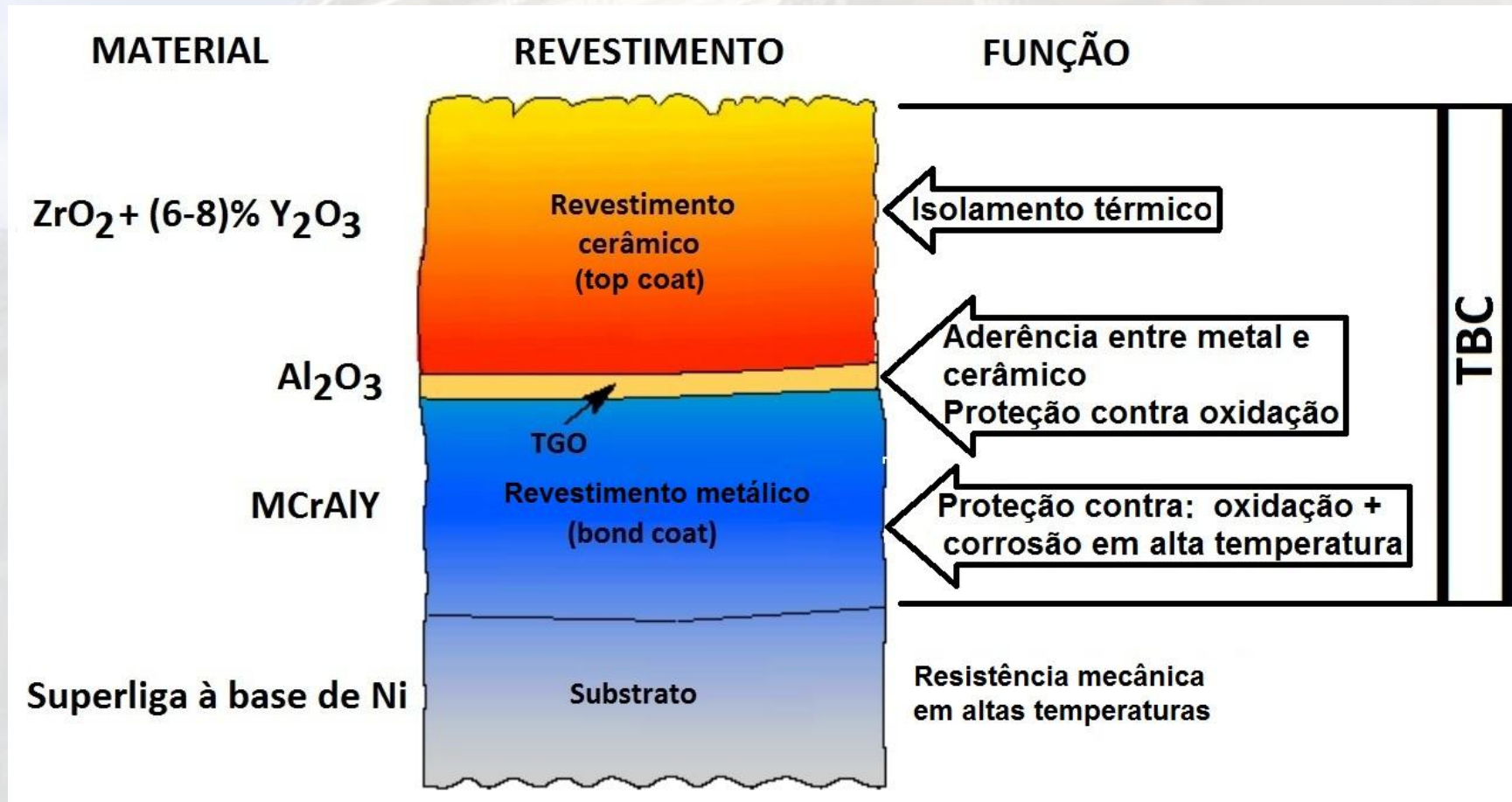


DEPOSIÇÃO DE REVESTIMENTOS CERÂMICOS POR APS COMO BARREIRA TÉRMICA

Artigos Base

- Manipulation of air plasma spraying parameters for the production of ceramic coatings. Khan, A. N., Lu, J.
- Characterization of thermal barrier coatings with a gradient in porosity. Teixeira, V.

