ISMCME 2010

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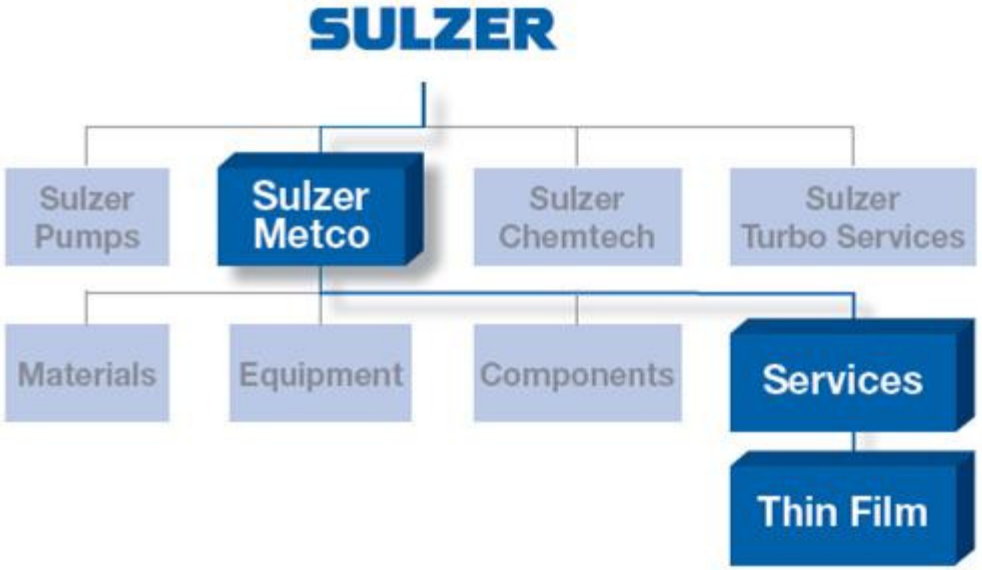
A novel approach to micro alloying and structure design of high performance coatings

高性能涂层的微合金化和结构设计

G.Erkens, J.Vetter, J.Müller | December 10-12, 2010, Beijing

Corporate Structure

- Founded in 1834
- Stock-quoted company (Switzerland)
- Sales 2009: 3.35 billion CHF
- 12,183 employees worldwide



高科技的驱动者
苏尔寿美科表面技术

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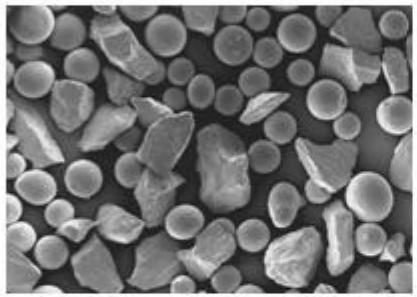
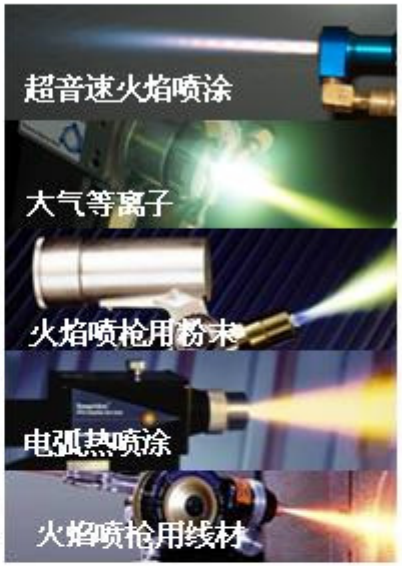
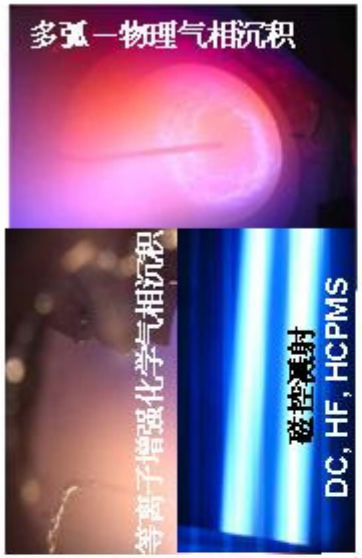
PTA*-焊接材料

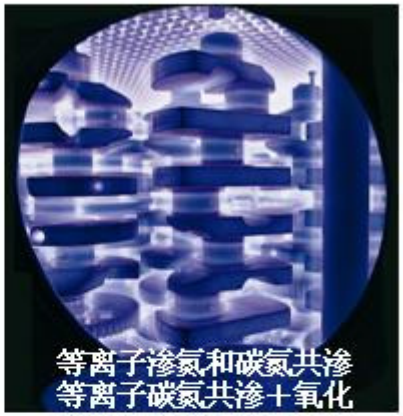
如：40% NiCrBSi和
60%的碳化钨

*等离子弧焊层

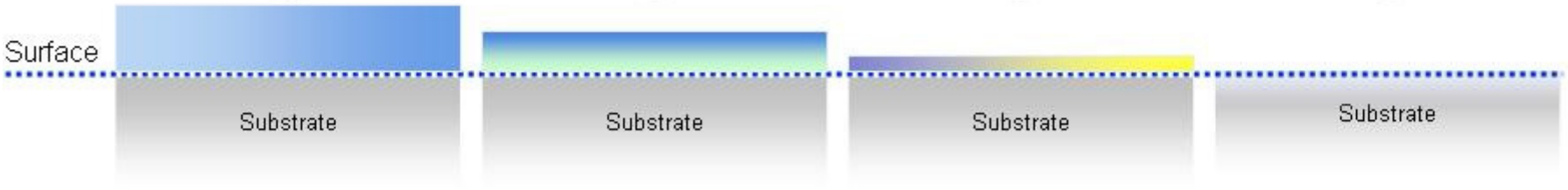








在基体表面增加 等离子弧焊层 (1'000 – 15'000 µm)	在基体表面增加 热喷涂层 (50 – 11'000 µm)	在基体表面增加 薄膜层 (PVD, PACVD, hybrid) (0.2 – 50 µm)	热化学的工艺 IONIT IONIT OX (渗入基体 10 up to 10 µm)



苏尔寿美科提供各种表面处理技术，为客户提供范围宽广的各种解决方案。

高科技的驱动者
引言

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- 引言
- 高离子化PVD技术
- —市场份额
- —挑战
- —涂层设计
- —多米诺技术
- —APA, MAC(微合金）
- —HIPAC(高等离子化脉冲磁控溅射技术）
- 技术发展趋势
  - —未来是混合技术的天下
    - 混合技术在微合金涂层上的应用
    - 等离子增强辅助多弧技术
    - ＋高等离子化脉冲磁控溅射技术
  - — 脉冲多弧技术的挑战

高科技的驱动者
ARC (多弧), MSIP (磁控溅射)的市场份额?

