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Application of ultrasonic technique to examination of interface between liquid metals and ferritic steel

ポテヒン アレクサンダー[1], クリモフ キリル[1], 大塚哲平[1], 奥田聖哉[2], 島田猛[2]
Alexander POTEKHIN, Kirill KLIMOV, Teppei OTSUKA, Seiya OKUDA, Takeshi SHIMADA

1 近畿大学近畿大学　総合理工学研究科, 2 株式会社KJTD
1 Kindai University, 2 KJTD Co., Ltd.

1. Introduction

Operation conditions of plasma facing components (PFC) in fusion reactors and tokamaks include very high heat and particle loads and neutron damage. Liquid metals (LM) usage for PFC seems to be a reasonable alternative for the current choice since they provide self-healing, self-replenishing plasma facing surface, which significantly elongates the life of PFC [1, 2]. Tin is one of the candidate LM for PFC due to its low vapor pressure [3]. Since LM need some solid substrate, corrosive interaction between solid and liquid metals would be a critical safety issue for such fusion reactor design.

It would be helpful if we can monitor interface between LM and substrate materials, e.g. steels, without cutting to understand reaction behavior of LM and materials in details. In this research a nondestructive ultrasonic technique (UT) has been applied to observe an interface between liquid tin (Sn) and ferritic steel SUS430.

2. Experimental

Liquid Sn was contacted with a SUS430 substrate plate as a bottom of a steel pot in a static condition at 650°C for different time periods ranging from 5 to 19 days. After that, an ultrasonic transducer (50 MHz) was placed at the back surface of the SUS430 substrate in a water bath (immersion type UT).

UT allowed obtaining a one-dimensional reflection of ultra-sound wave in a depth direction (A-scan) and two-dimensional distribution of reflection intensity at a certain depth from the bottom surface (C-scan).
Separately, existence of interlayer and its phase composition were examined in a cross-sectional view after cutting with scanning electron microscopy (SEM).

3. Results and discussion

Typical C-scan image at a depth of Sn-SUS430 interface is shown in Fig.1. Reflection intensity is higher as a color changes from blue, yellow to red. Various areas with different ultrasonic reflection intensity can be seen, indicating that intensive corrosion and formation of intermetallic compounds, or cracks occurred non-homogenously at the interface.

Assuming uniform formation of a reaction interlayer through thickness after exposure at 650°C for 15 days, the thickness of the interlayer was estimated to be about 160 μm from A-scan. From direct observation of the cross-section, it was 150-230 μm, which corresponded well with the UT result. We will discuss adaptability of UT and its limitation to distinguish the interlayer of intermetallic compounds near the interface of Sn and steels.

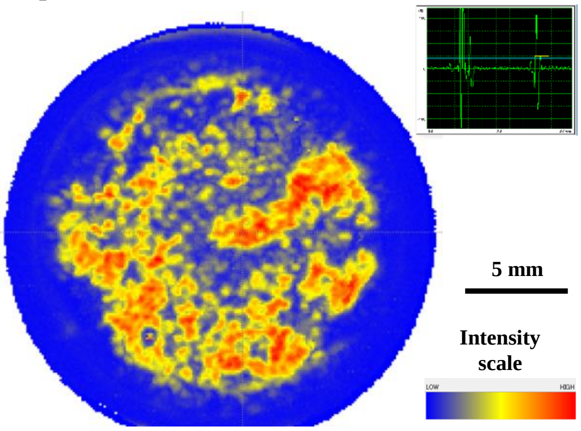

Fig.1. C-scan ultrasonic image of tin-steel reaction interlayer

References

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