Barreira Térmica

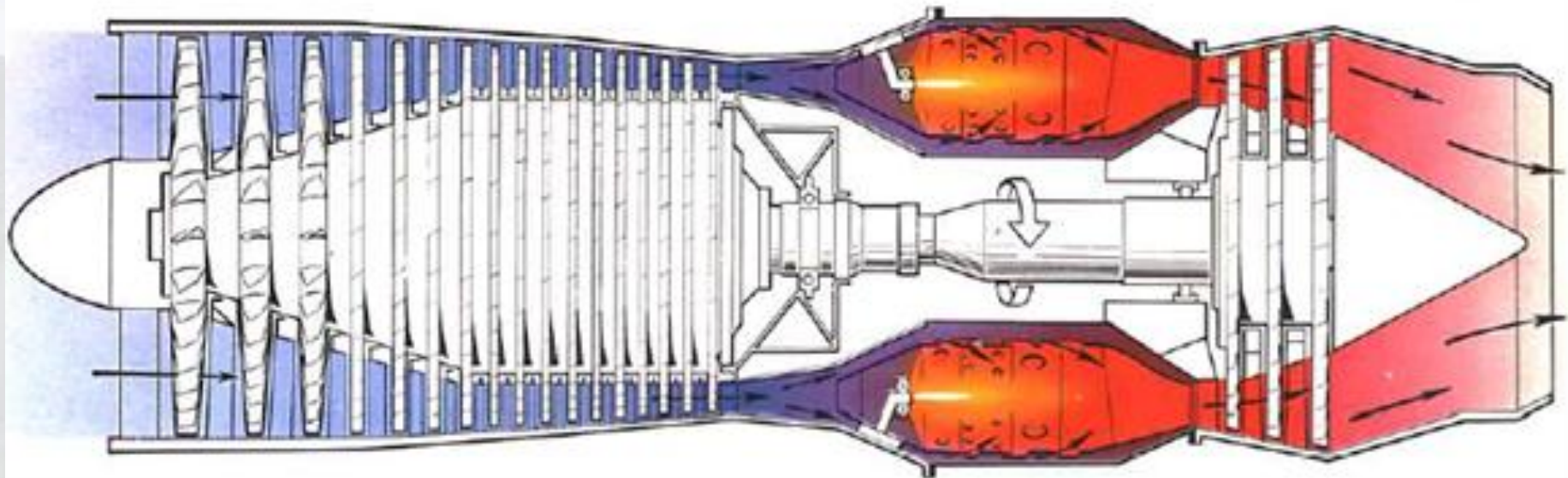


Turbinas a Gás

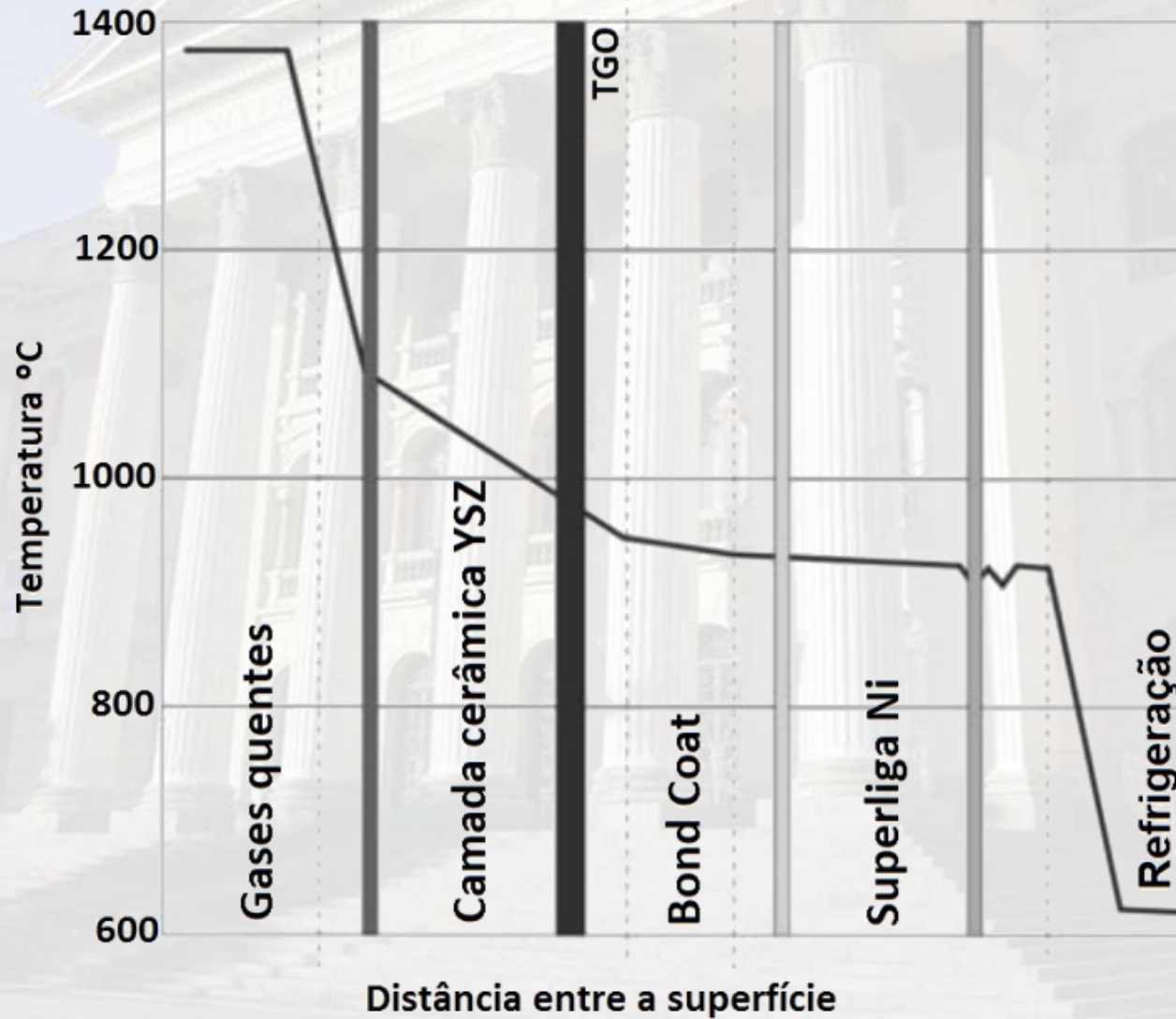
Entrada de Ar

Combustão

Exaustão



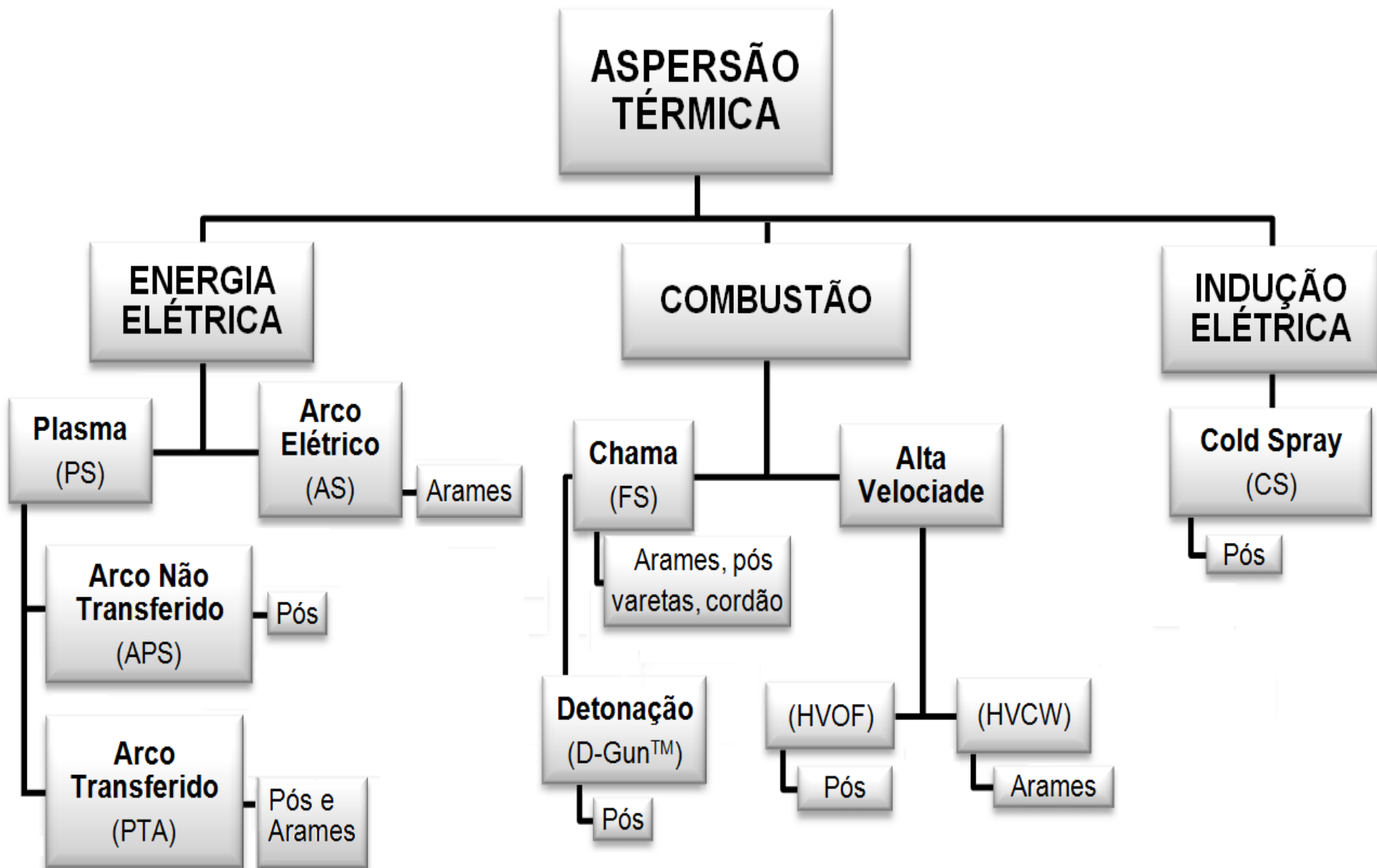
Desempenho



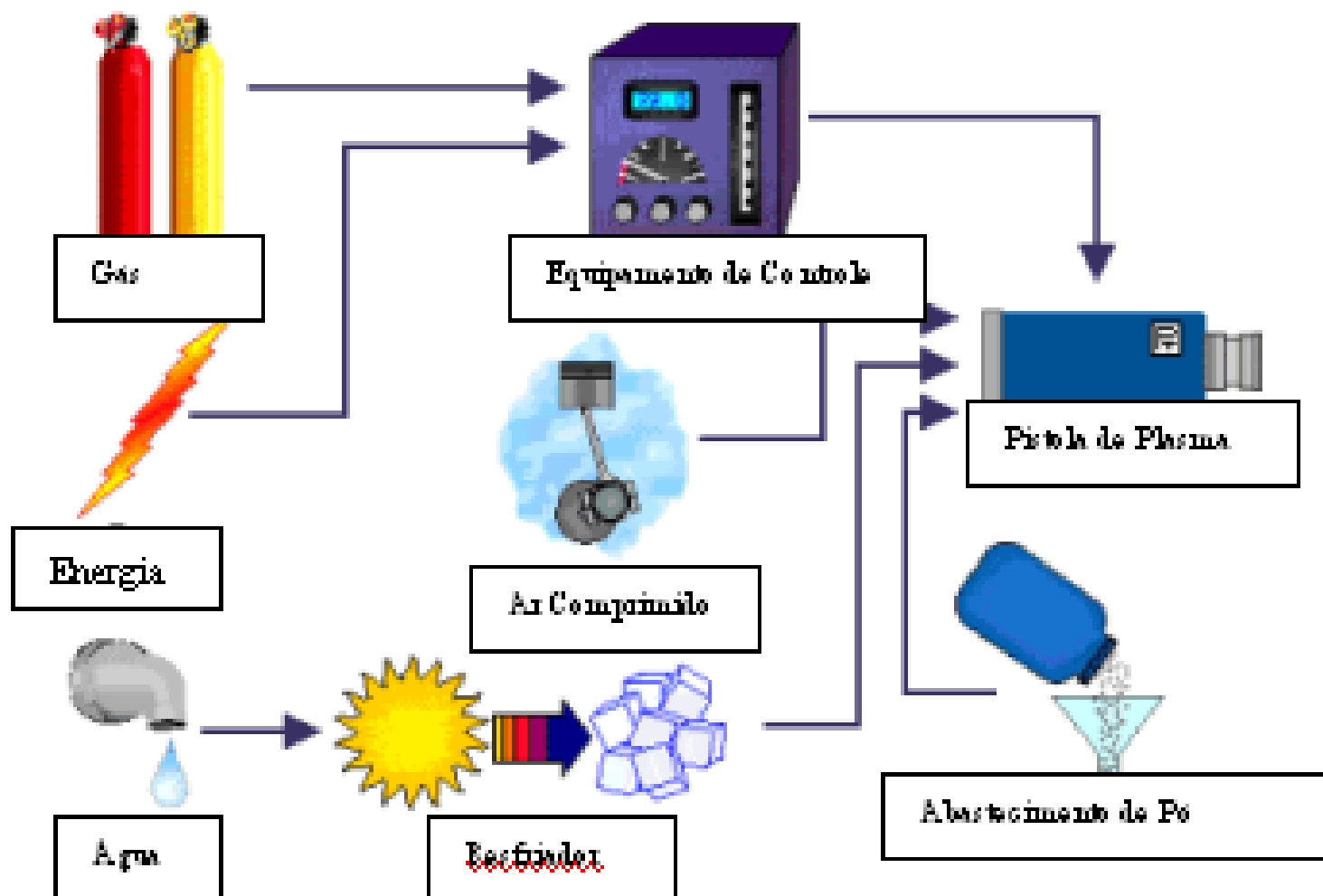
Revestimento Cerâmico

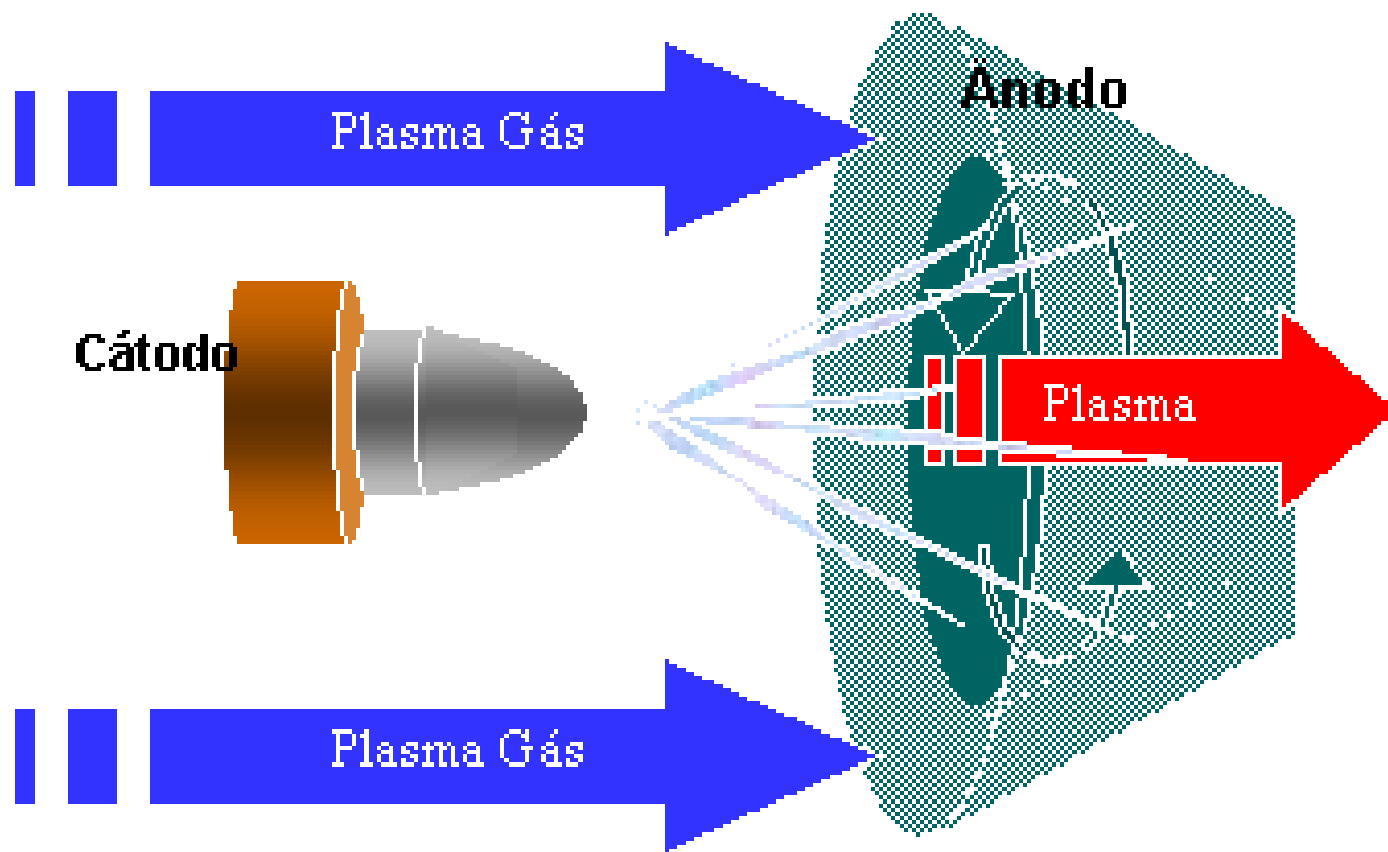
- Principal material utilizado é a zircônia estabilizada com ítria (YSZ – $ZrO_2 + Y_2O_3$);