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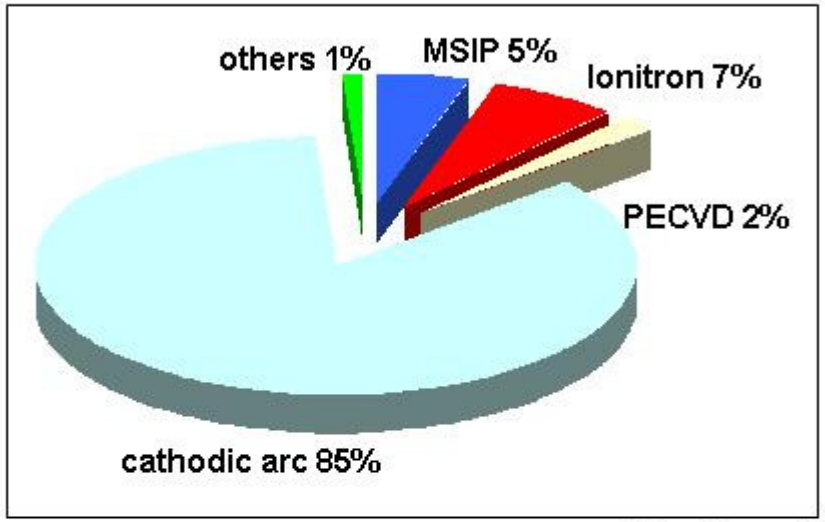
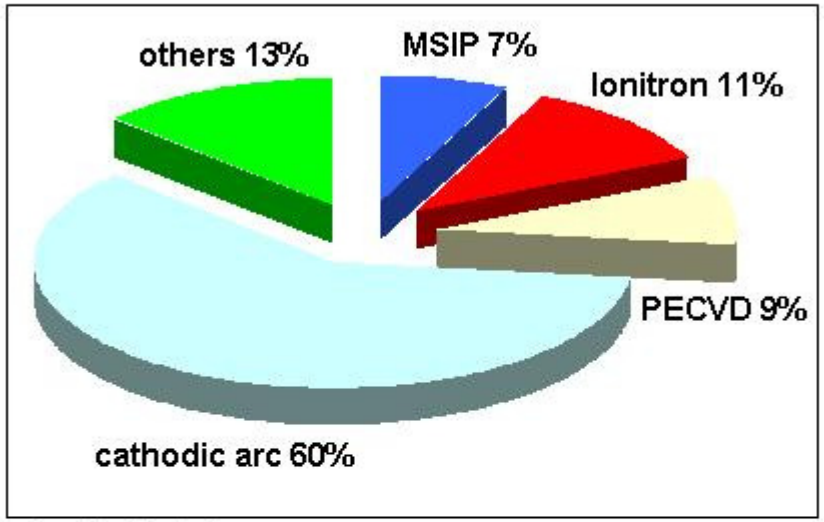
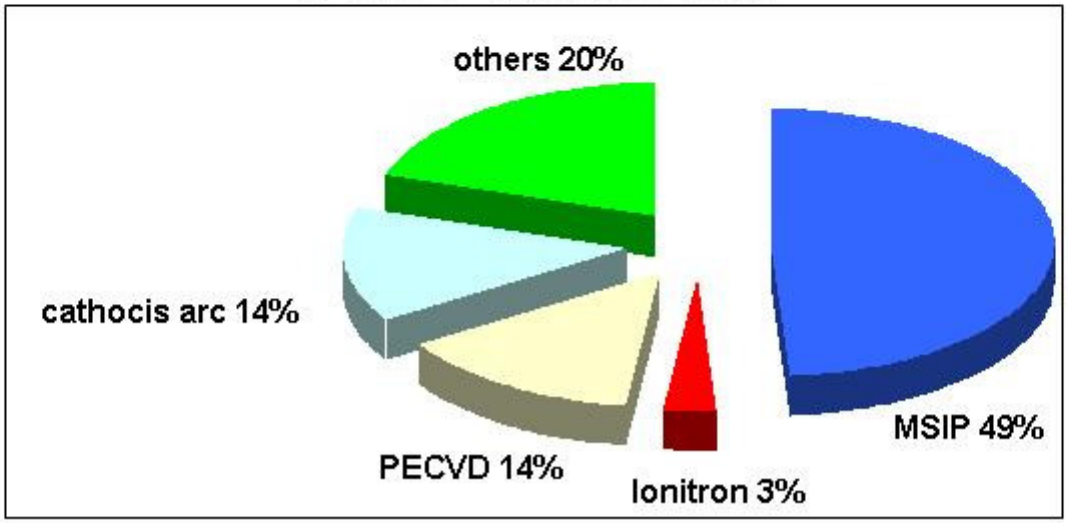
切削刀具涂层



成型模具涂层



零部件，易磨损件涂层



高科技的驱动者
材料沉积的特性

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高性能涂层

- 材料的低离子化率
- 多的氩离子

~~dcMS~~

提供更好的流程控制

- 提高的离子化率
- 高离子化程度的沉积材料 (+,++, 更高)
- 高流量的低能量离子
- 可控的涂层微观结构和相形成

Arc
HIPAC
HIPAC/Arc hybrid

高科技的驱动者
创新的APA多弧技术

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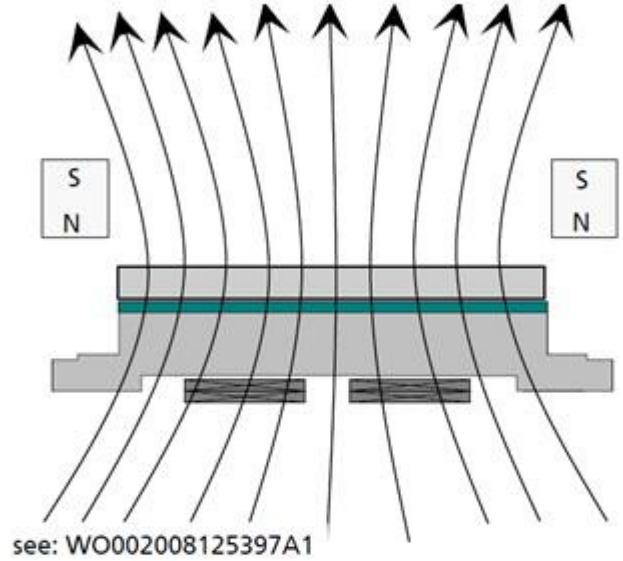
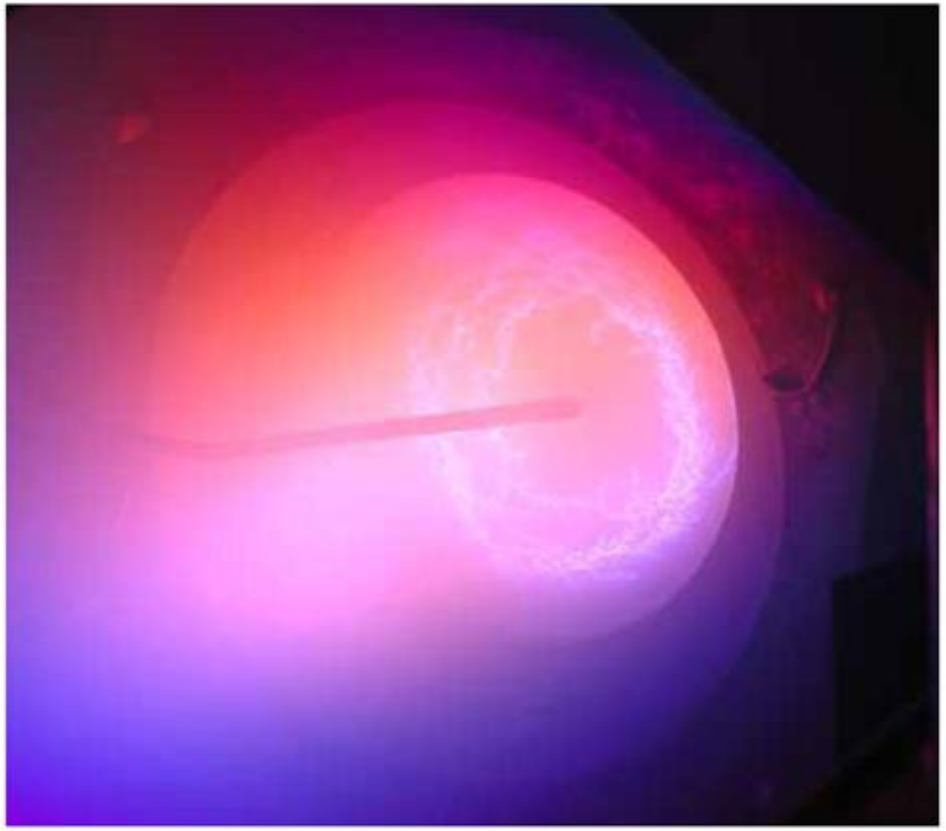
磁力区域扩大的阴极多弧技术



see: WO002008125397A1



APA cathode (Sulzer Metaplas GmbH)

