# Laser assisted brazing of titanium to aluminum alloy

I. Tomashchuk, P. Sallamand, M. Duband
Laboratoire Interdisciplinaire Carnot de Bourgogne, UMR 6303 CNRS - Université de Bourgogne-Franche-Comté, 12, rue de la Fonderie – 71200 Le Creusot, France

## Introduction

Laser assisted brazing with Al-Si fillers is a perspective method for joining of aluminum alloys to titanium. The quality of brazed interface is determined by Ti diffusion in the melted zone that becomes, after the solidification, a compact layer of Al-Ti-Si phases. The present work introduces multiscale model that allows estimating diffusion process at titanium-melted zone interface in function of thermal history of welded plates.

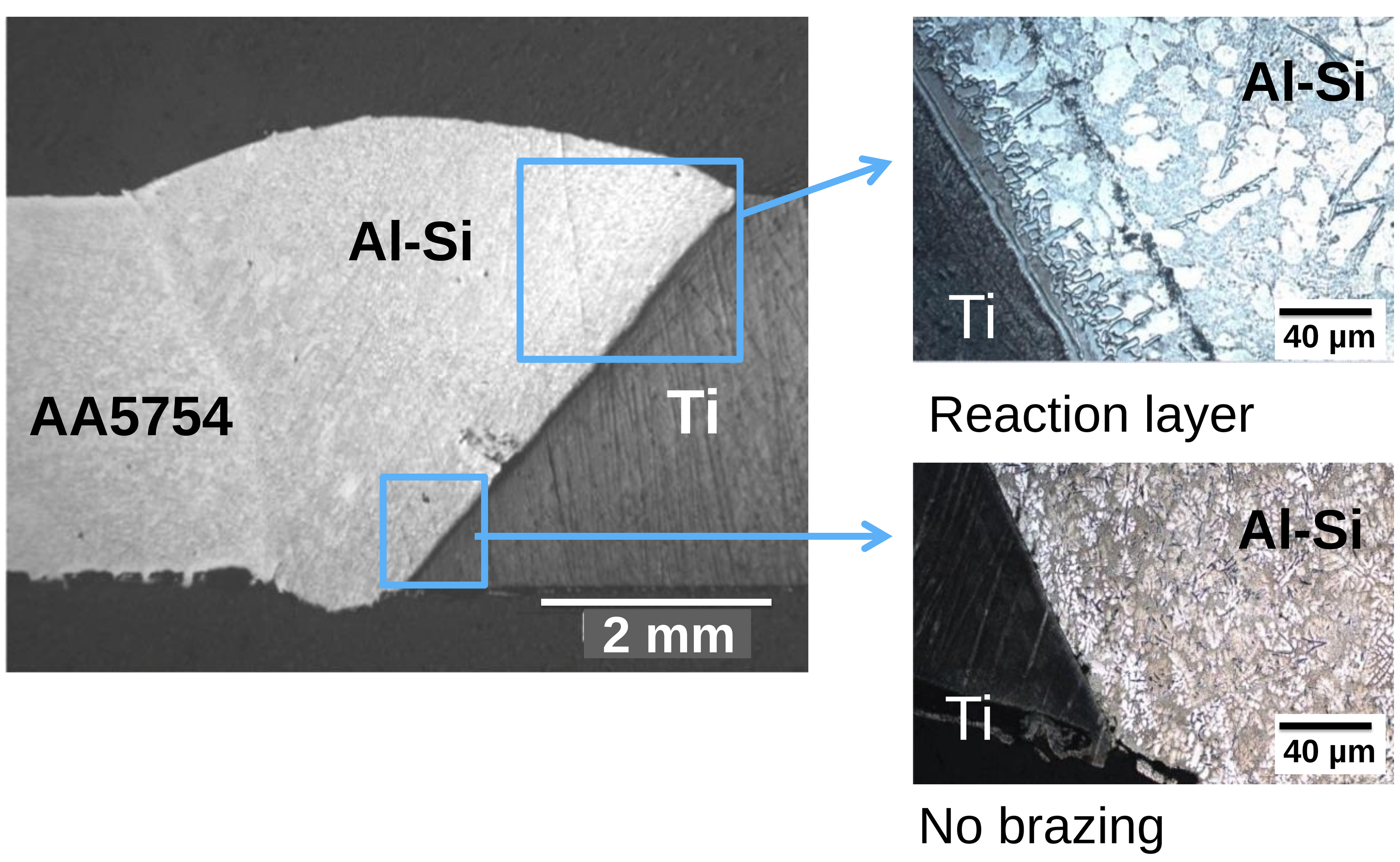



**Figure 1**. Typical joint aspect and microstructure

## Computational Methods

Heat transfer equation is solved in time dependent form over 3D domain including welded plates and pre-filled chamfer :

$$\rho \cdot C_p \cdot \frac{\partial T}{\partial t} + \vec{\nabla}\left(-k\vec{\nabla}T\right) = 0$$

Defocalized double spot laser is represented by a tandem of two half-spots with Gaussian distribution (distance between the spots 2b = 1.2 mm) :

$$q_1 = \frac{a \cdot P}{2 \cdot \pi \cdot R^2}\exp\left(-\frac{(x-b/2)^2}{R^2} - \frac{(y+V_w \cdot t)^2}{R^2}\right)\cdot[x > -b/2]$$

$$q_2 = \frac{a \cdot P}{2 \cdot \pi \cdot R^2}\exp\left(-\frac{(x+b/2)^2}{R^2} - \frac{(y+V_w \cdot t)^2}{R^2}\right)\cdot[x < b/2]$$

Resulted thermal field is exported into 2D model representing the transversal cut of the chamfer.
Fick equation is solved in 2D model :

$$\frac{\partial c_{Ti}}{\partial t} + \vec{\nabla}\left(-D_{Ti}\vec{\nabla}c_{Ti}\right) = 0$$