- Baixa condutividade térmica e coeficiente de expansão térmica próximo a superliga de níquel;
- Características variam de acordo com o método de deposição e parâmetros utilizados;

ASPERSÃO TÉRMICA

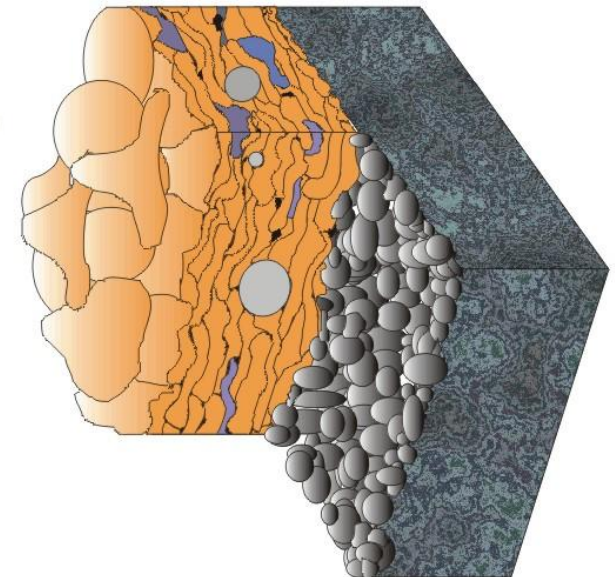
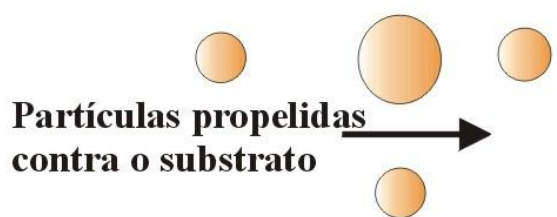
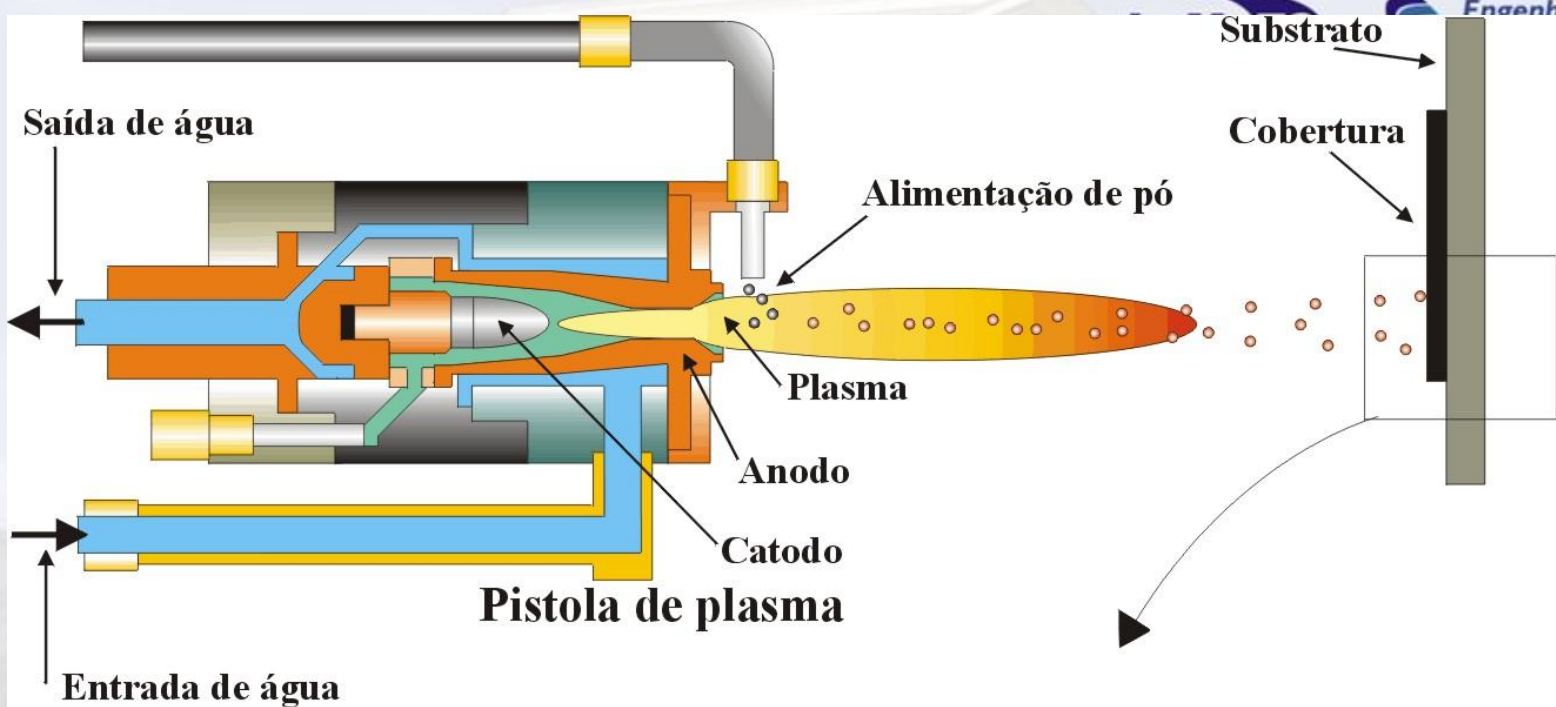


