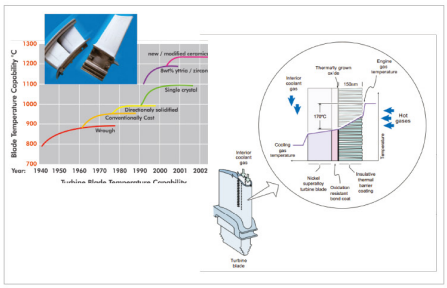
항공기 가스터빈엔진 블레이드용 EB-PVD 열차폐코팅 기술

EBPVD_TBCs Technology for Blades of Aircraft Gas Turbine Engine

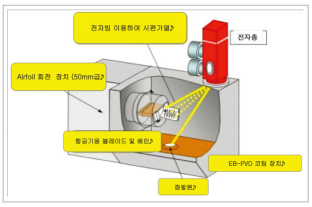
TRL3

기술내용

- 열차폐 코팅(TBCs)은 가스터빈 고온부품의 열부하 경감, 산화 저항성 확보 등의 목적으로 초내열합금 표면에 적용하는 첨단 재료 시스템으로서, 이트리아 부분 안정화 지르코니아 같은 내화성 산화물 세라믹 top 코팅이 열차단 효과를 담당하고, 초내열합금 모재와 코팅을 서로 결합시키며 동시에 내산화, 내부식을 담당하는 금속 bond 코팅(Aluminide MCrAlY 등)으로 각각 구성되어 있음.
- 가스터빈 블레이드의 열차폐 코팅에는 일반적으로 플라즈마 용사(PS)법과 EB-PVD 법이 사용되고 있는데, 코팅용 분말의 용융-충돌에 의해 적층형 층상구조를 갖는 PS법에 비해 EB-PVD 법의 경우 수직으로 성장된 주상정 (columnar) 구조를 가지고 있어 PS법과 비교하여 열적 사이클에서의 수축 팽창으로 인한 손상이 작다는 특징이 있음.

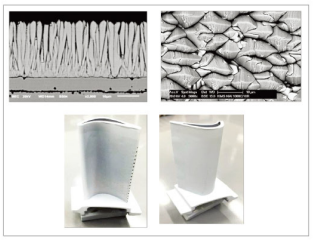


- 준양산급 EB-PVD 장치 운용기술
  - 3 crucible, 5 X 50kW e-beam gun
  - One Load-lock chamber
  - Sub. Heating & ingot melting by e-beam



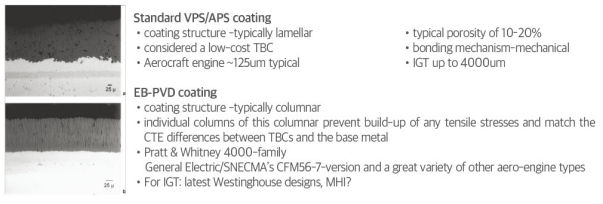
- Metal bond coat +YSZ top coat 일원화 공정 기술 (one-stage EB-PVD process)

- YSZ 미세조직 제어기술
  YSZ Columnar 구조 제어
  블레이드 시제 코팅기술



우수성

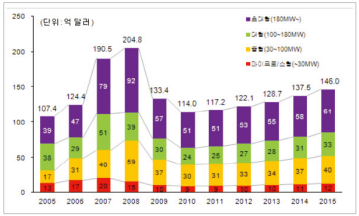
- 국내 최대급 EB-PVD 장치 보유 - 준양산 대응가능
- one-stage EB-PVD process를 개발하여 **Metal bond coat +YSZ top coat** 일원화 공정을 제공함으로써 기존의 이원화 공정 (bondcoat 형성공정 + EBPVD topcoat) 대비 제조단가 저감화
- Bondcoat 조성 제어 및 경사기능성 제공 가능



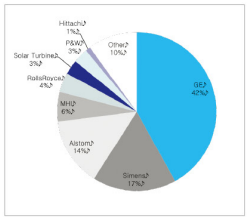
- **[특허] KR10-1438799 레이저를 이용한 초고온 열충격 및 산화시험장치**

사업성

- D사 : 150MW급 이상의 대형 가스터빈 생산
- H사 ·S사 : 30~64MW급의 중형급 생산
- H사 : G사와 기술제휴를 통해 22MW급의 소형 가스터빈을 조립·생산 (방산용)
- 민간용/군수용 항공기 엔진 After Market



