



# Development of Environmental Barrier Coatings on Ceramic Matric Composites assisted by LASAT (Laser Shock Adhesion Test)

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## ► To cite this version:

Guillaume Cottin, Vincent Guipont, Vincent Maurel, Emine Bakan, Robert Vassen, et al.. Development of Environmental Barrier Coatings on Ceramic Matric Composites assisted by LASAT (Laser Shock Adhesion Test). HT-CMC, Sep 2019, Bordeaux, France. hal-02185840

HAL Id: hal-02185840

<https://minesparis-psl.hal.science/hal-02185840>

Submitted on 2 Dec 2020

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# Development of EBC on CMC assisted by LASAT (Laser Shock Adhesion Test)

## COLLABORATIVE WORK

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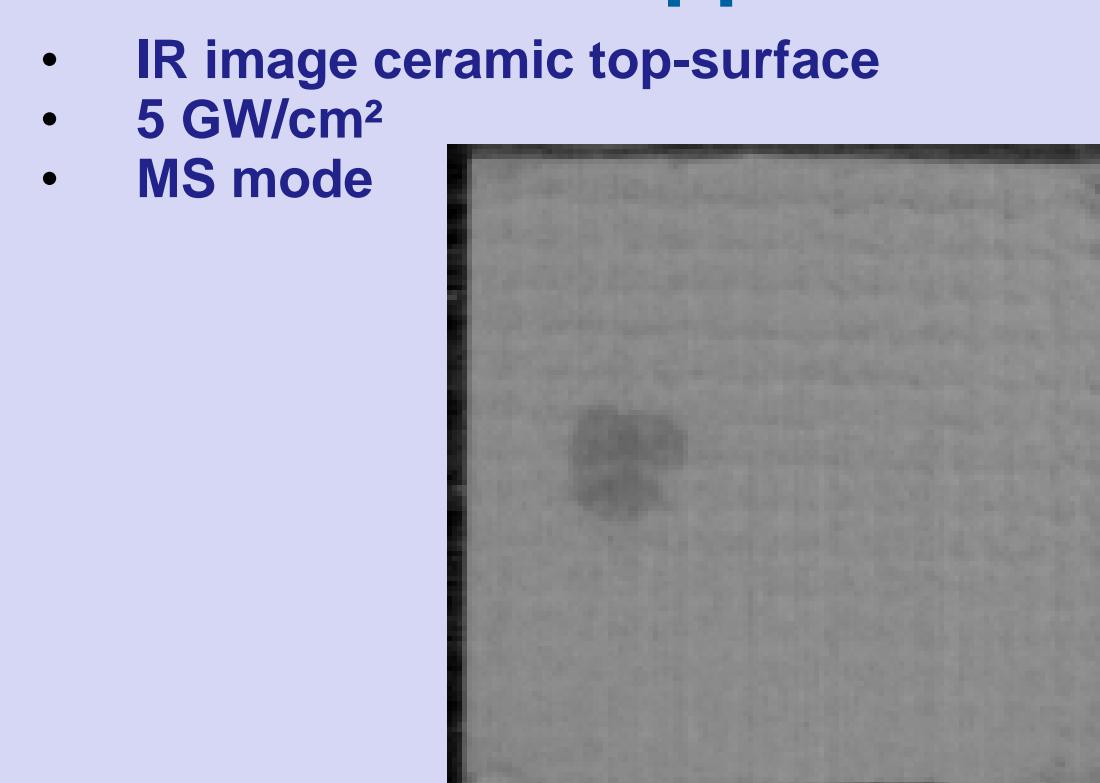
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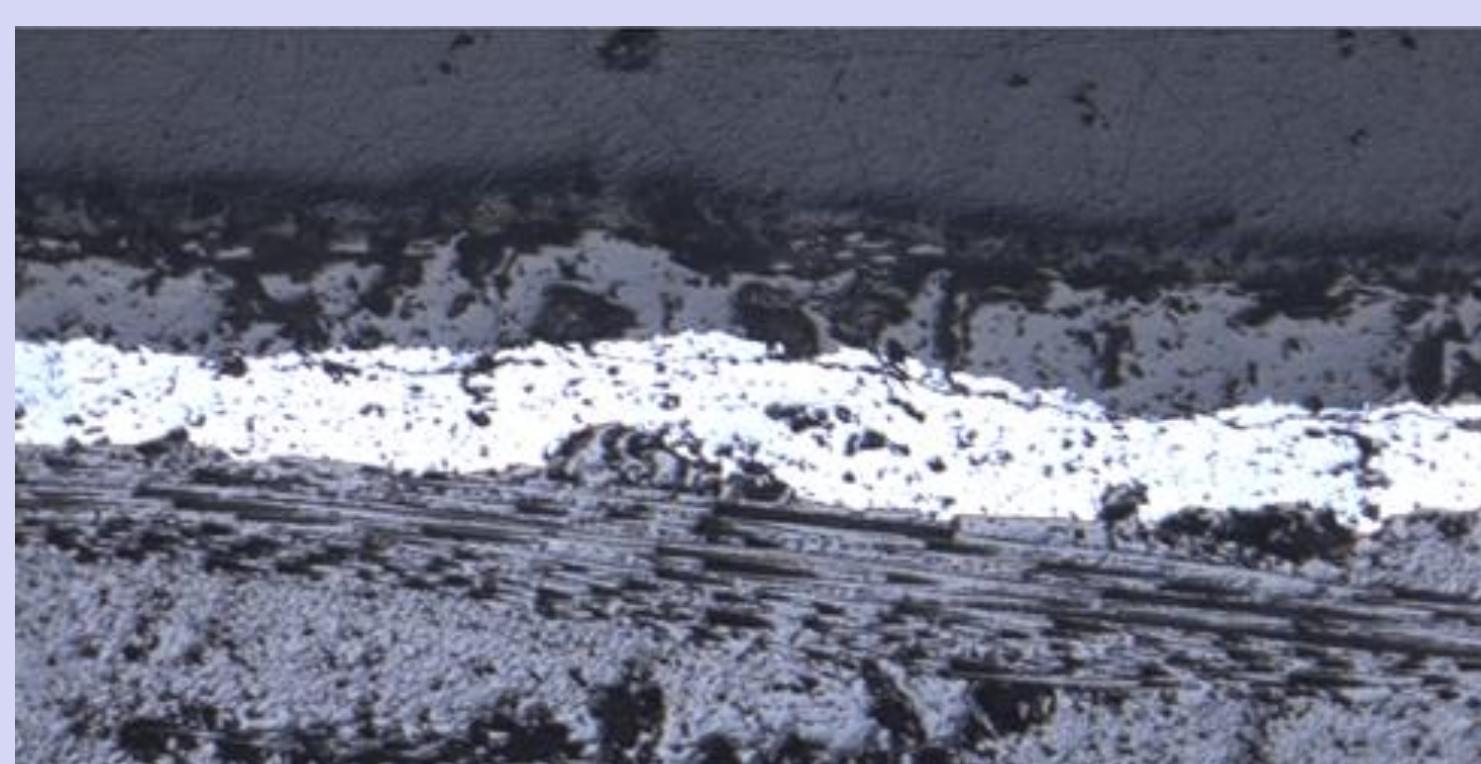