Aspersão Térmica Plasma Spray

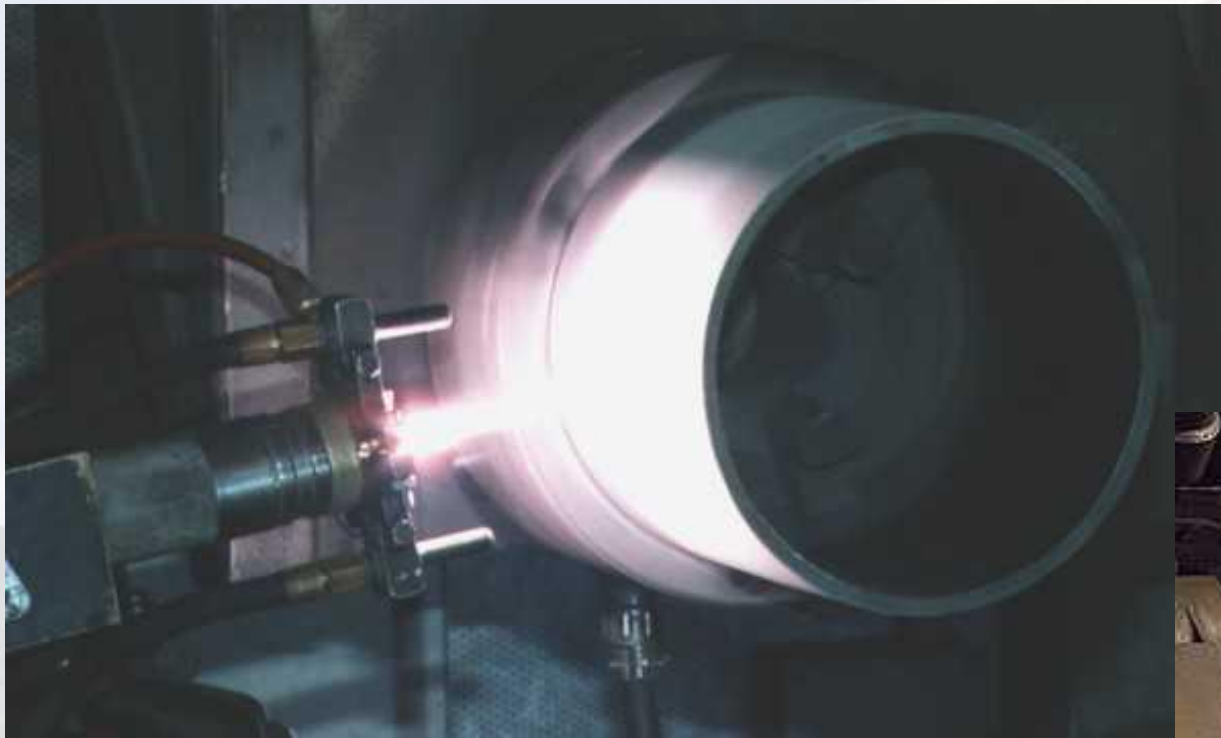




Esquema em corte de uma pistola para
aspersão térmica a plasma spray

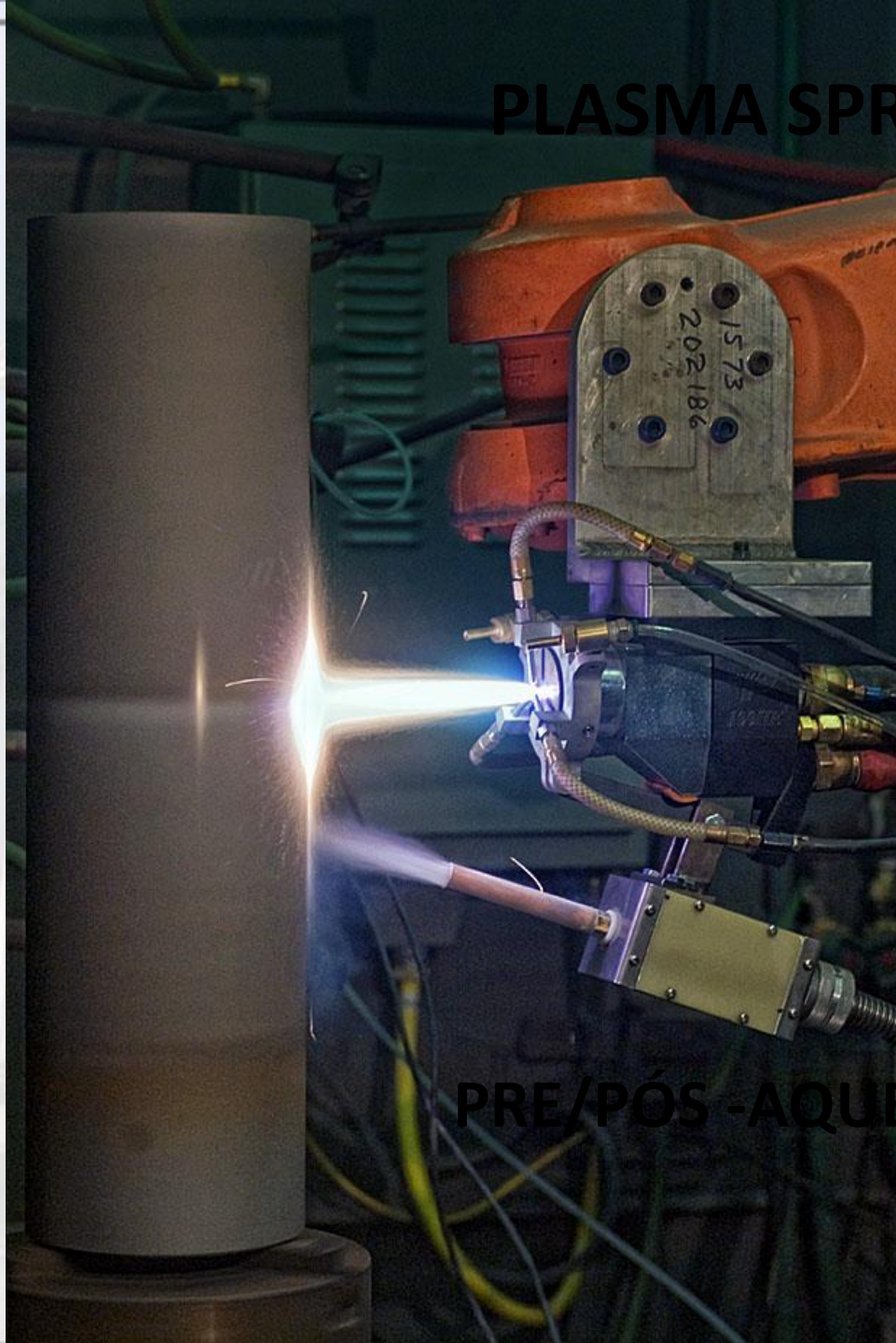


Detalhe da cobertura

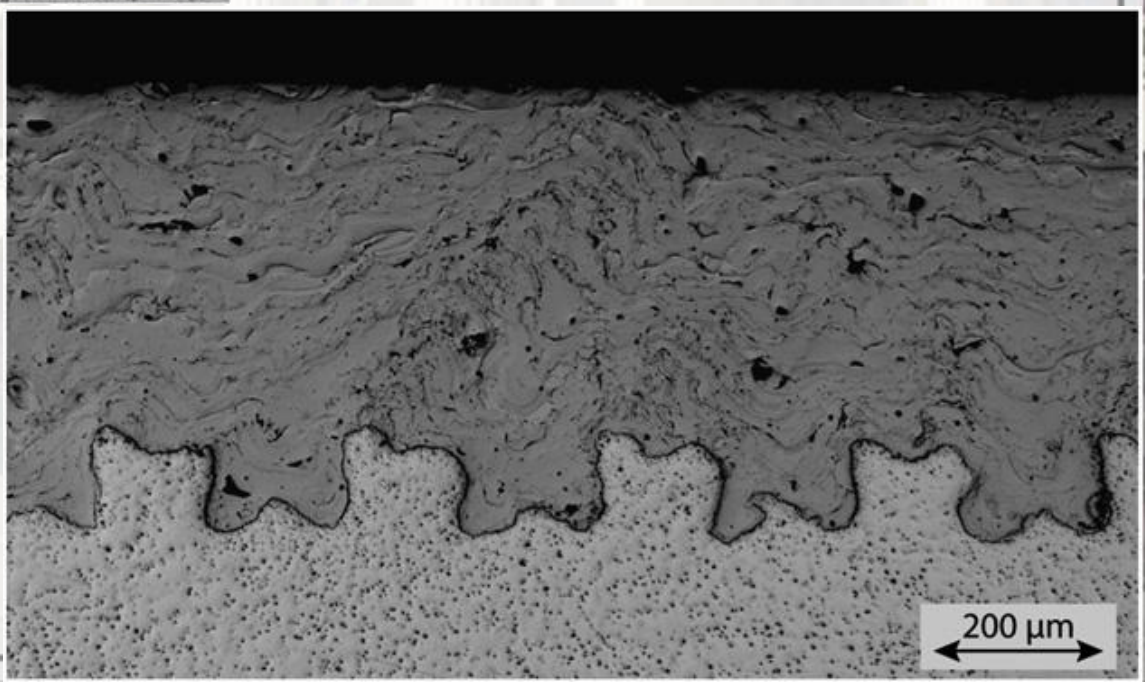
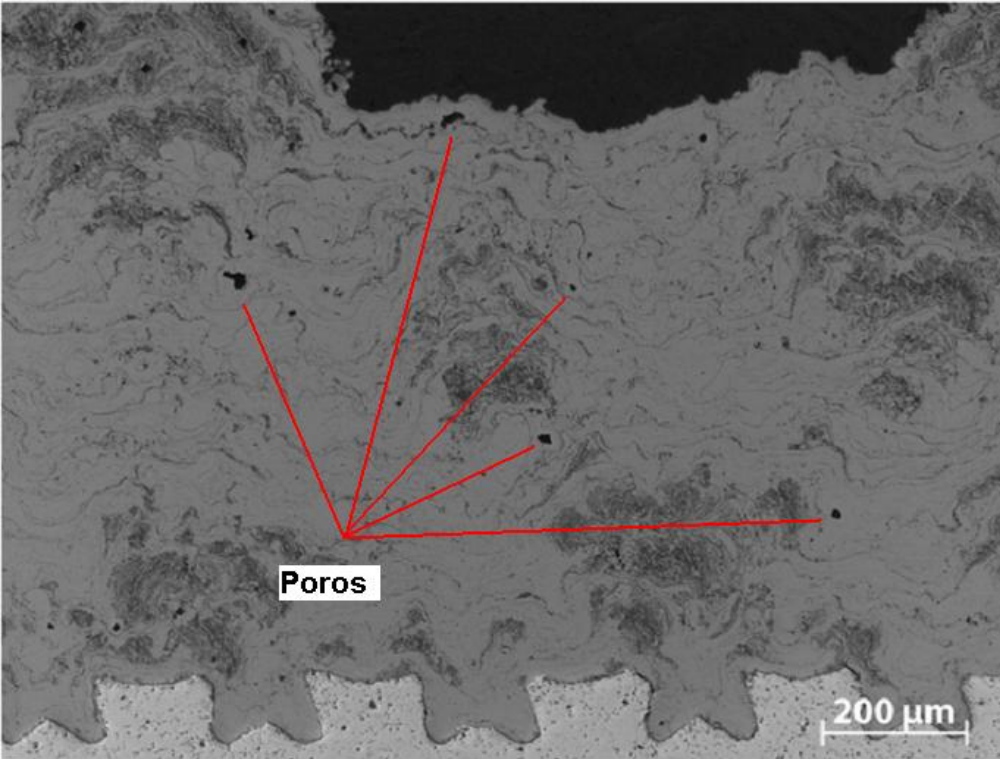


Plasma.wmv

PLASMA SPRAY



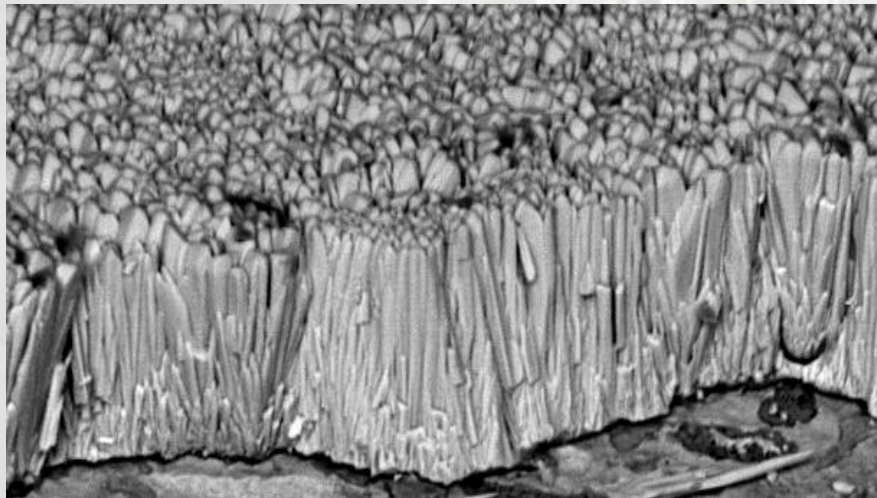
PRE/PÓS -AQUECIMENTO



Deposição

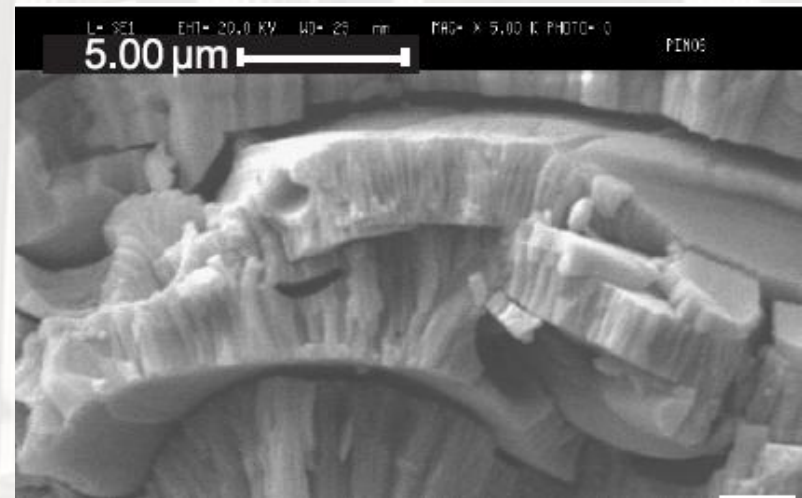
EB-PVD

Estrutura Colunar



APS

Estrutura Lamelar



Parâmetros APS

- Formação do jato de plasma: pistola, composição do gás, potência de operação;
- Pó e sua injeção: Composição, distribuição de tamanho, trajetória;
- Composição e pressão do gás inerte;

Propriedades Alteradas

- Porosidade / condutividade térmica;
- Espessura por passe;
- Dureza / Modulo de Elasticidade
- Trincas no revestimento;
- Resistência durante ciclagem térmica;

Objetivo dos Artigos

- *Manipulation of air plasma spraying* – Estudar o efeito de variação nos parâmetros na resistência durante ciclagem térmica;
- *Characterization of thermal barrier coatings with a gradient in porosity* – Aumento da eficiência com uma multicamada cerâmica;

Manipulation of air plasma spraying

- Variação dos parâmetros:

Table 1 - Different variables for topcoat

Sample designation	Thickness of topcoat (μm)	Spraying distance (mm)	Current (A)	Primary gas flow rate (SPLM)
1	377 \pm 14	80	600	32
2	532 \pm 12	80	600	32
3	688 \pm 9	80	600	32
4	562 \pm 13	80	600	32
5	371 \pm 10	125	550	32
6	289 \pm 10	125	650	32
7	286 \pm 4	125	600	46
8	314 \pm 10	125	600	39
9	355 \pm 14	125	600	32

- Vida durante ciclagem térmica:

Table 3 - Number of cycles to failure for different samples

Sample no.	Thickness (μm)	No of cycles to failure		
		Water quenched	Pressurized air quenched	Long cycling
1	377 \pm 14	90	800	53
2	532 \pm 12	35	755	26
3	688 \pm 9	10	260	4
4	562 \pm 13	26	174	8
5	371 \pm 10	59	228	6
6	289 \pm 10	65	510	16
7	286 \pm 4	70	880	46
8	314 \pm 10	46	358	8
9	355 \pm 14	40	176	5

Manipulation of air plasma spraying

Distância tocha-peça:

- Influência na fluidez e na energia das partículas, modificando a deposição das lamelas e a aderência entre elas;
- Promove um aumento na aderência e resistência a corrosão;

Manipulation of air plasma spraying

Espessura:

- Revestimentos mais espessos ($>300 \mu\text{m}$) tendem a criar trincas;
- Maiores espessuras geram maiores gradientes de temperatura, levando a maiores tensões internas;

Manipulation of air plasma spraying

Espessura:

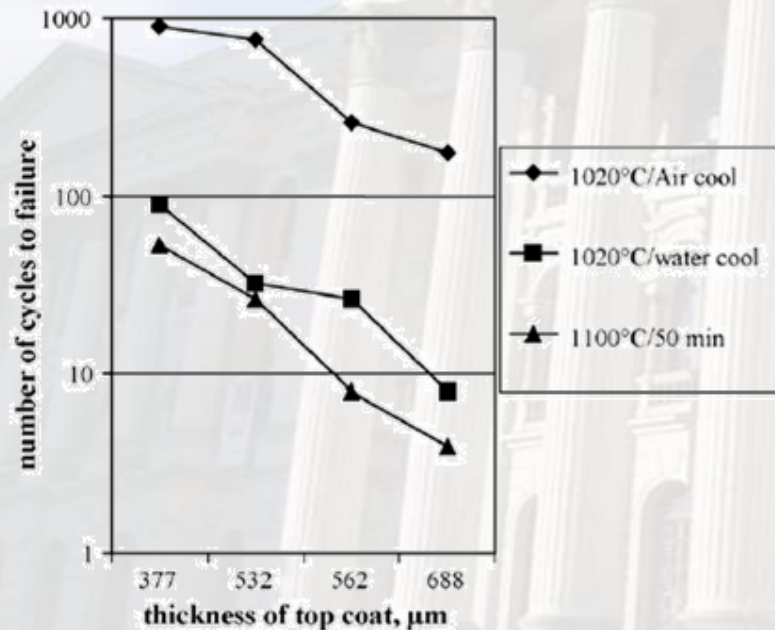


Fig. 1 - Semi-log plot showing the effect of topcoat thickness on the number of thermal cycles in different thermal cycling conditions.

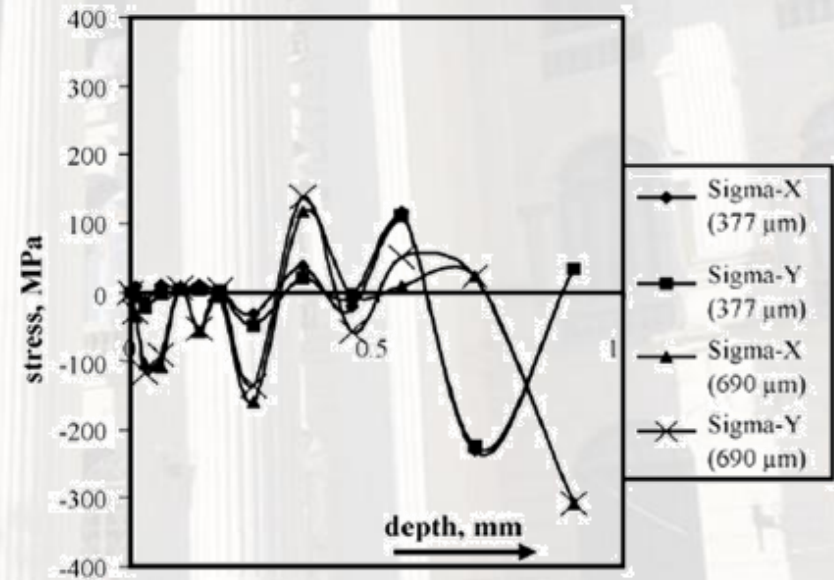


Fig. 2 - Residual stresses in as-sprayed 377 and 690 μm thick topcoats.

Manipulation of air plasma spraying

Potência do Plasma:

- Maior potência do plasma tende a diminuir a porosidade e aumentar a tenacidade;

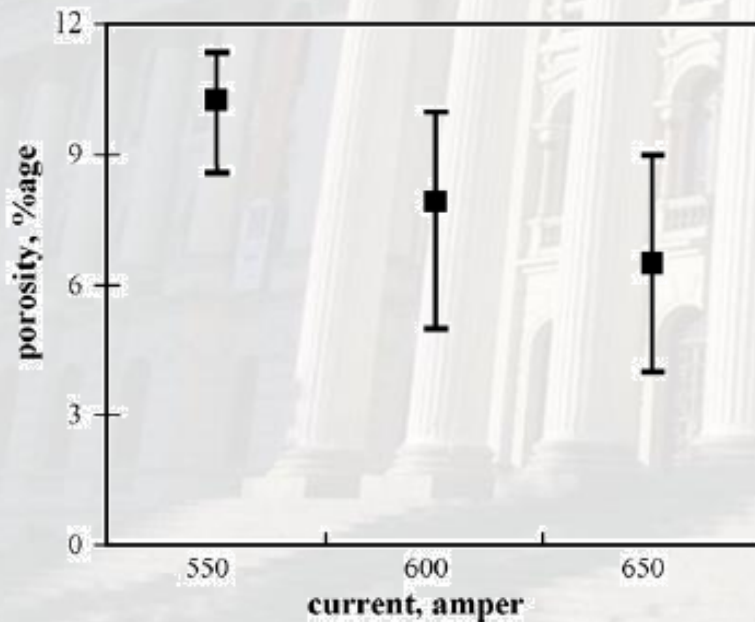


Fig. 3 - Effect of torch power on porosity.

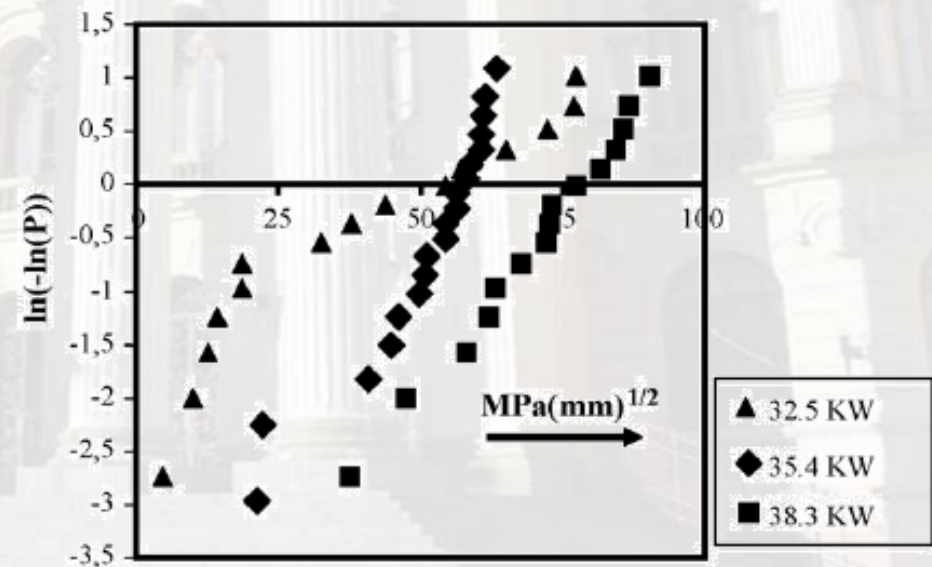


Fig. 4 - Effect of torch power over the interfacial indentation toughness.

Manipulation of air plasma spraying

Efeito do gás de arraste:

- Aumento no fluxo do gás aumenta a porosidade e diminui a tenacidade;

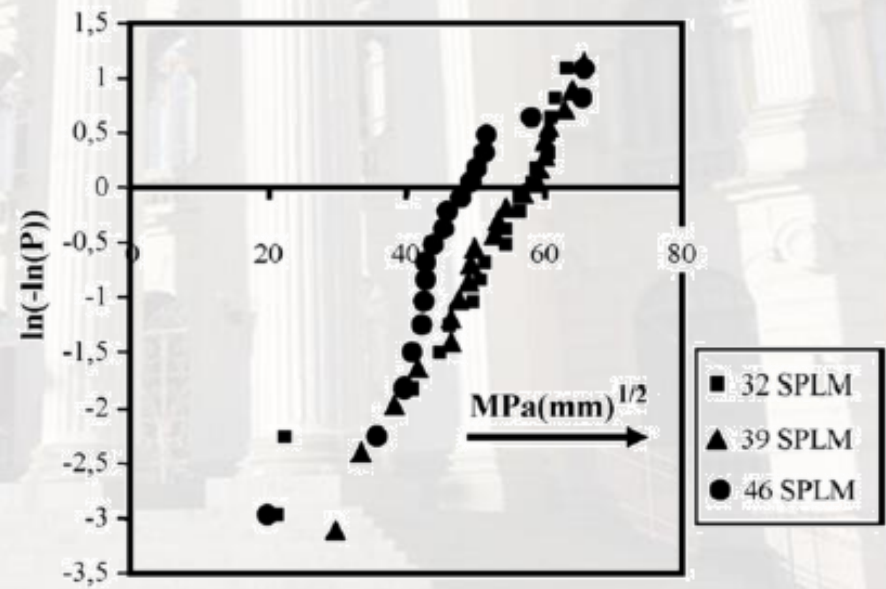
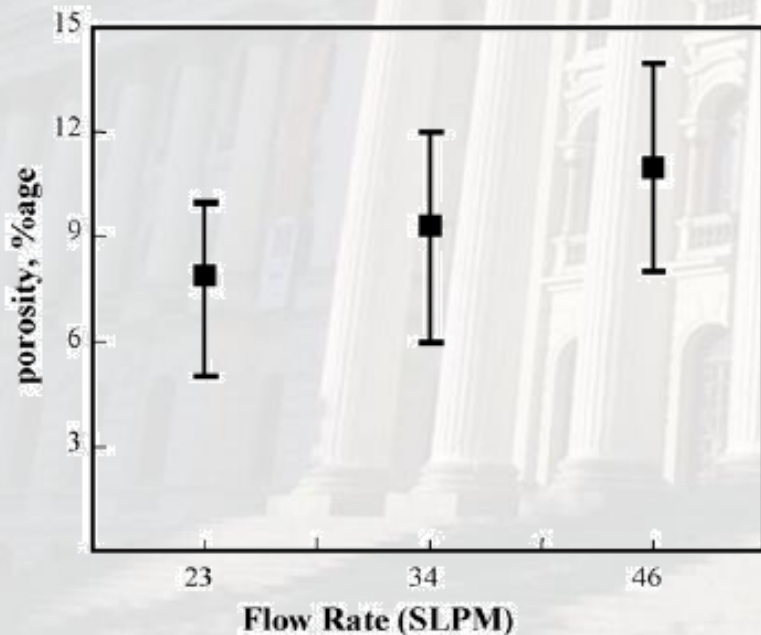