APA: 等离子增强辅助技术

- 更快的电弧运动
- 更小的电弧尺寸
- 微量的液滴喷射
- 更高的蒸发率
- 更高的靶材利用率
- 改良的涂层结合力和性能，更光滑的表面

高科技的驱动者
创新的APA多弧技术

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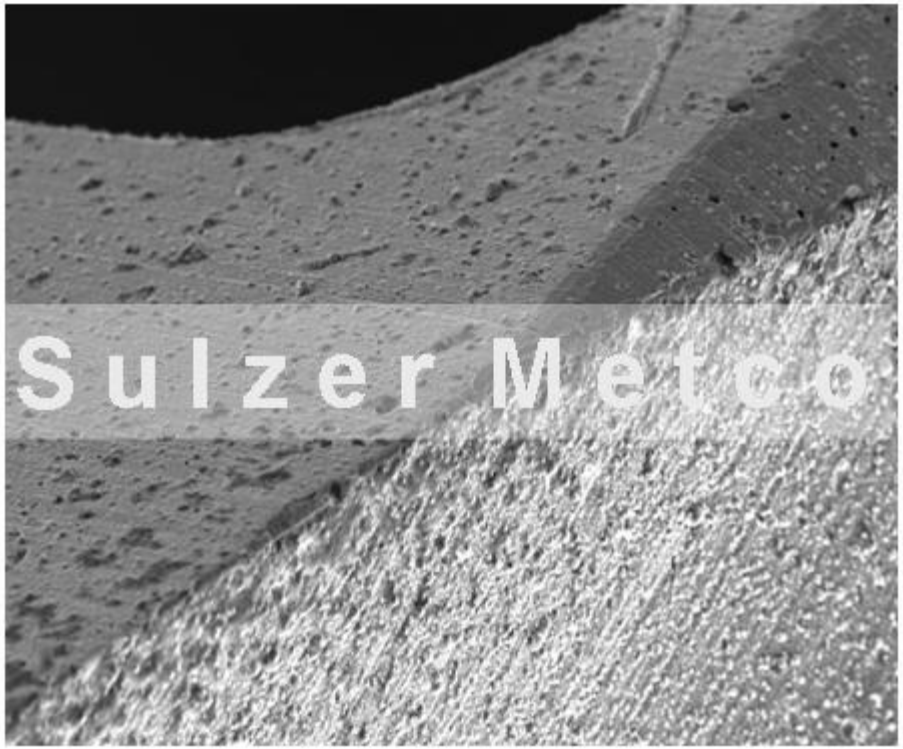
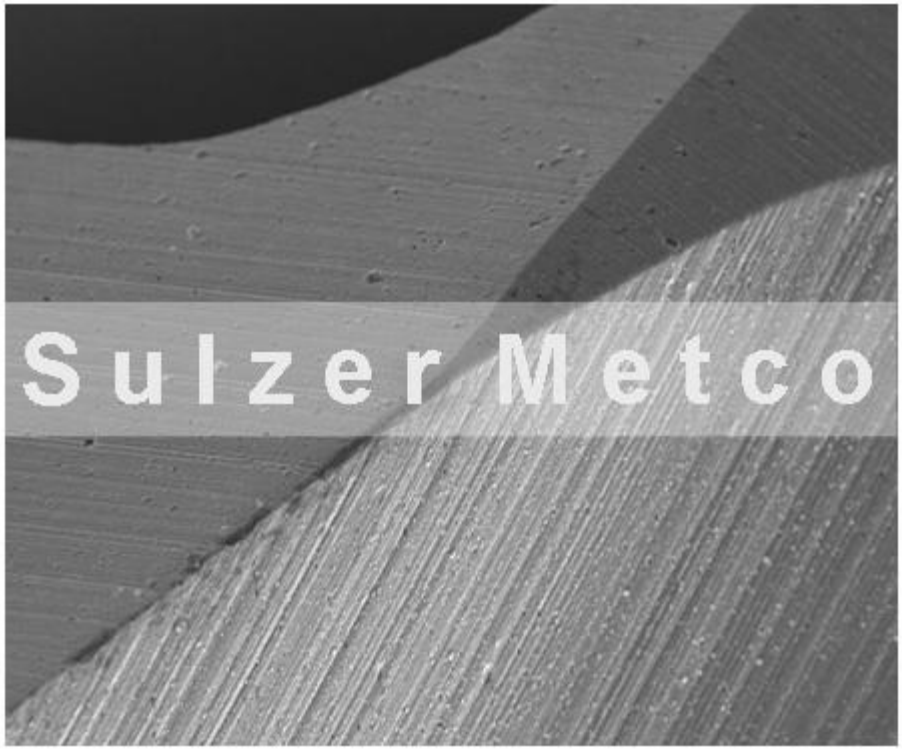


传统的多弧技术生成的
涂层沉积表面



采用APA多弧技术生成的
涂层沉积表面

高科技的驱动者
涂层设计和优化

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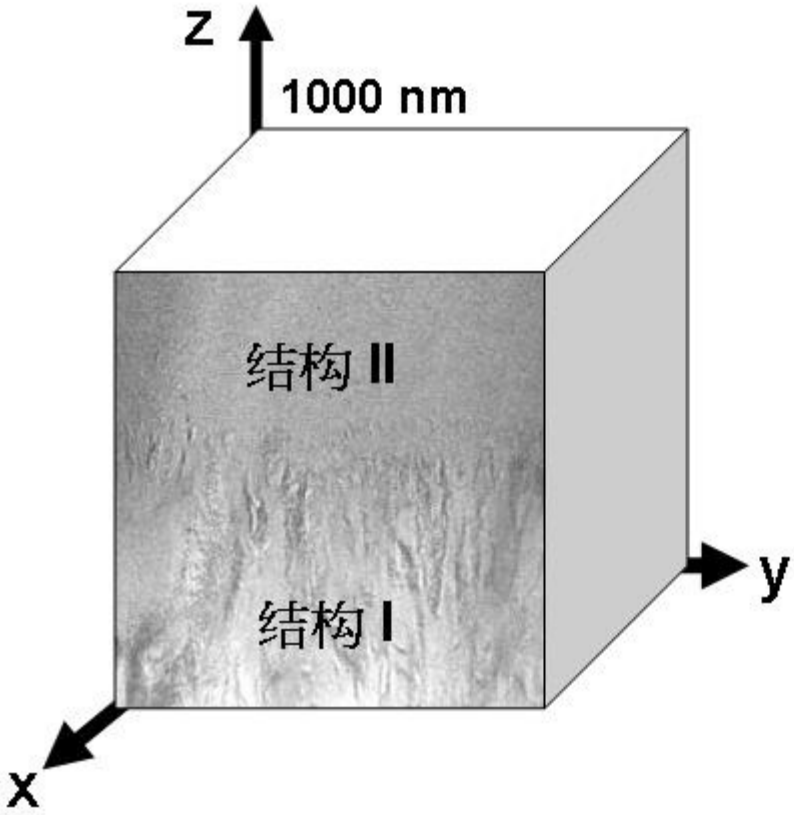
元素 = F(x,y,z)
元素，杂质 …

原子结构 = F(x,y,z)
结合层状况，点阵，
族群…

晶体 = F (x,y,z)
晶体点阵，颗粒边界，
无定形状态…

晶体排列 = F (x,y,z)
晶格空位，位错密度
等等…

形态 = F(x,y,z)
颗粒，针孔，液滴



时间决定流程 F = (x,y,z,t)

Driving high technology 高科技的驱动者
AlTiN Saturn

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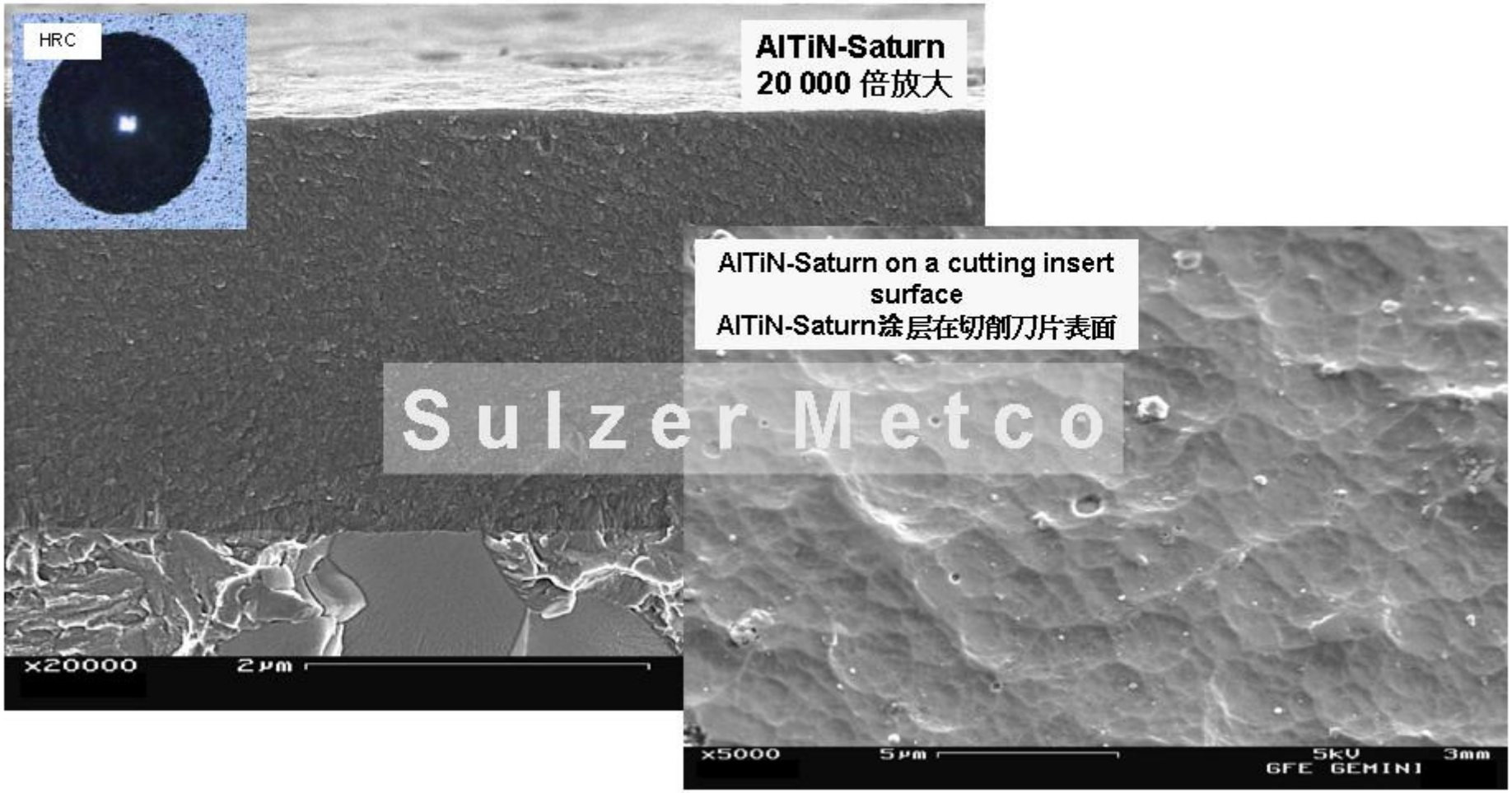
Still one of the best all-round high performance coatings
至今仍是最佳的高性能涂层之一