## HIGHLIGHTS

### 1. LASAT can be applied to CMC/EBC



### 2. Laser-induced crack is located within the Si layer (HV-APS sample)



### 3. LASAT on ceramic side is applicable

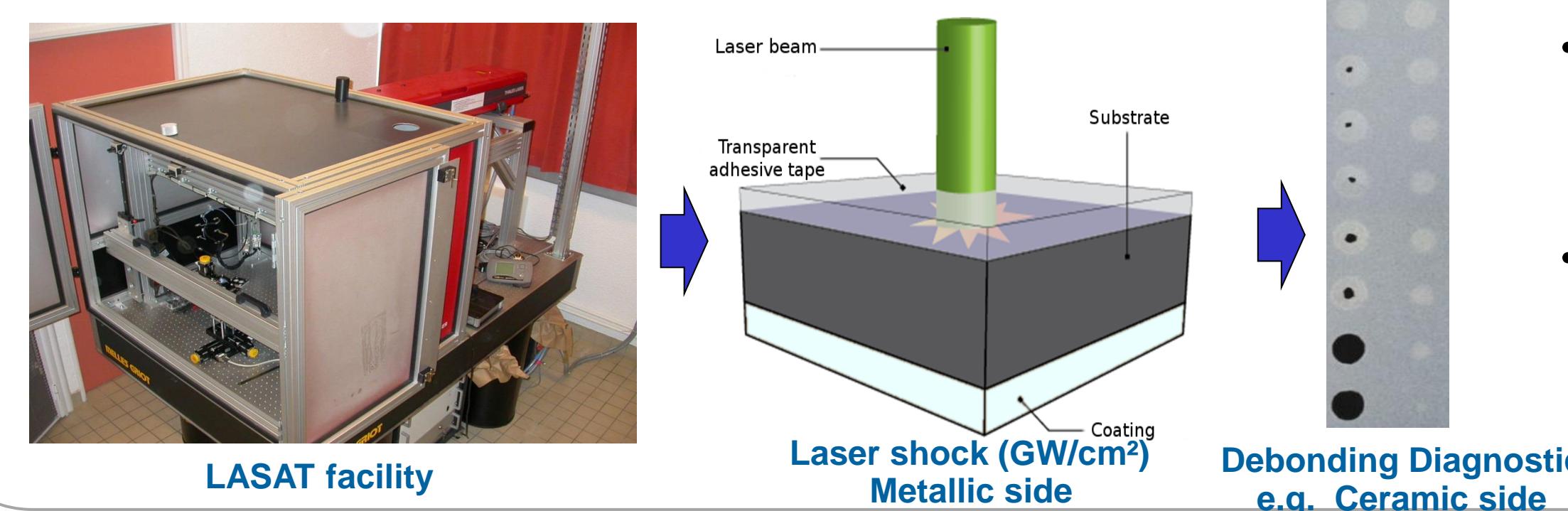
## CONTACT

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## CONTEXT: Laser-driven debonding → Interface strength of ceramic coatings

### LASAT: Laser Shock Adhesion Test



#### Saga –Thales Laser :

- maximum energy: 2J
- pulse duration: 5.2 ns
- wavelength: 532 nm

#### Two settings parameters are:

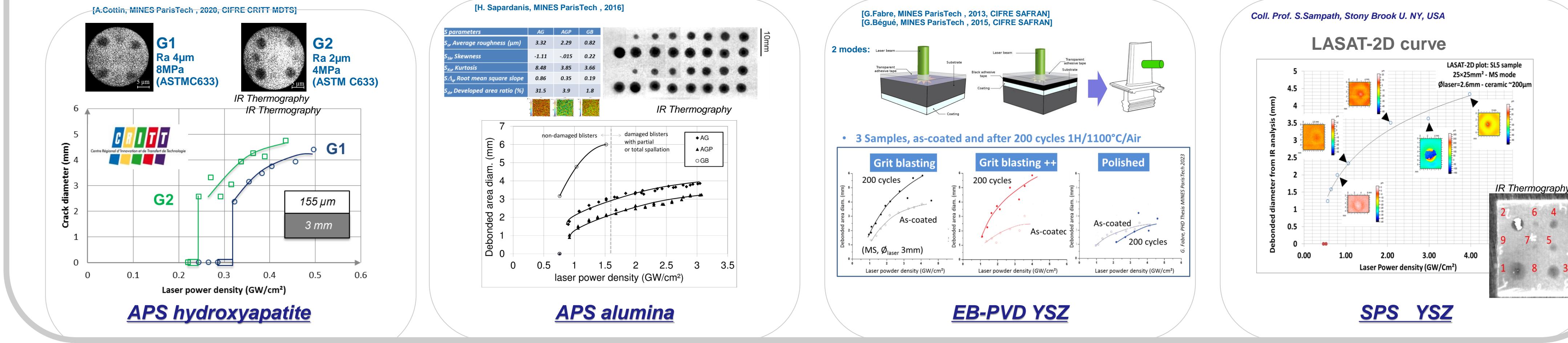
- Irradiated area diameter,  $\varnothing_{\text{laser}}$
- Laser energy, J

