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# A novel method for observing the micro-morphology of keyhole wall during high-power fiber laser welding

J. L. Zou, S. K. Wu, W. X. Yang, Y. He, R. S. Xiao*
High-power and Ultrafast Laser Manufacturing Lab, Institute of Laser Engineering, Beijing University of Technology, Beijing 100124, China
*Corresponding author, email: rsxiao@bjut.edu.cn

**Abstract:** Most of the laser welding defects are likely to be related to the welding process transport phenomena induced by the energy conversion process in the keyhole. The keyhole wall is the interaction interface between the laser and welded material, and studying its micro-morphology is significant for understanding the energy conversion process. Because the current measuring methods are limited, observation of keyhole wall micro-morphology is still a challenge. In this paper, a novel method was designed. The keyhole wall was preserved as the high-power fiber laser was suddenly shut off during welding process, and then it was measured by using a scanning electron microscopy (SEM). The results show that the laser beam directly acted on the keyhole front wall during welding. The concentric elliptical rings, wrinkles, and ripples were found on the laser-action region. These micro-morphologies indicate that the energy coupling is mainly the absorption of the keyhole front wall, and the keyhole formation is similar to a laser drilling on the keyhole front wall during welding. The novel method can be used to investigate on the formation of the welding defects during high-power fiber laser welding in the future study.

**Keywords:** Fiber laser welding; Keyhole; Concentric elliptical rings; Wrinkle; Energy coupling.

## 1. Introduction

Worldwide, welding is a multibillion-dollar fabrication technology that is used extensively in a variety of industries [1, 2]. Compared to traditional welding techniques, laser welding is expected to be one of most promising advanced connection technologies of the 21st century due to the numerous advantages it offers, such as high speed, high aspect ratio (weld depth to weld width), high precision, high flexibility, and small heat-affected zones [3]. Nevertheless, there are still many problems that plague laser welding technology, such as porosity, excessive spatters, ejection of the plume, and poor welding joints shapes [4~12], and consequently, the development of laser welding technology has been severely restricted. Generally, the nature of laser welding is a energy conversion process from the light of a laser to the heat of a material, and these weld defects are likely to be related to the welding process transport phenomena induced by the energy conversion process, such as heat flow, melting, evaporation, solidification phase changes, melt flow, vapor flow, etc. The keyhole wall is the interaction interface between the laser and the welded materials during laser welding. Thus, obtaining a clear micro-morphology of the keyhole wall will be highly significant to understanding the energy conversion process during laser