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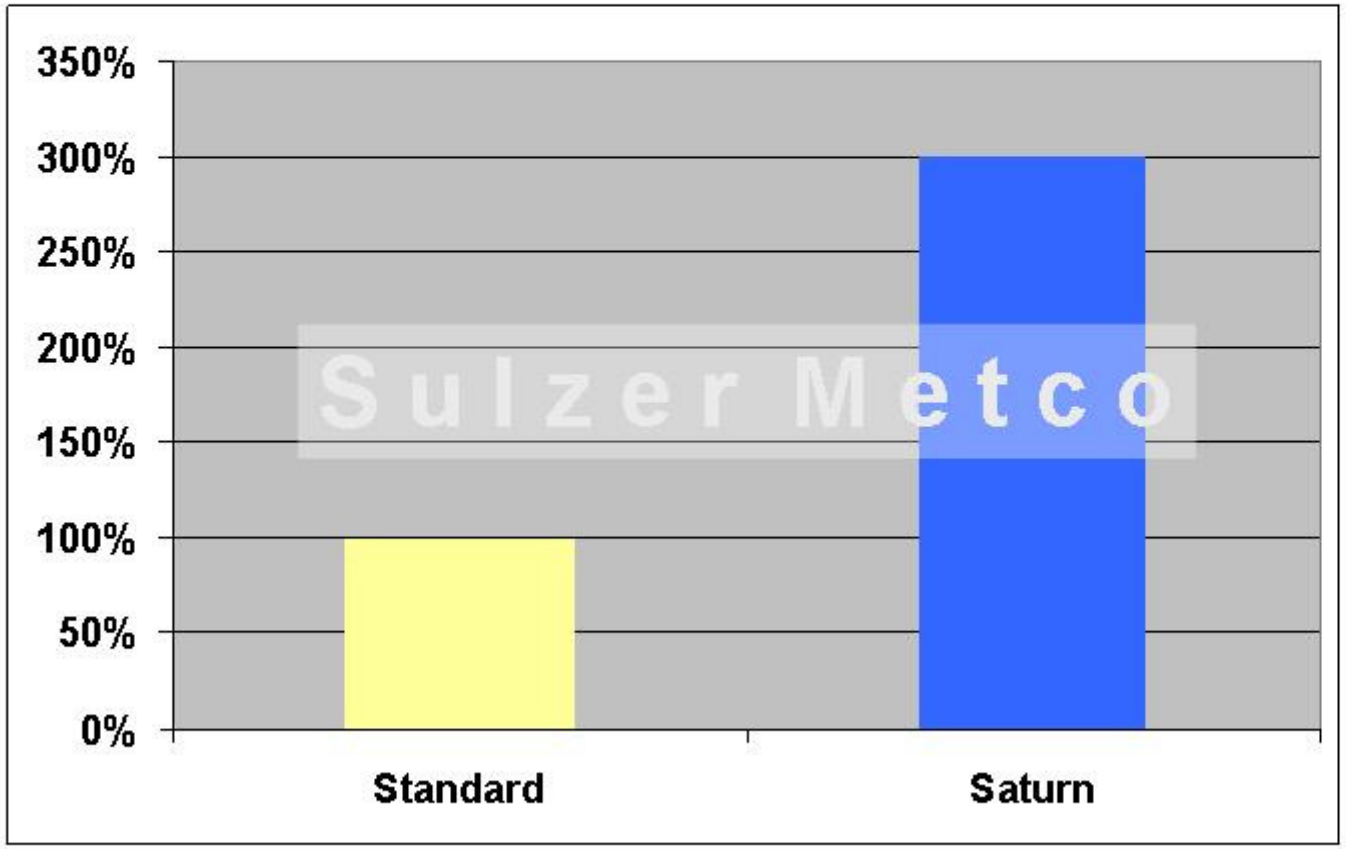
Rough milling of mold steel (HRC <54)
模具钢粗铣 (HRC <54)

Pocket milling with increased material removal rate
高速大进给模具型腔铣削



Driving high technology 高科技的驱动者

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Duplex treatment for various type of HSS tools

不同类型刀具的组合处理

Soft nitriding of HSS steel plus PVD in one cycle

在高速钢材料上一次完成软氮化加PVD涂层的组合处理

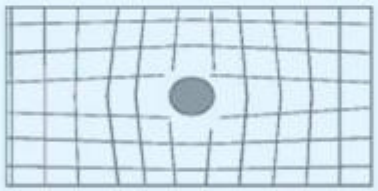
Effect of dislocation

"**dislocations**": stacking faults that disrupt regularity of crystal

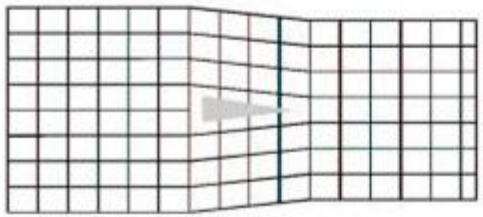
→ kinetically: adsorbing species does not have enough time to find thermodynamic equilibrium (correct position)

→ composition: adsorbing impurity atom disrupts packing

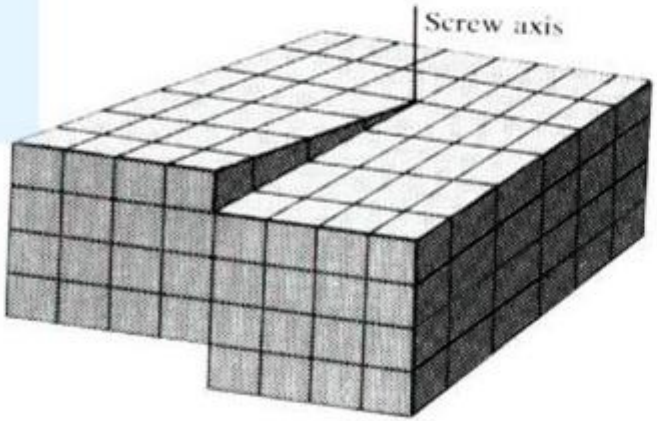
• **point defect**, missing atom, impurity:

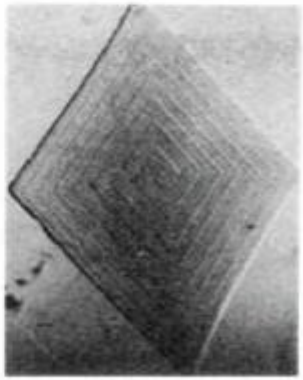


• **step dislocation**, line defect:



• **screw dislocation**:
propagates through crystal





⇒ dislocations contribute to mechanical properties (ductility, brittleness) and influence crystallization speed (trapping sites)

Source: R. Nix, www.chem.acuk/surfaces/scc

Driving high technology 高科技的驱动者
Sulzer Metaplas´ Micro Alloyed Coatings (MAC´s)

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苏尔寿美科的微合金涂层

The changed electron structure leads to:
电子结构的变化可带来:

- **increased electrical resistivity** 更高的电阻性能
- **improved phase stability** 更好的相稳定性
- **reduced thermal conductivity** 降低热传导性能
- **increased Chemical resistance** 提高抗化学性能
- **increased formation of oxide top layers** 提高表层氧化保护层的形成
- **improved fatigue resistance** 提高抗疲劳性能
- **increased yield, compressive and shear strength** 提高屈服、压缩及剪切强度

- **the stochastic incorporation of a significant amount of larger elements (0.1-3at%) will influence the atomic crack propagation**
  e.g. $R_x > R_{Cr} > R_{Si} > R_B$

随机组合的大尺寸元素(0.1-3at%) 将影响原子的裂纹延展表现

高科技驱动者
多米诺系统平台

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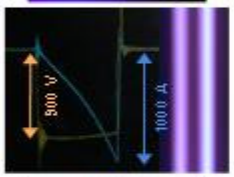
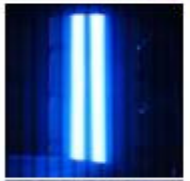
设备模块
多米诺 **S**:
可用容积: **D450*500mm**
多米诺 **L**:
可用容积: **D600*700mm**