– laser fluency (power density),  $0,1 \rightarrow 10 \text{ GW/cm}^2$

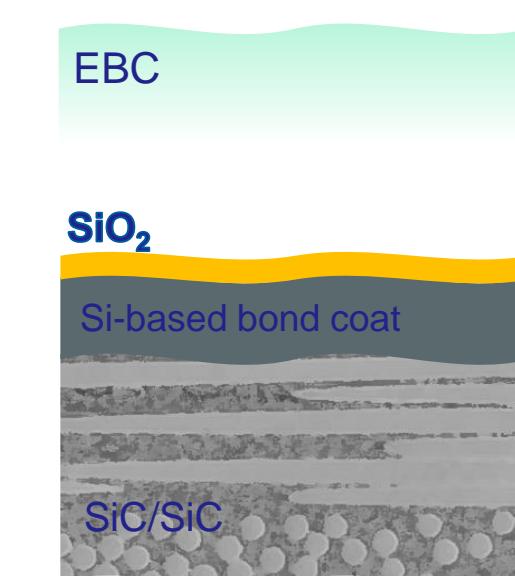
#### For coating system:

- Substrate thickness
- Coating thickness
- Failure threshold / LASAT 2D curves
- No specific geometry
- No contact, Local assessment

## BACKGROUND: LASAT applied to ceramic coatings on metallic substrates



## OBJECTIVES



### Development of Plasma Spray Multilayered Environmental Barrier Coatings on CMCs

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LASAT applied to EBC?  
→ Assessment of interface strength of CMC/EBC

## MATERIALS AND PROCESSES

### Spraying experiments



### Sample 1 Samples Dimensions

	SIC/SIC	Si	$\text{Yb}_2\text{Si}_2\text{O}_7$	Plasma
#1	25x25 mm <sup>2</sup>	3.4 mm	115 $\mu\text{m}$	109 $\mu\text{m}$ APS
#2	25x25 mm <sup>2</sup>	3.4 mm	92 $\mu\text{m}$	123 $\mu\text{m}$ HV-APS

