An Original Way Of Using COMSOL Multiphysics® Application Builder To Enhance Simulation Of Laser Welding

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Abstract

The present work introduces a new methodology, based on COMSOL Multiphysics® Application Builder, to account for the "beam trapping" effect in multiphysical modelling of laser welding.

Incident intensities involved in laser welding processes are high enough to induce material vaporization. When such phenomenon occurs, a depression is exerted onto the melt pool by action-reaction principle. As this vapor depression reaches a critical aspect ratio, the incident laser irradiation is reflected several times by the melt pool and get somewhat "trapped", defining the keyhole melting mode. The energy coupling of the whole system thus increases, and the keyhole becomes unstable, as the laser incident power is redistributed heterogeneously by multi-reflections effect. It is thus determinant to account for this phenomenon in multiphysical modelling of laser welding, to better understand keyhole formation process and to assess the conditions of its stability.

To achieve these objectives, the methodology works as follows. On one hand, there is a melt pool model developed with COMSOL Multiphysics® CFD Module, which account for relevant physics to treat the hydrodynamic problem - surface tension, Marangoni convection, recoil pressure. The Arbitrary Lagrangian Eulerian (ALE) method is additionally used to track the metal/gas interface, as it deforms under the action of recoil pressure. On the other hand, there is a laser beam model based on Ray Optics Module, to compute the absorbed laser heat flux in accordance with the keyhole geometry. Both models are run sequentially via a JAVA® method, developed with COMSOL Multiphysics® Application Builder, so that laser heat source is updated self consistently, as the keyhole forms, deforms and fluctuates.

Despite its simplicity, the method is quite efficient and allow simulating transient keyhole formation in accordance with most recent state-of-the-art dynamic x-ray images.