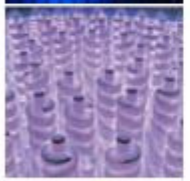
APA-ARC 模块
等离子增强辅助技术



HIPAC 模块
高等离子化的先进涂层



溅射模块
增强直流溅射，脉冲直流溅射，
磁控溅射



组合技术模块
氮化+ **PVD/PACVD**

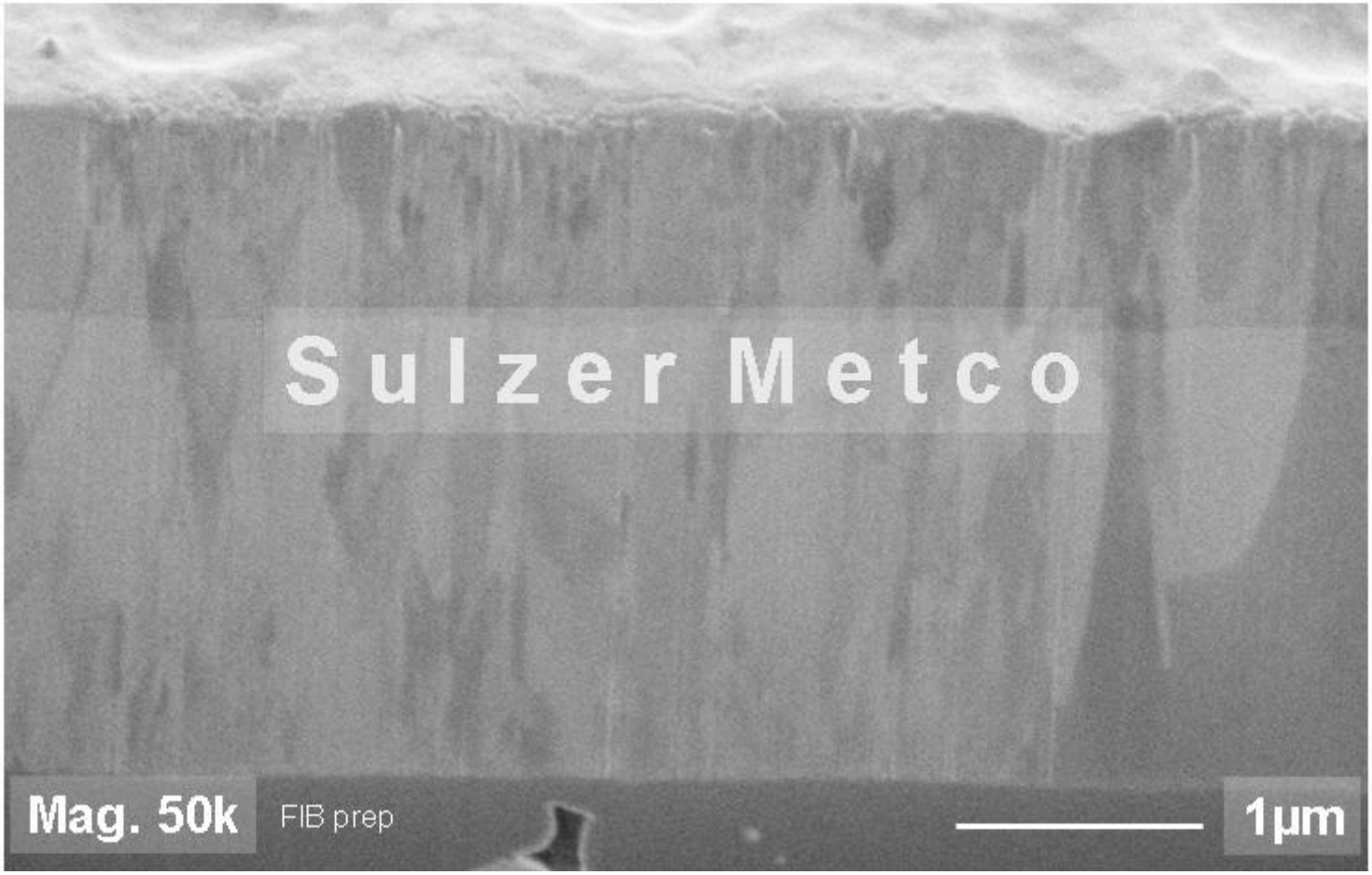
DLC 模块
PACVD, 磁控溅射+ **PACVD**

M_{flex} from the Sulzer Metaplas machining Series
M_{flex} 来着苏尔寿美科切削家族
fracture cross section 横截面

M_{flex} from the Sulzer Metaplas machining Series
M_{flex} 来着苏尔寿美科切削家族

fracture cross section 横截面

M_{power} from the Sulzer Metaplas machining Series
M_{power} 来着苏尔寿美科切削家族
fracture cross section 断裂横截面



M_{power} from the Sulzer Metaplas machining Series
M_{power} 来着苏尔寿美科切削家族

as nano-laminate ideal for Ti machining
完美的纳米多层结构应对钛金属加工

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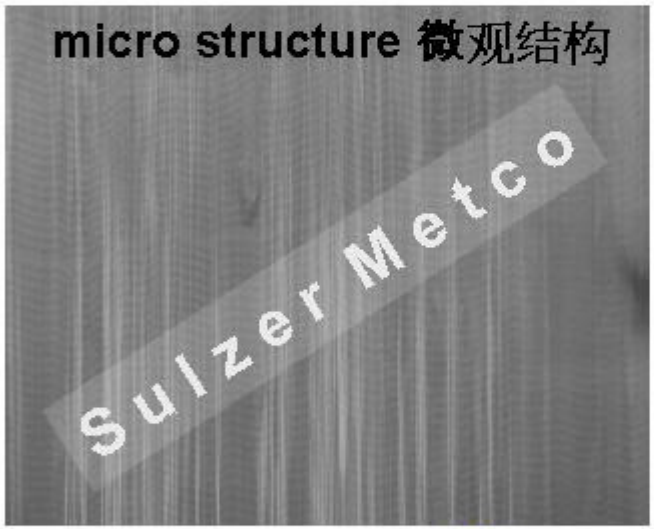
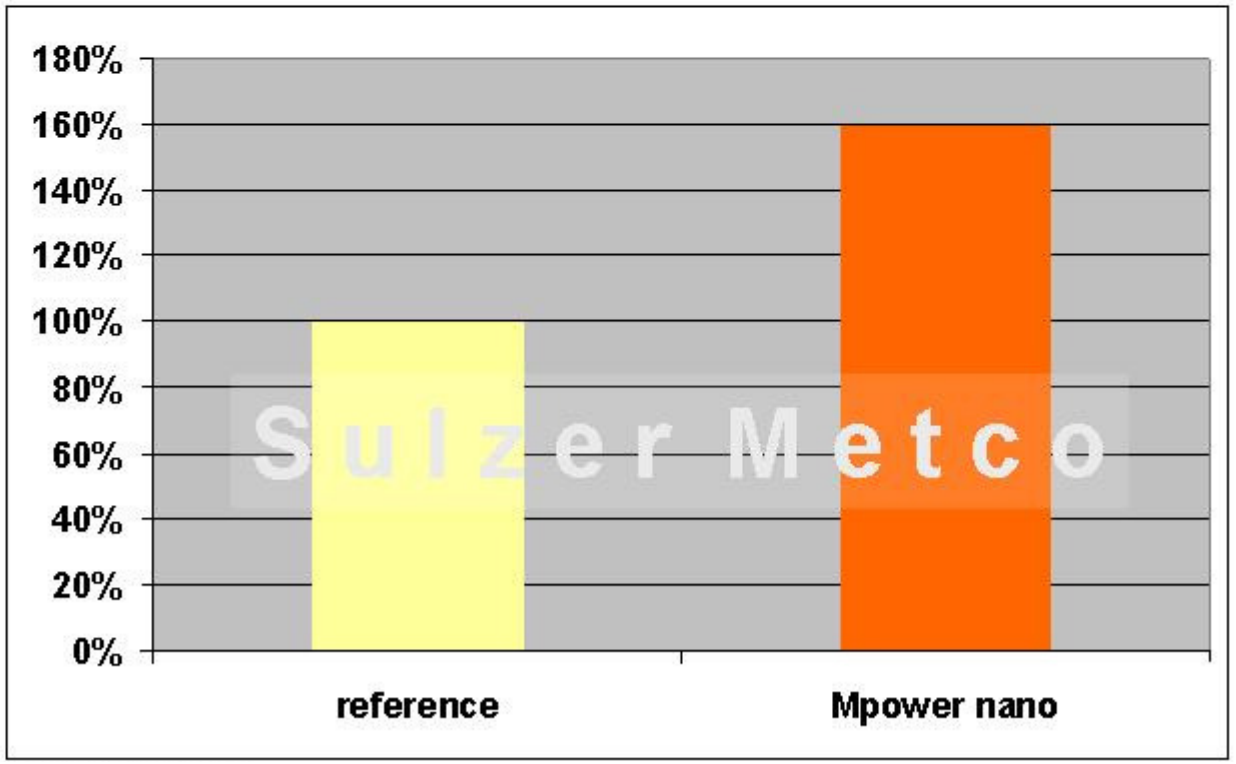
Machining of beta-Ti: nano laminated M_{power}

加工Beta-Ti: 纳米多层结构的 M_{power}

rough milling of 粗铣 β-Ti (Ti3Al8V6Cr4Zr4Mo)
Ø 25mm endmill 端面铣刀, v_c = 60 m/min



nano laminated M_{power}
纳米多层结构的



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Dedicated structure design 针对不同应用的结构设计: M power Sulzer Metco