Sample #1 :  $\text{Yb}_2\text{Si}_2\text{O}_7$  APS

Sample #2 :  $\text{Yb}_2\text{Si}_2\text{O}_7$  HV-APS

### LASAT experiments

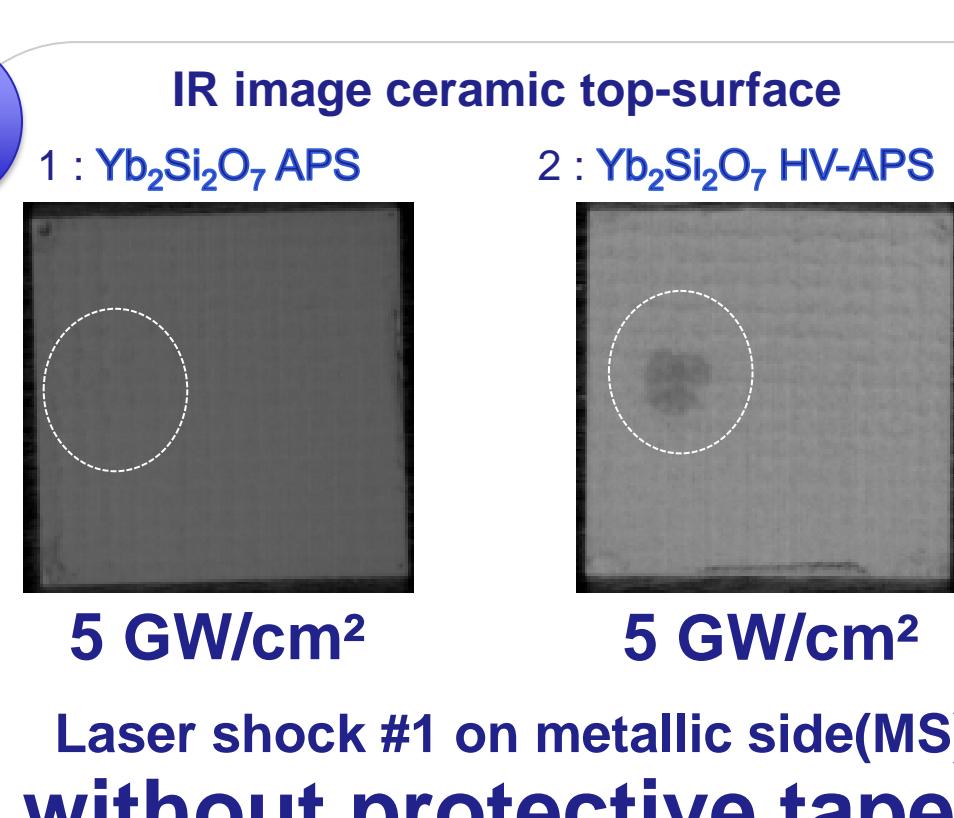
- $\varnothing_{\text{laser}}=3.1\text{mm} / P=2\rightarrow5 \text{ Gw/cm}^2$
- Confinement: water, adhesive tape with/without protective tape
- Metallic side (MS) or ceramic side (CS)

### Diagnostics:

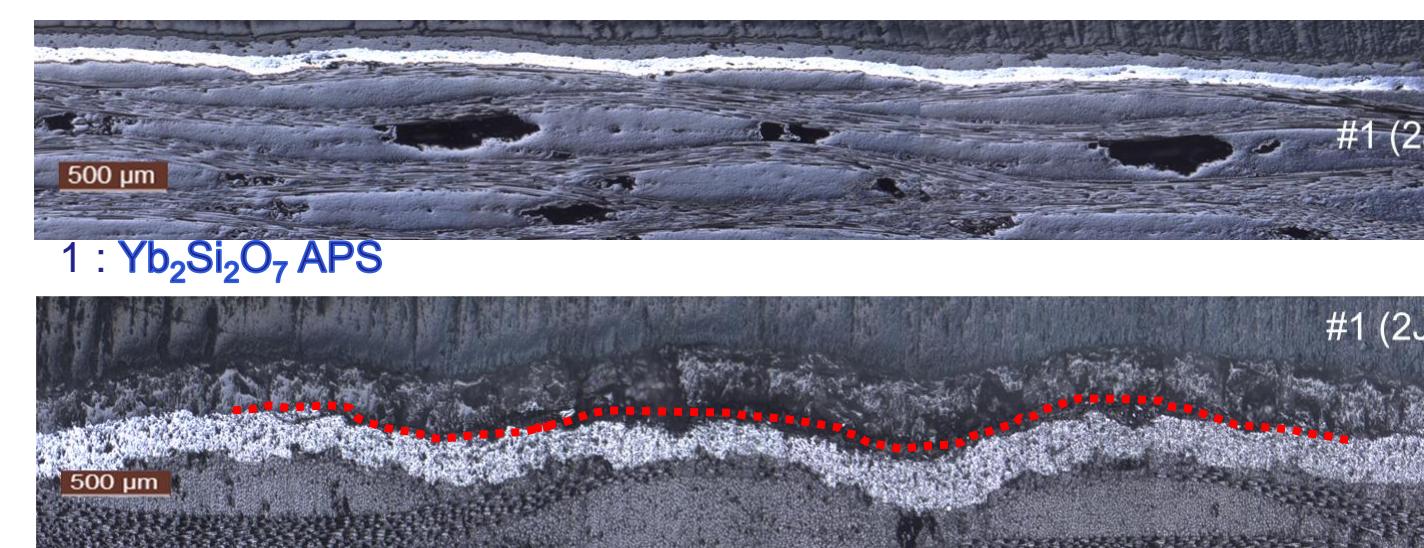
- Optical top-surface image
- IR camera / substrate @50C
- Cross-section / OM