Figures used in the abstract

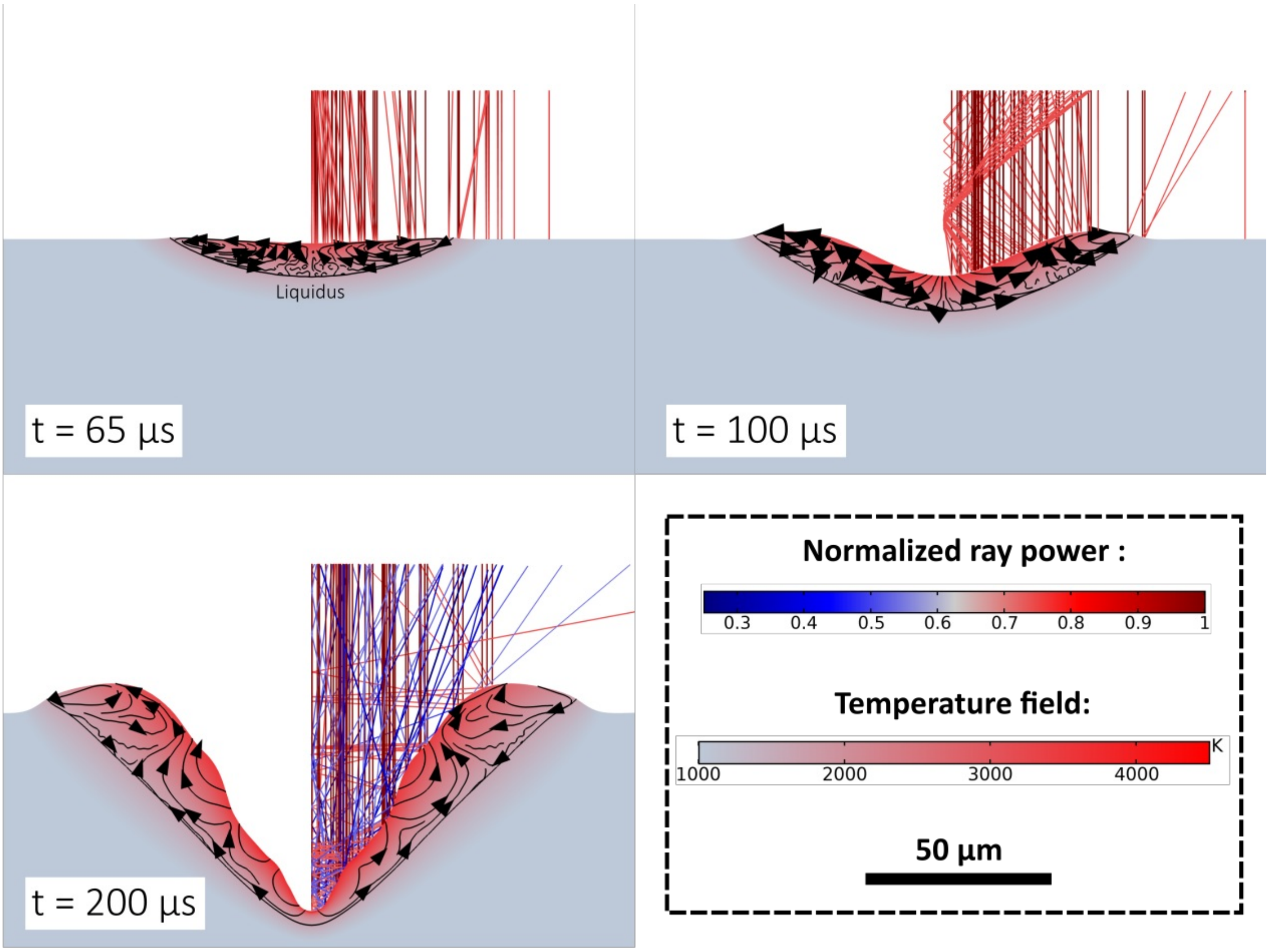

Figure 1 : Keyhole formation process in static laser mode.

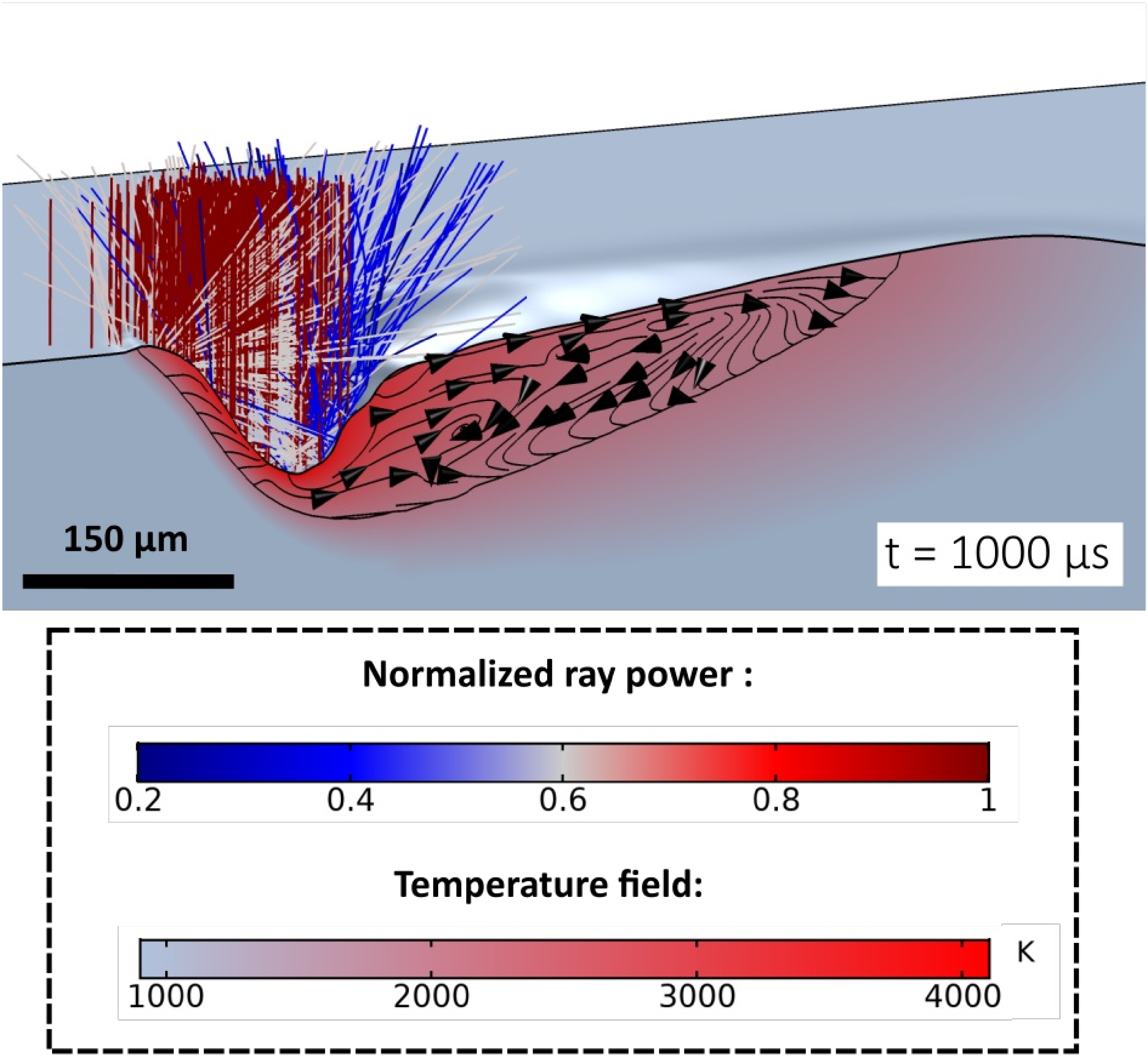

Figure 2 : Keyhole in scanning laser configuration