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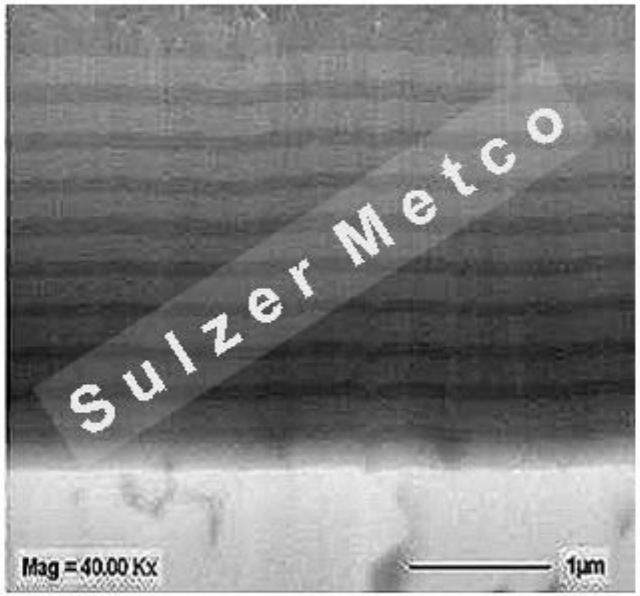
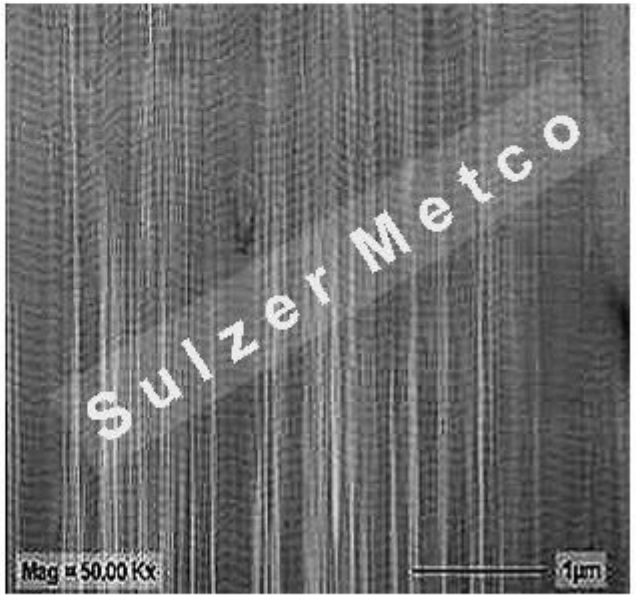
2 layer structure 双层结构

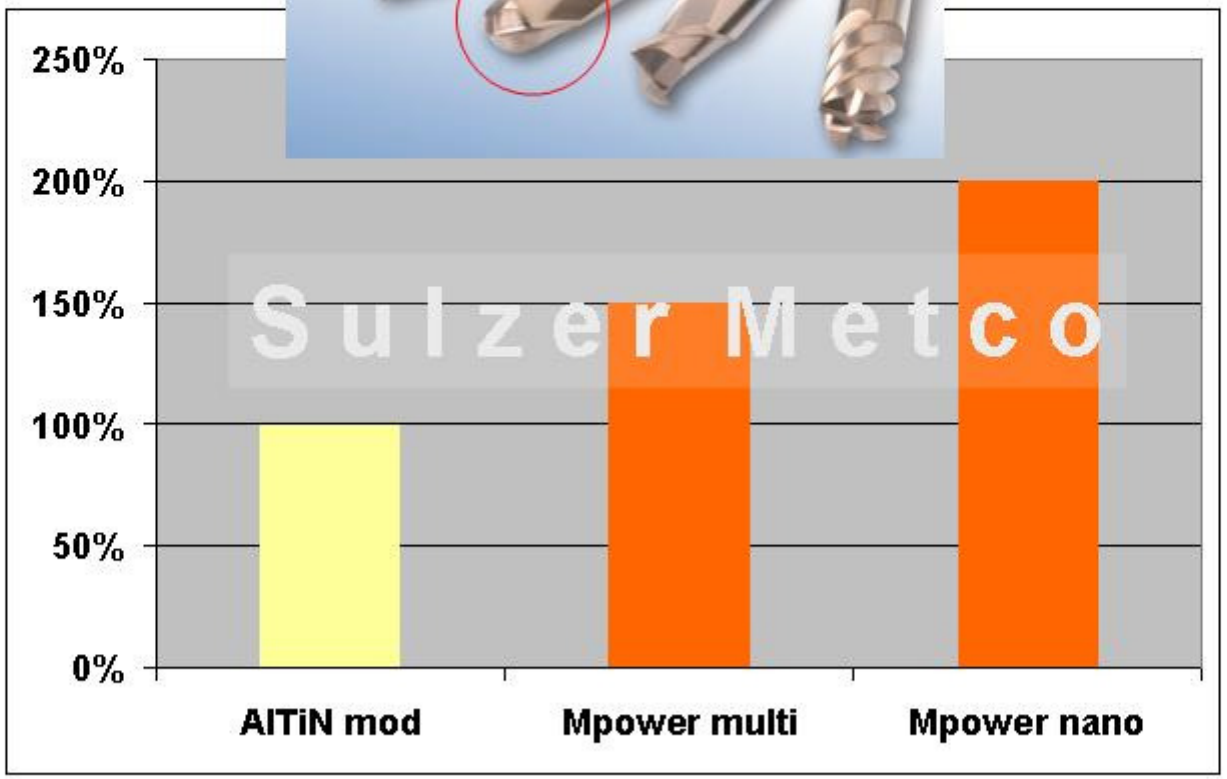
multi-layer architecture
多层结构



nano-laminated film
纳米多层结构



Milling of hardened steel, material 1.2379 60-62 HRC
铣削硬化钢材，材料 1.2379 60-62 HRC



dry, v_c = 115m/min, f_z = 0,05mm, a_p = 0,1, a_e = 0,2

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Technology module: Oxide / Oxinitride

技术模块：氧化/氧化氮化

Oxinitride / Oxide
氧化氮化/氧化

inert surface
惰性的表面

Driving high technology 高科技的驱动者

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Technology module: Oxide / Oxinitride

技术模块：氧化/氧化氮化

Example for an oxidic top layer by Arc

例如多弧技术生成的氧化表层

glass like
Cr_2O_3 morphology
类似玻璃的
Cr2O3 表层

dense
CrN morphology
致密的
CrN 底层

other variants by Arc: e.g. AlTiCrNO … .
多弧技术生成的其它不同种类涂层：如 **AlTiCrNO … .**

高科技的驱动者
HIPAC: 苏尔寿美科在HCPMS技术上的创新

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HIPAC =高等离子化脉冲磁控溅射技术
HCPMS = 高电流脉冲磁控溅射技术
Patented AEGD = 等离子增强辉光放电多弧专利技术