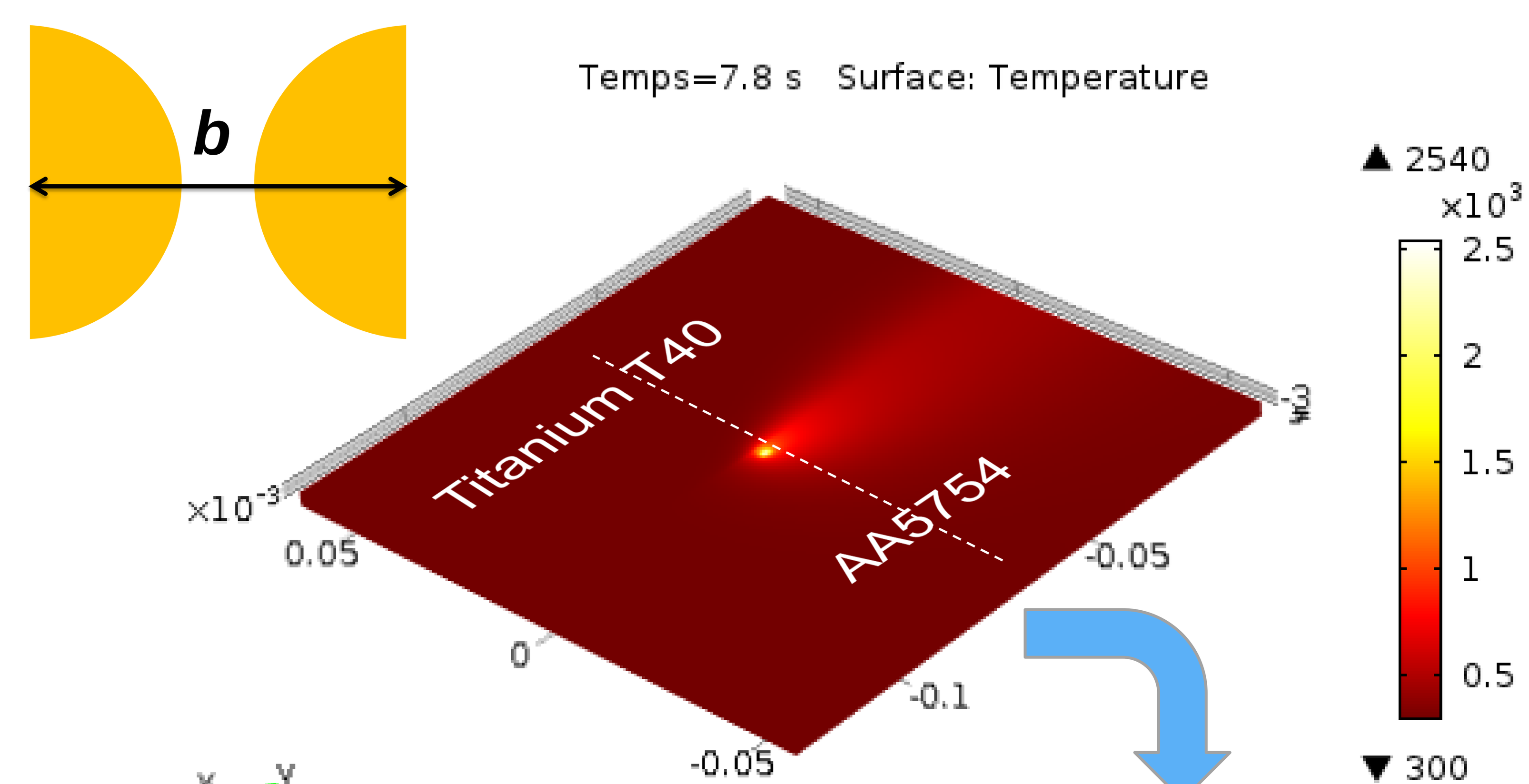
where $D_{Ti} = D_0 \cdot \exp\left(-\frac{E}{RT}\right)$