## MAIN RESULTS

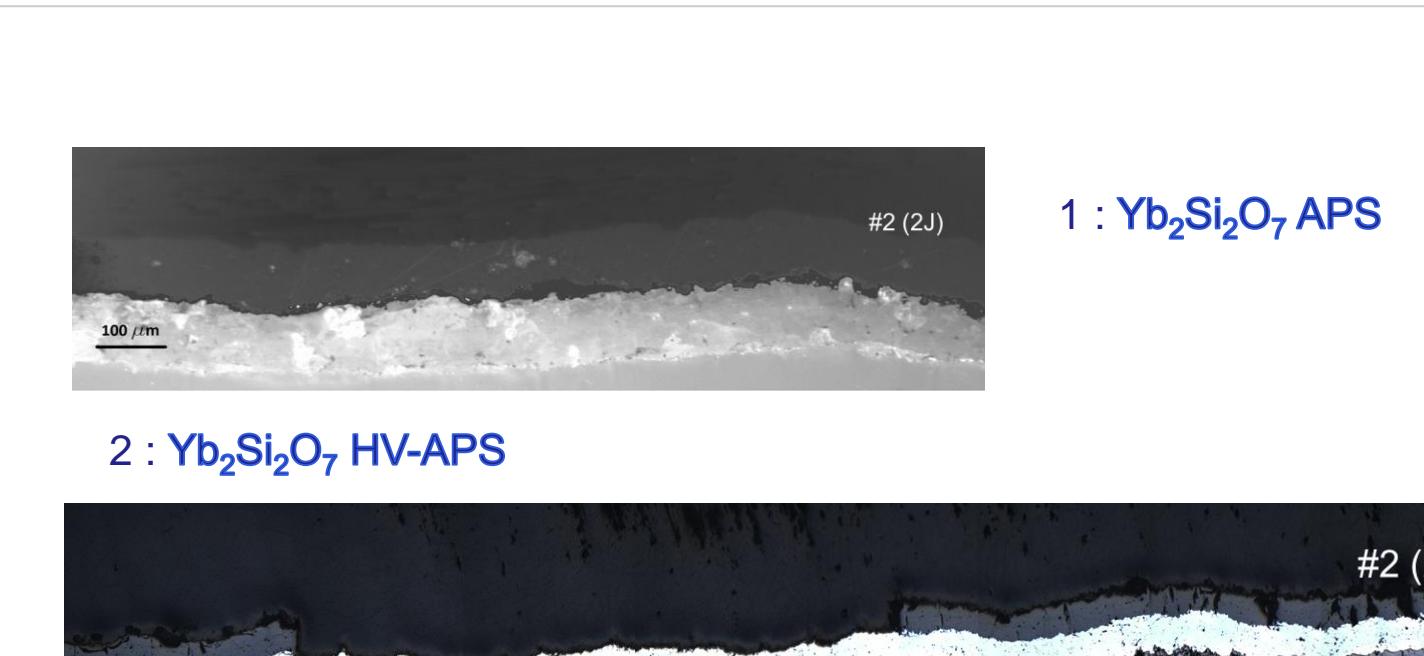
1



Laser shock #1 on metallic side(MS)  
without protective tape



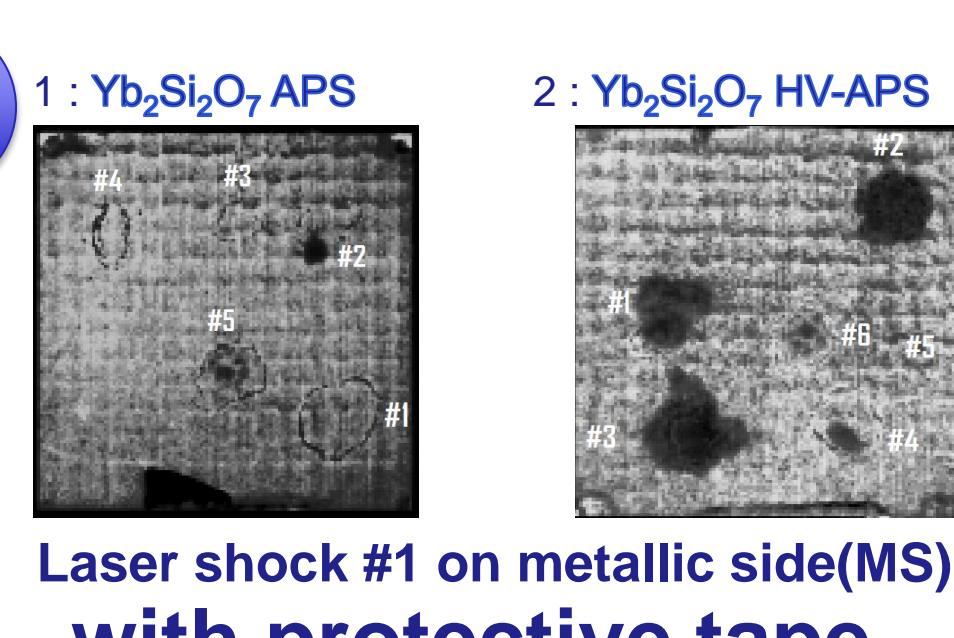
#1 (2J)



#2 (2J)

- Debonding occurred only for HV-APS sample