HIPAC = AEGD + HCPMS

- 提高的离子化率
- 高离子化程度的沉积材料 (+,++, 更高)
- 高流量的低能量离子
- 可控的涂层微观结构和相形成
- 低沉积温度的可能

高科技驱动者
HIPAC: 原理

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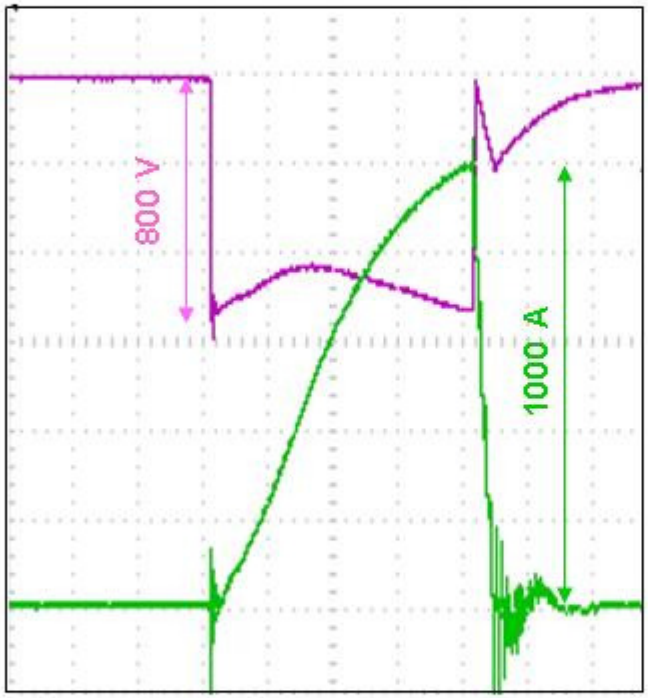
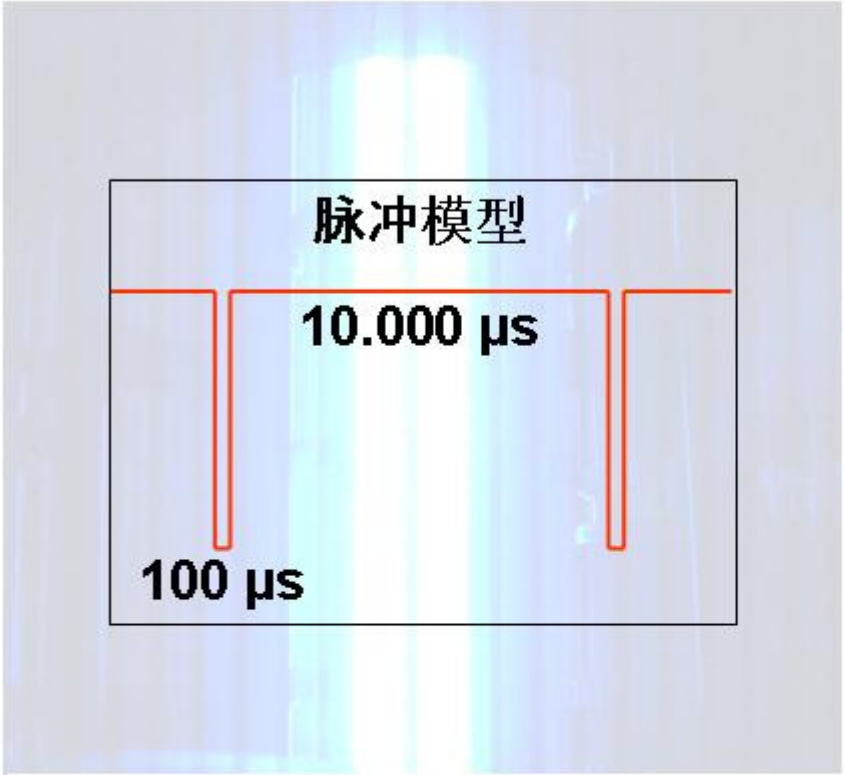
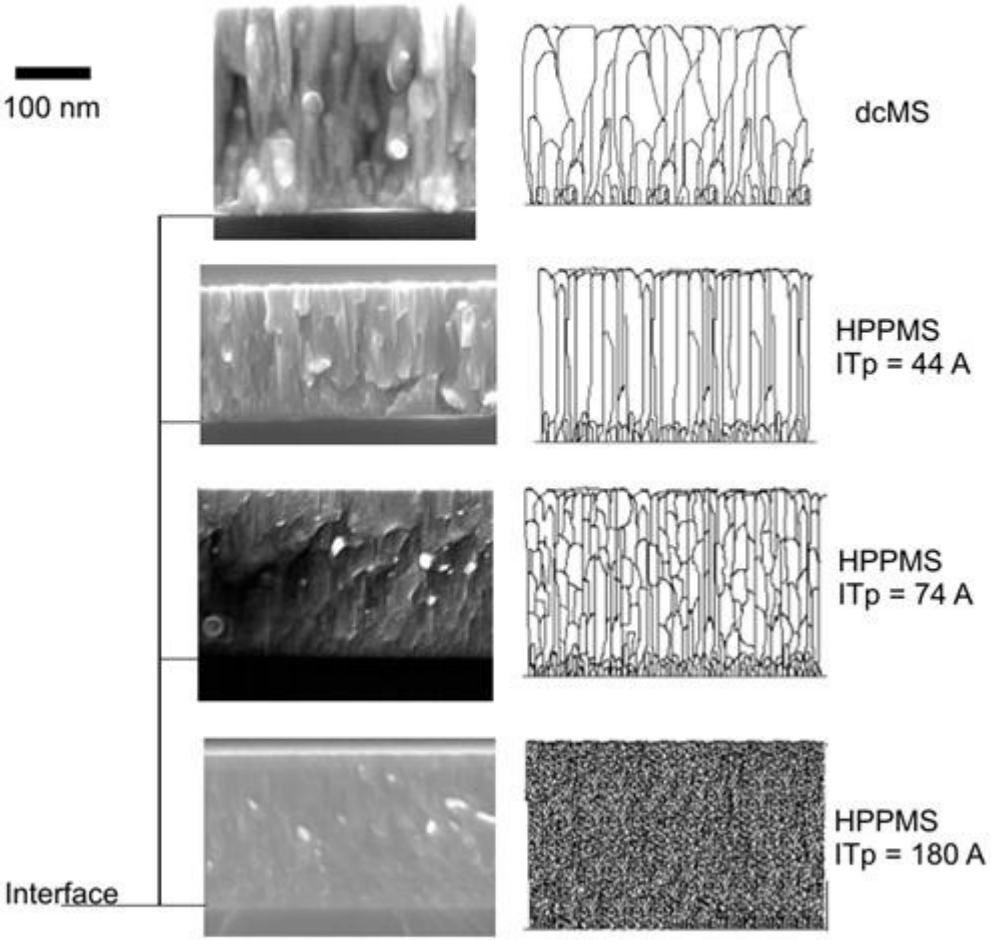




- 低脉冲工作时间
- 低频（<1 kHz)
- 高功率峰值（>0.5MW)
- 低平均功率（相对于传统溅射）

Film morphology 涂层形态



Ion irradiation
离子辐射

↓

Interruption of columnar growth and re-nucleation
中断柱状生长和晶核再形成

↓

Featureless morphology
非晶结构

[J. Alami, K. Sarakinos *et al.*, J. Phys. D: Appl. Phys. 42 (2009) 015304]

高科技的驱动者
HIPAC技术生成的CrN涂层应用在造币模具上

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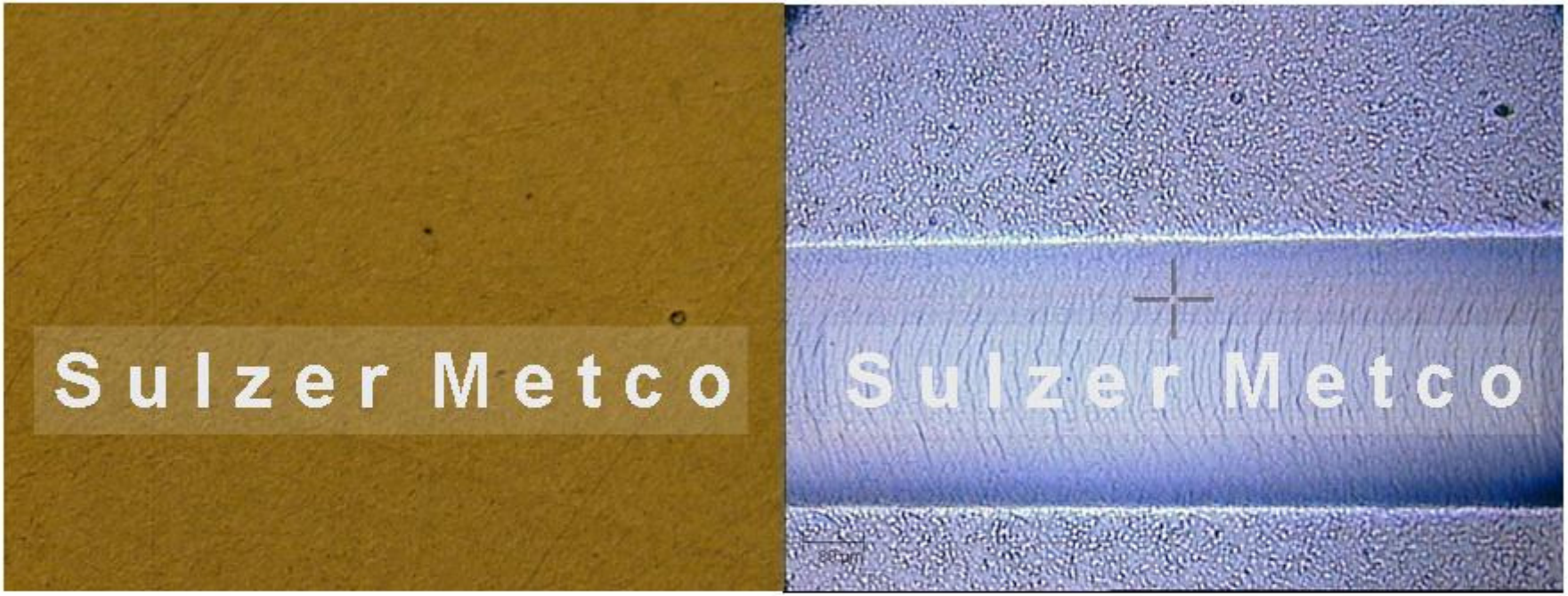