Fig. 6 - Effect of primary gas flow rate over the interfacial indentation toughness.

Fig. 5 - Effect of flow rate over the porosity.

Manipulation of air plasma spraying

Parâmetro crítico de choque térmico:

- Criação de um parâmetro correlacionando potência do plasma, espessura da camada cerâmica, fluxo do gás de arraste e distância entre tocha e peça para avaliar a resistência ao choque térmico;

$$CTSP = \frac{(\text{power})(\text{thickness})(\text{flow})}{(\text{distance})}$$

Manipulation of air plasma spraying

Parâmetro crítico de choque térmico:

- Porosidade possui comportamento similar com a resistência ao choque térmico;

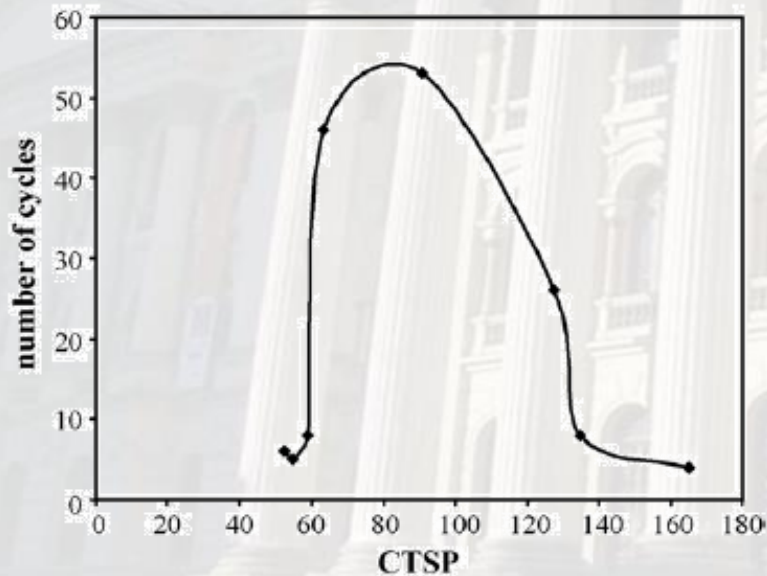


Fig. 9 - Number of sustained cycles achieved during 1100 °C/50 min thermal cycling as a function of critical thermal shock parameter.

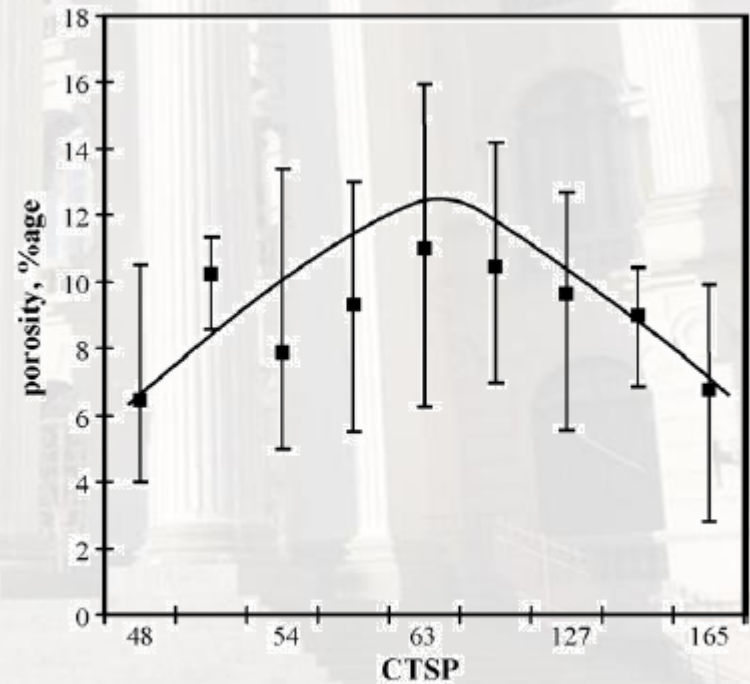


Fig. 12 - Variation of percentage porosity with factor CTSP.

Manipulation of air plasma spraying

Parâmetro crítico de choque térmico:

- Porosidade é relacionada com o aumento a resistência ao choque térmico;

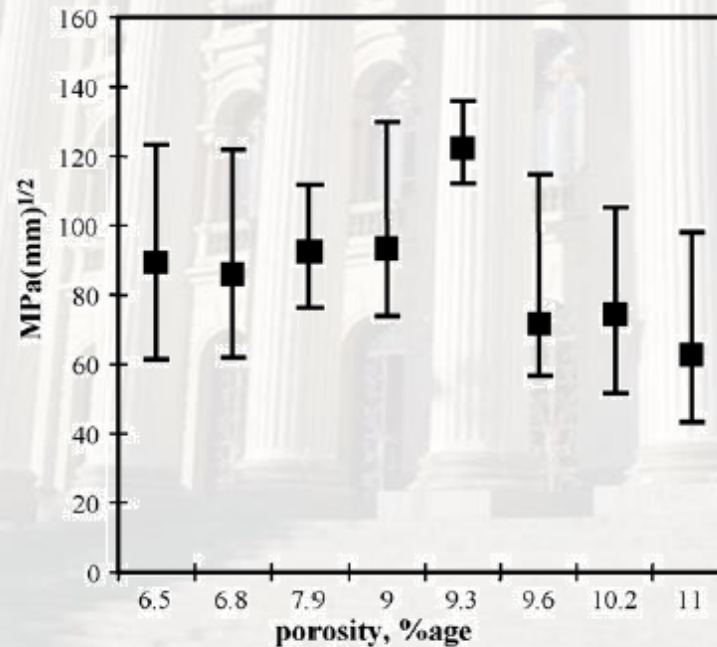
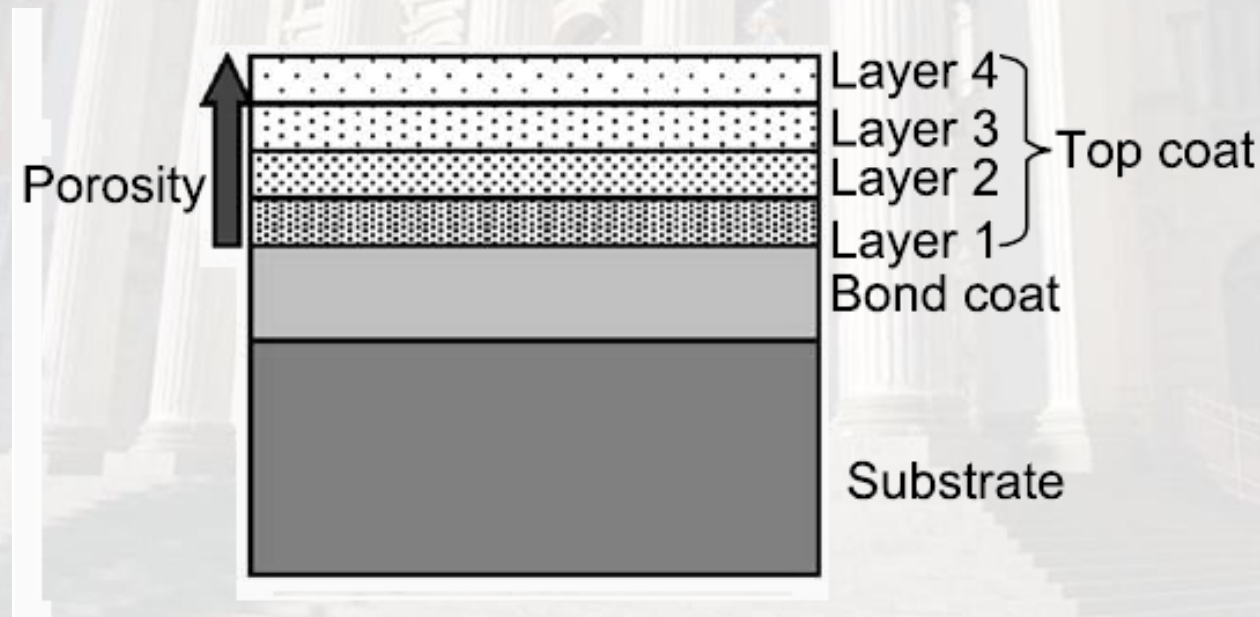


Fig. 11 - Variation of fracture toughness with porosity.