- IR imaging is applicable, not optical imaging
- Pores are evidenced within CMC substrate

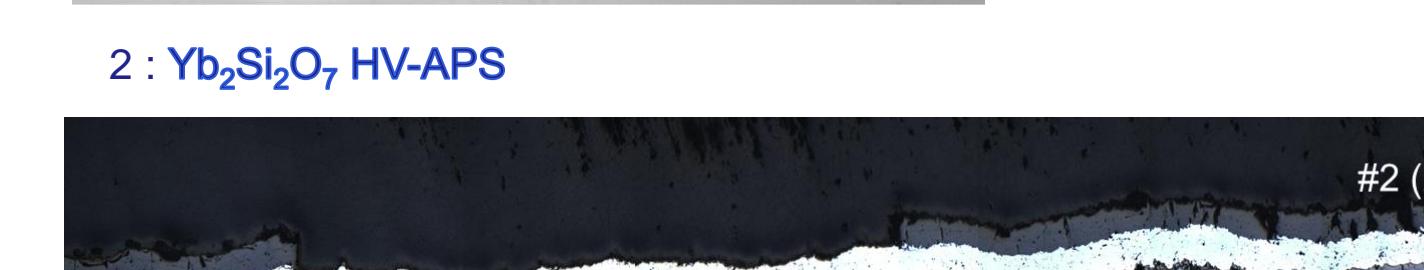
2



Laser shock #1 on metallic side(MS)  
with protective tape  
IR image ceramic top-surface