涂层厚度：2um
粗糙度：
涂层前Ra: 7nm
涂层后Ra: 9nm

结合力（用AEGD技术对基体进行过离子束清洗）：划痕失效测试(持续加载)：110N

沉积温度在130摄氏度

高科技的驱动者
高性能涂层：未来是混合技术的天下

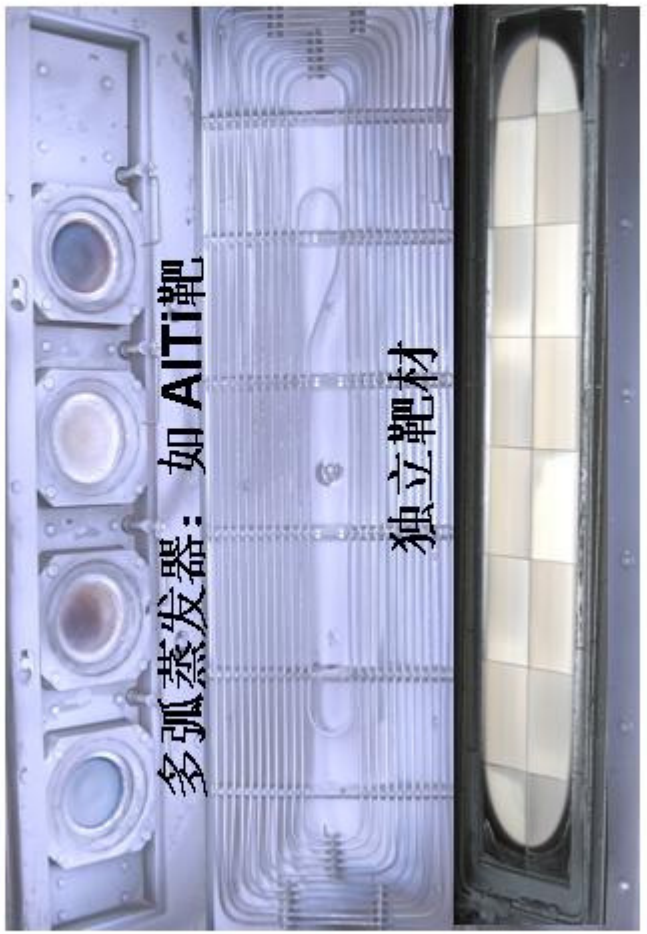
SULZER
Sulzer Metco

谁精通这两种技术谁就是未来趋势的掌控者

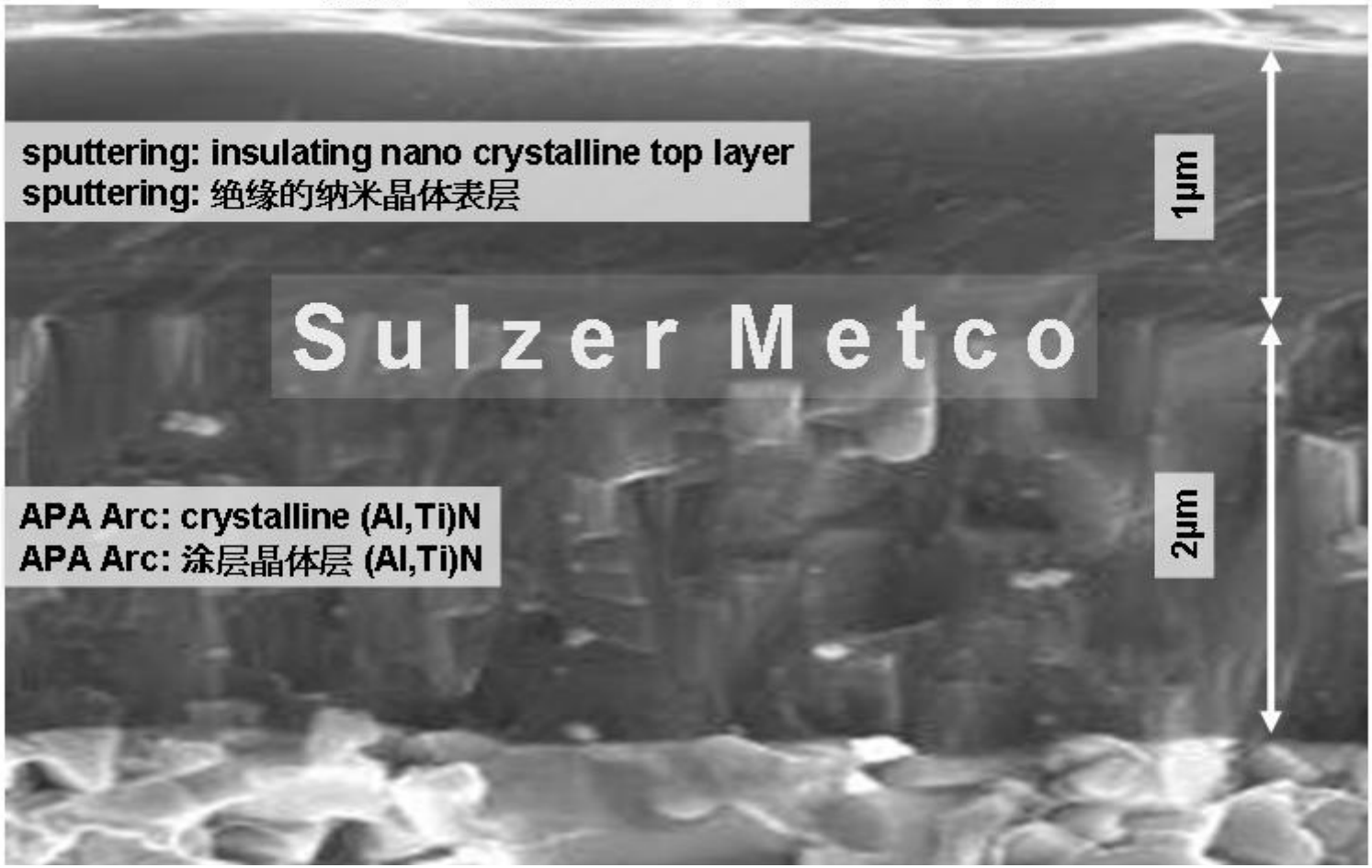
高科技驱动的趋势：
应用APA Arc - HIPAC混合技术的微合金涂层

SULZER
Sulzer Metco

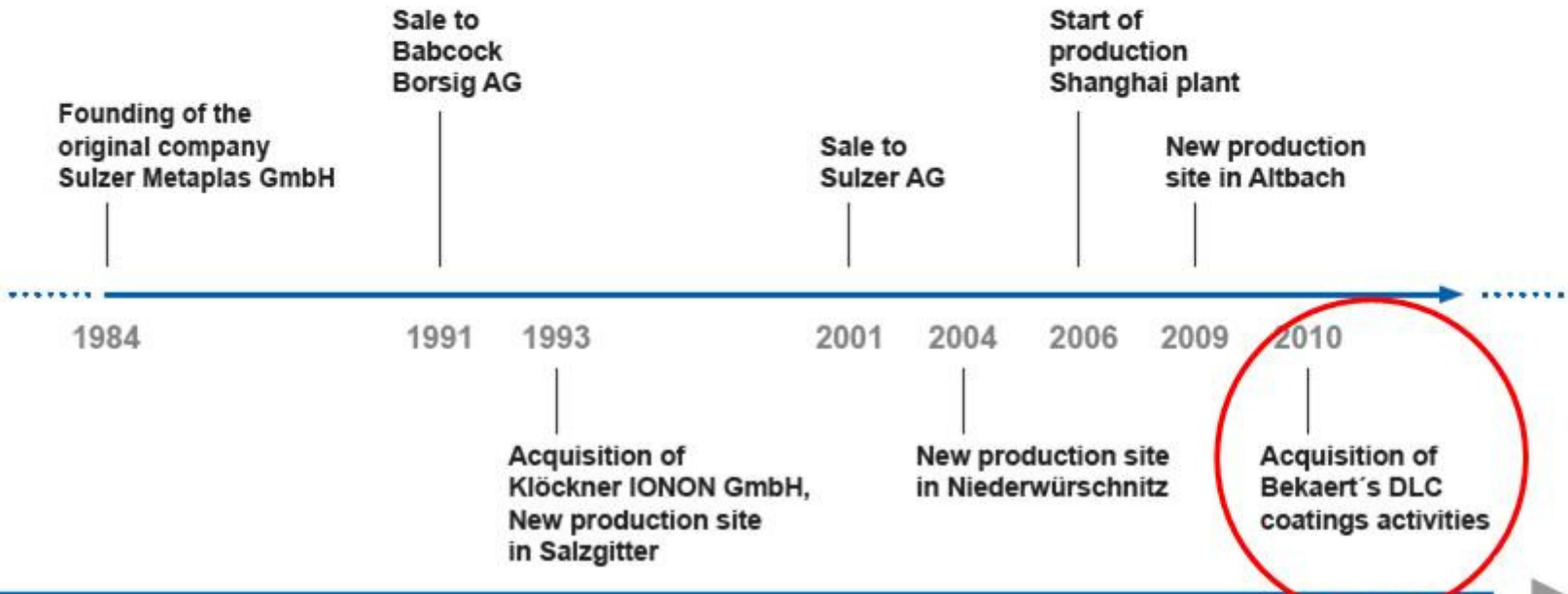
微合金涂层: AlTiSiXN



Smooth and dense sputtered insulating top coat
溅射生成的光滑而致密的绝缘表层



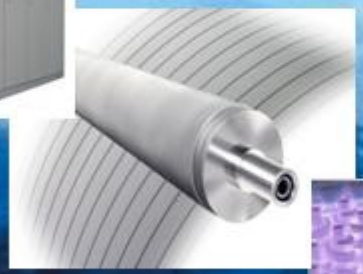
History



谢　谢!







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