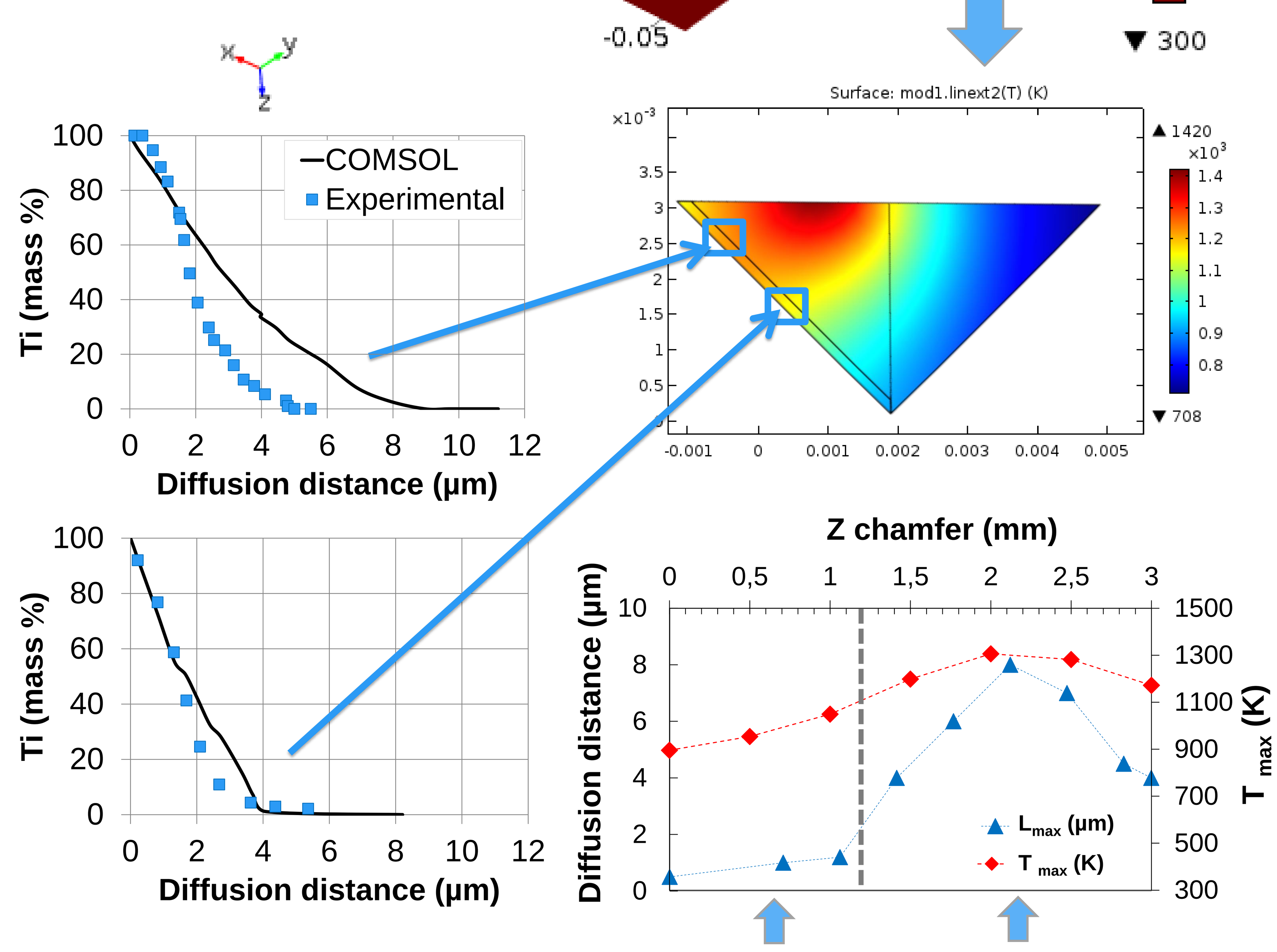
## Results

Accordingly to experimental data, efficient brazing can take place if diffusion distance of Ti reaches 3 µm. In this way, it is possible to track the zones of efficient brazing by application of following condition:

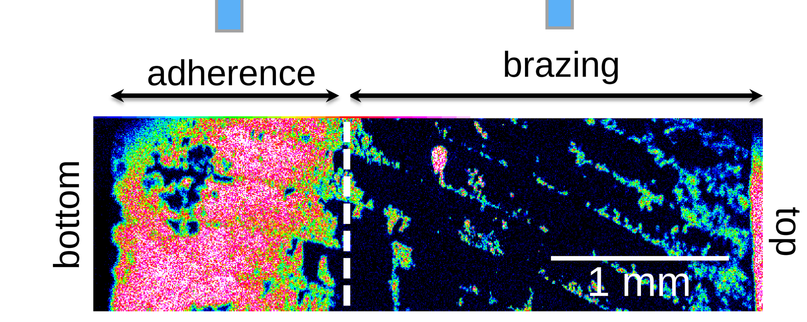
$$z'_B = (z'_{max} - z'_{min}) \cdot (L^{max}_{C_{Ti} \geq 0.01} \geq 3 \cdot 10^{-6})$$

- Calculated thermal history of Ti/melted zone interface indicates that brazing develops if maximal temperature reaches 1200 K.
- Diffusion distances at the top part of chamfer are overestimated because of neglection of convection phenomena.




Laser power :3.0 kW
Scan speed : 0.55 m/min
Defocalization : 8 mm
Chamfer angle : 45°
Offset to Ti : 0.9 mm




Al X-map of broken surface of the chamfer

**Figure 2**. Resulting thermal field and diffusion distances

## Conclusions

Model allows estimating the effect of thermal field on diffusion distance of Ti in the melted zone and thus predicting the fraction of brazed surface of chamfer. Associated parametric studies open the perspectives of optimization of joint geometry and operational parameters.

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