Characterization of thermal barrier coatings with a gradient in porosity

- Criar um revestimento com gradiente de porosidade;

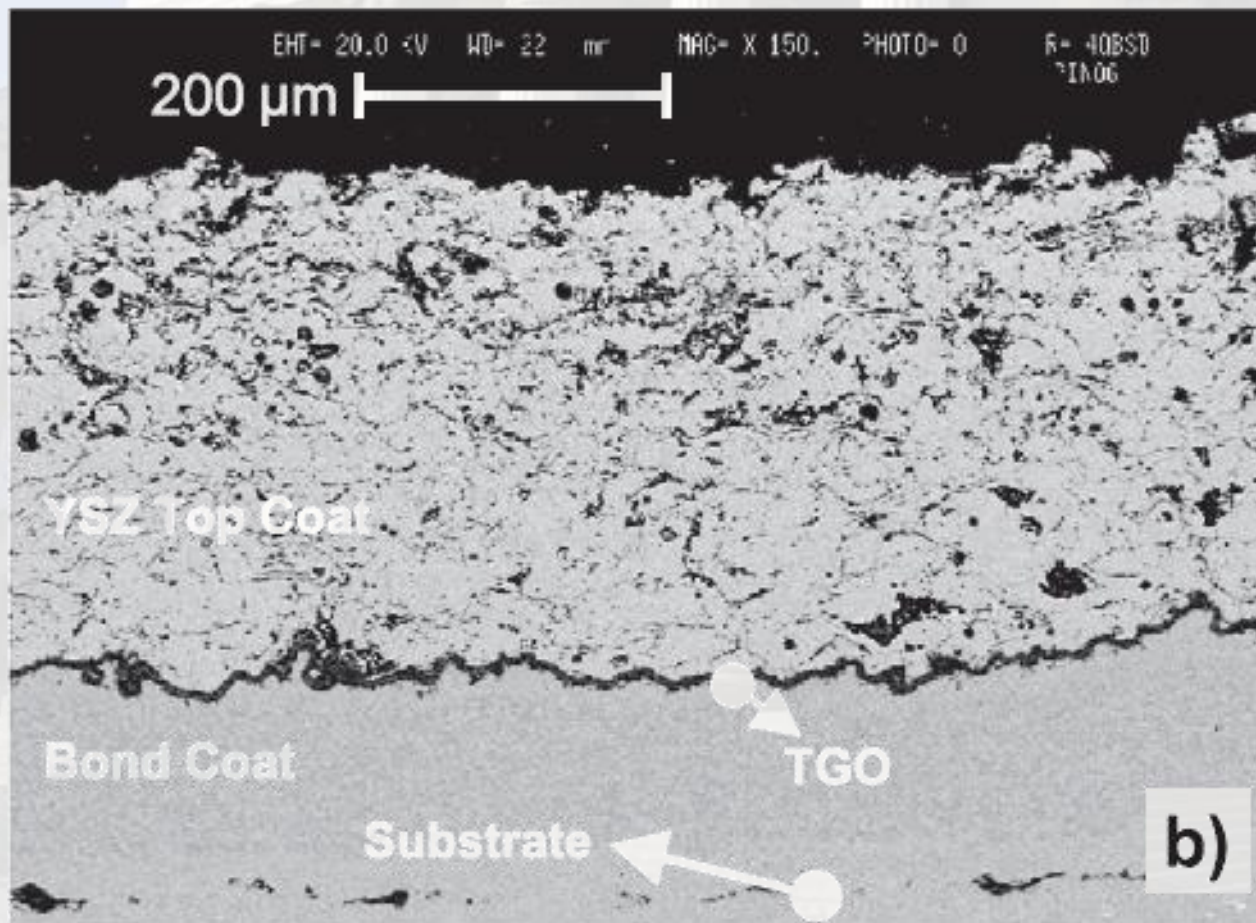


Characterization of thermal barrier coatings with a gradient in porosity

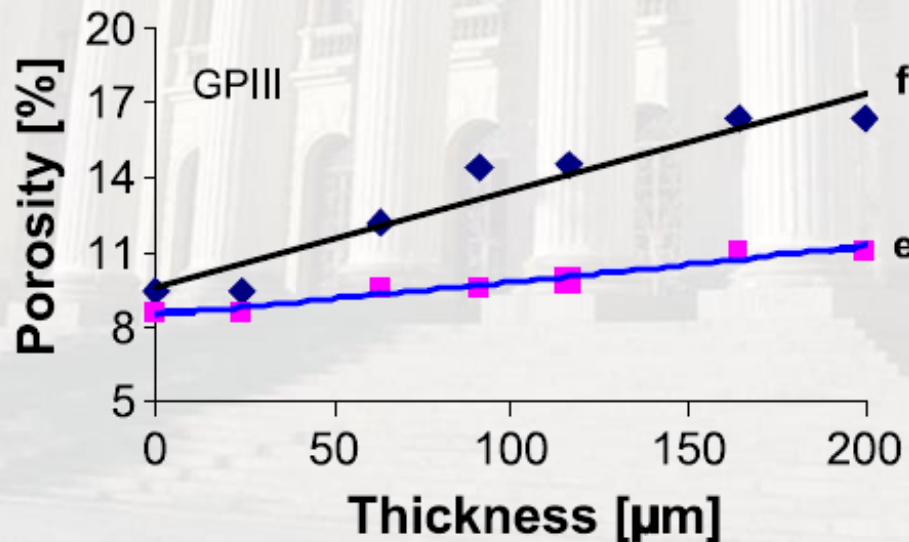
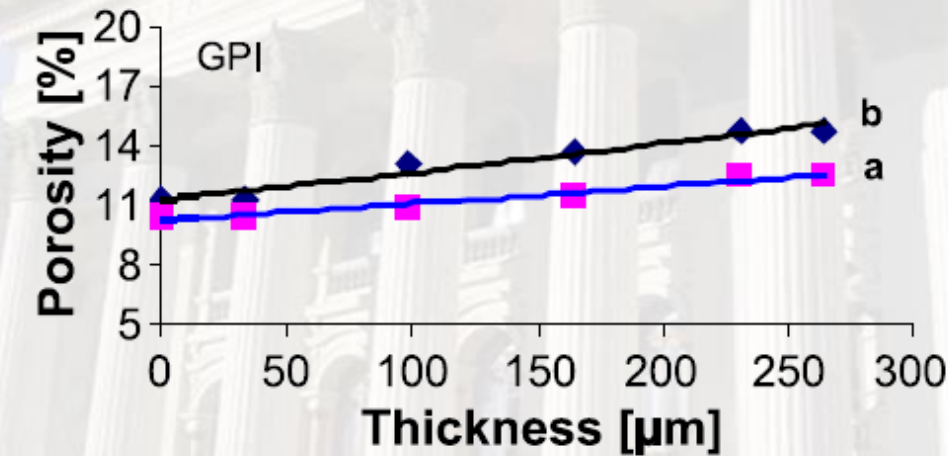
Deposition parameters

Deposition parameters	APS			
	HP	GPI	GPII	GPIII
Power (kW)	14.5	20.5 to 14.5	20 to 15	20.5 to 14.5
Int. of current (A)	240	300 to 240	300 to 240	300 to 240
Gas plasma (slpm)	20.1/13.1 (Ar/He)	20.1/13.1 (Ar/He)	20.1/13.1 (Ar/He)	20.1/13.1 (Ar/He)
Gas transport (Ar) (slpm)	1.5	1.5	1.5	1.5
Diameter of nozzle (mm)	10	10	10	10
Flux of powder (g/min)	8.5	8.5	8.5	8.5
Distance of gun to substrate (mm)	90	90	120	90 to 120
Pressure in the chamber (mbar)	atm	atm	atm	atm
Substrate temperature (K)	423	473–423	453	423
Thickness of the total layer (μm)	300	265	305	200
Gun speed (mm/s)	500	500	500	500

Characterization of thermal barrier coatings with a gradient in porosity



Characterization of thermal barrier coatings with a gradient in porosity



Characterization of thermal barrier coatings with a gradient in porosity

- Segundo os autores ocorreu um aumento na resistência a ciclagem térmica nessas amostras, demonstrando que pode-se aumentar a vida do revestimento junto com sua eficiência.

Obrigado.