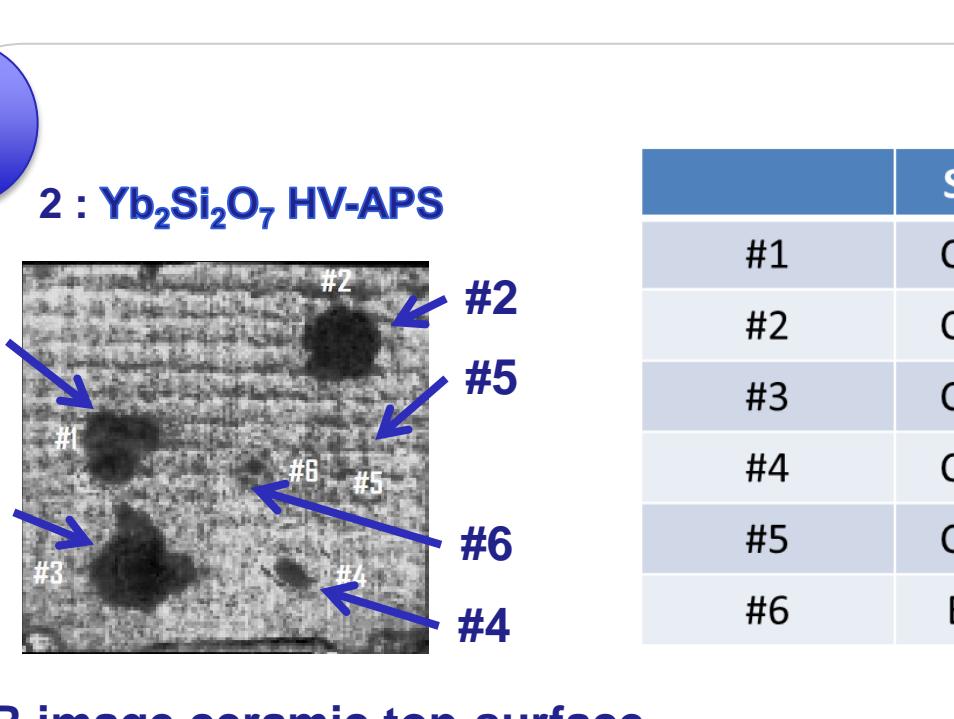
#1 (2J)



#2 (2J)

- Small crack in case of 1 :  $\text{Yb}_2\text{Si}_2\text{O}_7$  APS
- Spallation in case of 2 :  $\text{Yb}_2\text{Si}_2\text{O}_7$  HV-APS
- IR imaging is applicable for small crack
- Protective layer and water increase laser-induced input pressure

3



IR image ceramic top-surface

	Side	$\text{GW/cm}^2$	Damage	Laser shock conditions
#1	CMC	5,1	Crack 5 mm	Without protective tape + transparent tape
#2	CMC	4,8	spallation	With protective tape + water
#3	CMC	3,7	spallation	With protective tape + water
#4	CMC	2,5	Crack 1.2 mm	With protective tape + water
#5	CMC	1,9	Crack 0.8 mm	With protective tape + water
#6	EBC	4,9	Crack 0.5 mm	With protective tape + water

- Crack size is decreasing with laser energy
- Crack located Si Si near  $\text{Yb}_2\text{Si}_2\text{O}_7$  coating
- LASAT with CS mode is applicable

## CONCLUSIONS

- LASAT can be applied to CMC/EBC systems involving SiC/SiC -Si-Yb<sub>2</sub>Si<sub>2</sub>O<sub>7</sub>
- HV-APS 25x25 mm<sup>2</sup> sample exhibited a conventional behaviour upon LASAT → LAST 2D curves can be envisaged
- IR imaging can be advantageously envisaged for a non destructive assessment of the interfacial damage
- MS or CS modes can be envisaged, the use of a protective layer is preferred
- The weakest and lowest toughness interfacial zone seems to be located within the Si layer after deposition
- The presence of large pores within CMC may have attenuated the propagating shockwave in case of the APS sample

