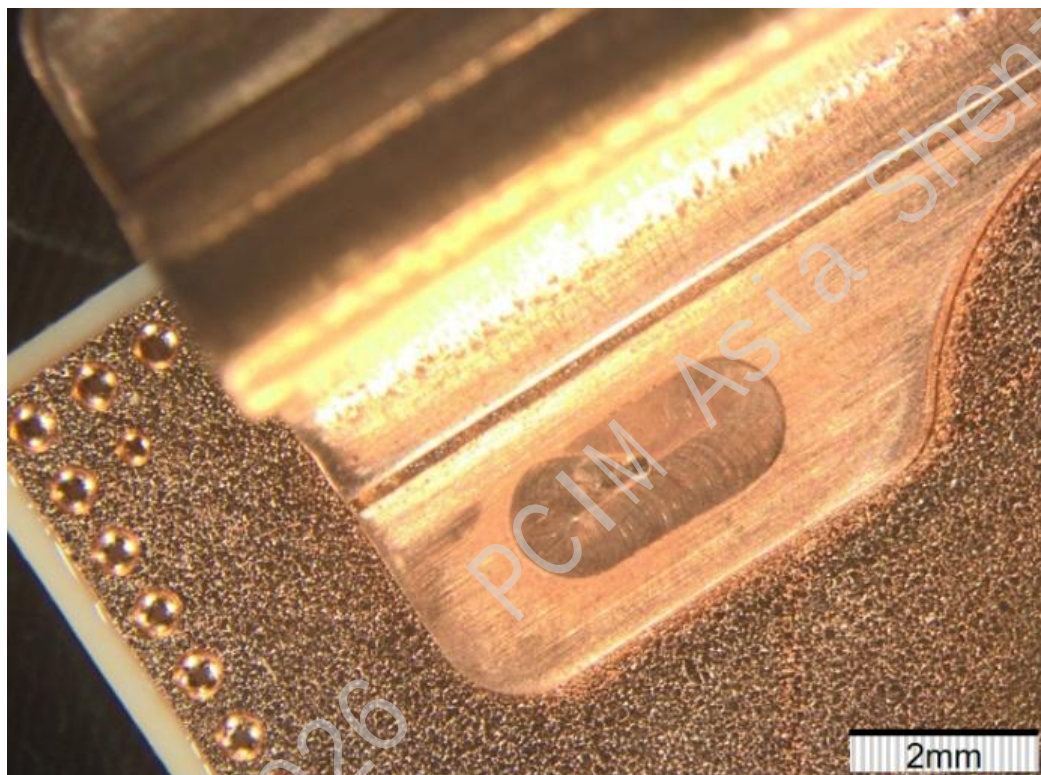
绿光：在室温下铜材料可吸收高达40%

→ 吸收率比红外光高8倍

在室温、抛光面和垂直光束下的吸收

应用

案例：DCB触点焊接

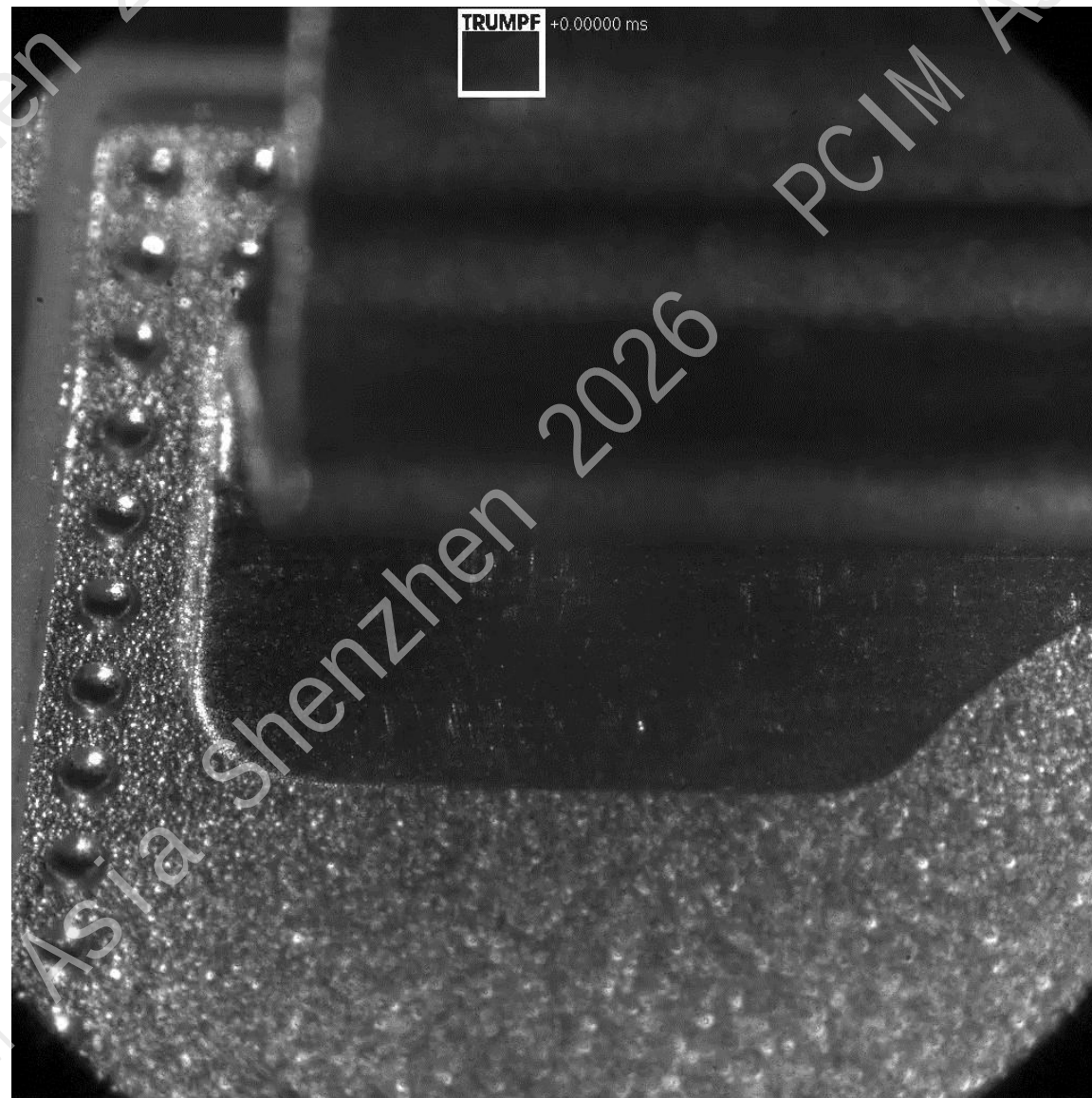


TruDisk 1020

焊接时间 0.1 s

材料厚度 0.3 mm + 0.3 mm

焊接深度: 0.35 mm



TruDisk 1020 产品视频



TruDisk 1020
Copper welding with green wavelength



3

通快激光公司简介



Since 1923

Innovation guarantor



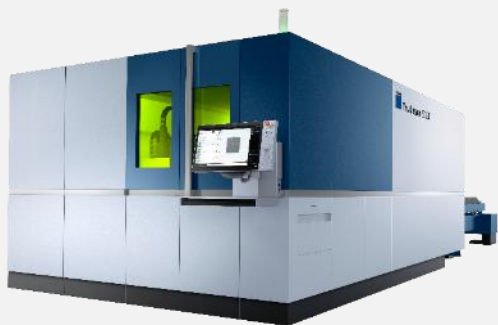
TRUMPF



业务范围

Machine Tools

for flexible sheet metal manufacturing



Laser Technology

Laser for Production Technology



Extreme UV Light

TRUMPF Laser Amplifier

High-Power Laser Systems for EUV Lithography



ADDITIVE MANUFACTURING

for innovative components

Laser Metal Fusion (LMF) | Laser Metal Deposition (LMD)

PHOTONIC COMPONENTS

Laser Diodes for photonics and digital products

>1 Billion cell phones worldwide are already equipped with this laser diode technology