Land-base Gas turbine 세계 시장규모



기업별 제품 시장 점유율

* 항공용 가스터빈 시장 자료에 대한 자료 부족으로 지상용 가스터빈 시장자료로 대체하였음

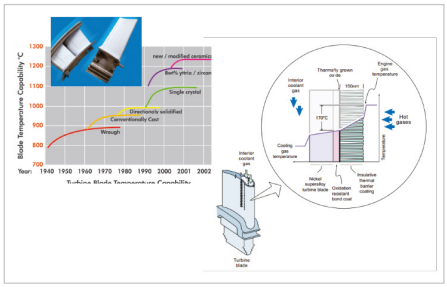
KIMS 이성훈 책임연구원 shlee@kims.re.kr

EBPVD_TBCs for Blades of Aircraft Gas Turbine Engines

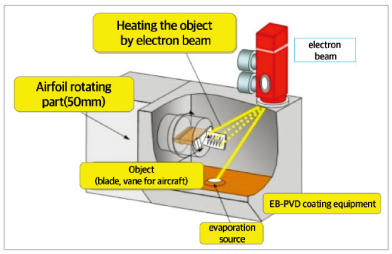
TRL3

Technology Overview

- The thermal barrier coatings (TBCs) offer the potential to improve efficiencies of aero engines significantly. TBCs, typically consisting of an yttria-stabilized zirconia top coat and a metallic bond coat deposited onto a superalloy substrate, are mainly used to extend a lifetime of gas turbine engine parts.
- TBCs fabricated by EB-PVD are favored for high-performance applications, because of reduced thermal conductivity, increased temperature capability, life prediction modeling, process modeling, bond coat oxidation, and hot corrosion resistance as well as improved erosion behavior.

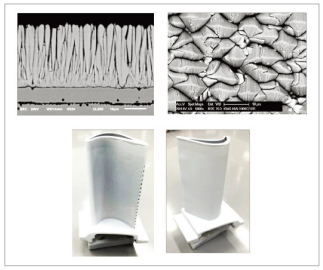


- EB-PVD devices for near mass production:
  - 3 crucible, 5 X 50kW e-beam gun,
  - One Load-lock chamber,
  - Sub. heating & ingot melting by e-beam



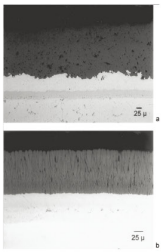
- [Metal bond coat +YSZ top coat] combined process (one-stage EB-PVD process)

- YSZ microstructure control; YSZ columnar structure control; blade co-initiator coating



Highlights and Strengths

- Korea's largest EB-PVD device available for semi mass production
- Lower production cost based on one-stage EB-PVD process that can control [metal bond coat + YSZ top coat]
- Bond-coast : composition controllability, functionally graded layer formation



Standard VPS/APS coating

- coating structure -typically lamellar
- considered a low-cost TBC
- Aerocraft engine ~125um typical
- typical porosity of 10–20%
- bonding mechanism-mechanical

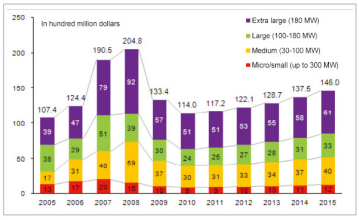
EB-PVD coating

- coating structure -typically columnar
- individual columns of this columnar prevent build-up of any tensile stresses and match the CTE differences between TBCs and the base metal
- Pratt & Whitney 4000-family
  - General Electric/SNECMA's CFM56-7-version and a great variety of other aero-engine types

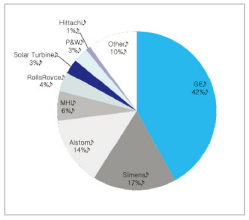
- **[Patent] KR10-1438799 ULTRA HIGH TEMPRATURE SHOCK AND OXIDATION TEST EQUIPMENT USING LASER BEAM**

Business Cases

- 'DH' : Heavy-duty gas turbines of over 150 MW
- 'HT' / 'ST' engine: Mid duty of 30-64 MW
- 'HT' : Light-duty gas turbines of 22 MW in partnership with 'G' (for the defense industry)
- After-market for civil/military aircraft engines



Global market for land base gas turbines



Market share by maker

* Data on aircraft gas turbine market is not available.

KIMS Sung-hun Lee shlee@kims.re.kr