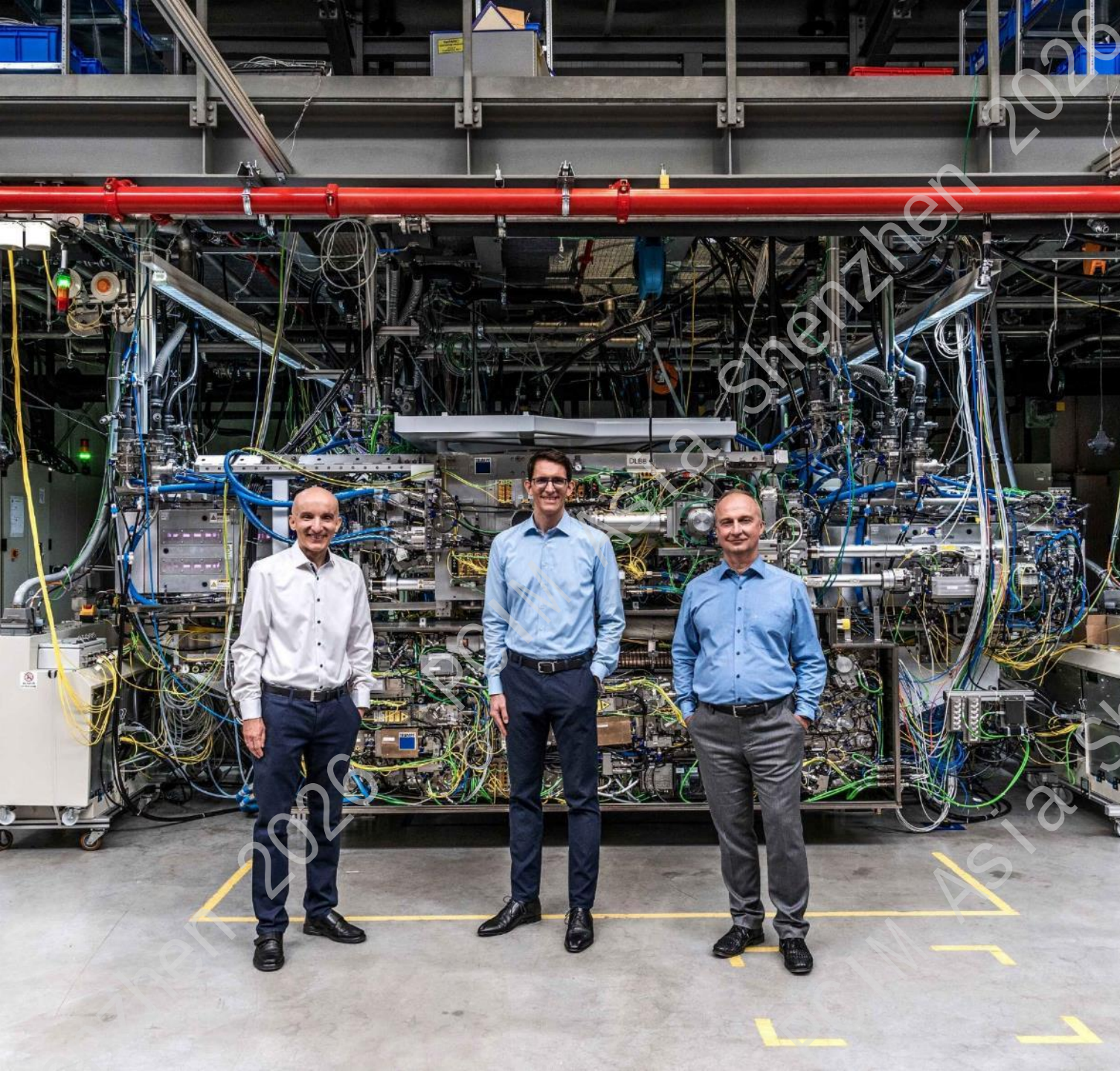
Datacom VCSEL and photodiode array

FINANCIAL SERVICES

Company-owned Full-Service bank for purchase loans

TRUMPF customers receive a lease or hire purchase offer.





2020德国未来奖

+

EUV光刻机光源



„EUV Lithography – New Light for the Digital Age“

Awarded by German President Frank-Walter Steinmeier with his Prize for Technology and Innovation

Researcher Team: f.i.t.r.

Dr. Peter Kürz
ZEISS Sparte Semiconductor Manufacturing Technology

Dr. Michael Kösters
TRUMPF Lasersystems for Semiconductor Manufacturing

Dr. Sergiy Yulin
Fraunhofer-Institut for Applied Optics and Precision Engineering IOF, Jena

1923于德国成立

全球布局 贴近客户

2025/26营业额

43.4 亿欧元

R&D 占比

>10%

全球布局

>90 国家/地区

中国区分公司

太仓&深圳





TRUMPF Laser

Always the right beam source for you on offer

TRUMPF



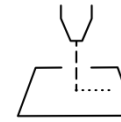
Disk lasers



Fiber lasers



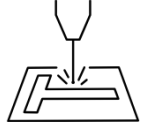
Diode lasers



Short/ultrashort
pulse lasers



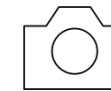
Pulsed lasers



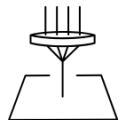
Marking lasers



CO₂ lasers



Sensor systems



Optics



Scientific lasers

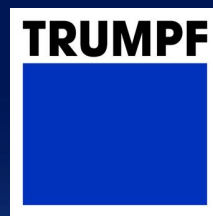


Aaron Wang

Sales CE

177 7223 8532

aaron.wang@trumpf.com



www.trumpf.com

14号展馆D12展台