Joining of Metals using Super-Spread Wetting

J. Yeon[1] M. Nakamoto[1] and T. Tanaka[1]
[1]*Department of Materials and Manufacturing Science, Graduate School of Engineering, Osaka University, Japan*
e-mail: yeon.jaebong@mat.eng.osaka-u.ac.jp

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Our group developed a region-selective super-spread wetting [1,2] through a surface fine crevice structure [3] (Figure 1), created by laser-irradiation. We achieved the metal-metal joining by exploiting the characteristic of super-spread wetting. In this research, we attempted 1. the spontaneous joining of multiple Cu blocks on base Cu substrate by using super-spread wetting into laser-created "surface fine crevice structure". In order to expand the scope of applications for joining of metals using super-spread wetting, moreover, we tried to create the following two novel fine structures: 2. powder metallurgy-based "surface fine crevice structure" & 3. "Interface fine mesh structure" which can lead to super-spread wetting, and further attempted Cu-Cu joining using super-spread wetting based on these two structures.

➢ Multiple joining

The multi-route paths that connect the one source area to the 10 target areas were created on the base Cu substrate by laser-irradiation. One piece of the Sn and 10 Cu blocks with laser-created surface were placed respectively on the source and the targets, and then the sample was heated to 773K in H_2 gas atmosphere. Figure 2 shows the appearance of the sample after cooling. The Sn completely spread to all the tartgets through the multi-route paths by super-spread wetting. Furthermore, we successsfully joined all 10 Cu blocks on the base Cu substrate spontaneously.

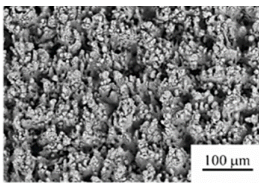

Fig. 1 Surface fine crevice structure by laser irradiation.

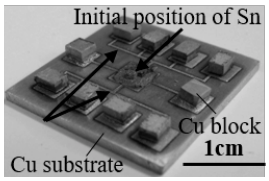

Fig. 2 Appearance of the sample after joining.

➢ Powder metallurgy-based "surface fine crevice structure"

The reduction-sintering of CuO powder on a substrate under a reducing atmosphere was proposed as a new method to create a surface fine crevice structure. As shown in Figure 3, a surface fine crevice structure, which consists of porous network formed by interconnected Cu particles with fine pores. In the joining experiment, we prepared the stair-shaped Cu object and Cu block with the powder-based fine structures on the specified region of their surfaces. Sn was melted on the bottom step of Cu object at 773K in H_2 gas. Figure 4 shows the appearance of the sample after cooling. A super-spread wetting of the molten Sn occurred on the surface fine crevice structure of the vertical wall against the gravitational force. Consequentially, the joining of Cu block on the upper step of the stair-shaped Cu object was succeeded.

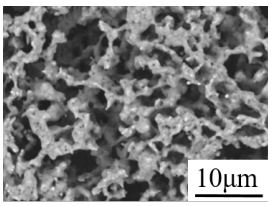

Fig. 3 Surface fine crevice structure by reduction-sintering CuO powder.

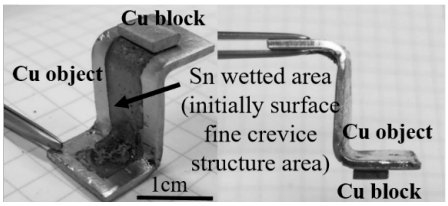

Fig. 4 Appearance of sample after joining.

➢ "Interface fine mesh structure"

We figured out a way to create a fine structure formed at the interface between a Cu mesh with a high-porosity and Cu plates. The fine structure is composed of three kinds of gaps, i.e. fine gaps between the mesh wires, fine gaps between the Cu plate and mesh, and mesh square openings, as shown in Figure 5. We termed this characteristic structure "interface fine mesh structure". Figure 6 shows the wetting front of the super-spread wetting in interface fine mesh structure. It was confirmed that the super-spread wetting occurs by penetration of molten Sn into the above-mentioned three kinds of gaps. Further, the Cu-Cu joining by using the super-spread wetting into the interface fine mesh structure was achieved as shown in Figure 7.

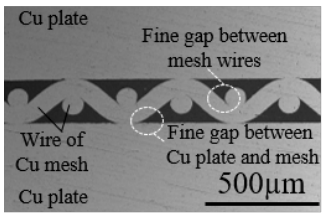

Fig. 5 Cross-section of interface fine mesh structure

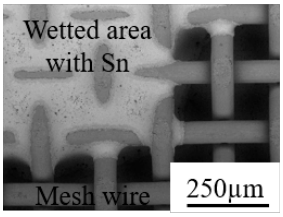

Fig. 6 Wetting front of liquid Sn on Cu mesh

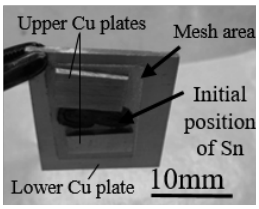

Fig. 7 Appearance of sample after joining by using Cu mesh.

[1] N. Takahira et al.: Unusual Wetting of Liquid Metals on Iron Substrate with Oxidized Surface in Reduced Atmosphere., *Mater. Trans.*, **46**, 3008, 2005.
[2] N. Takahira et al.: Wettability of Liquid In and Bi on Flat and Porous Solid Iron Substrate., *Mater. Trans.*, **48**, 3126, 2007.
[3] A. Fukuda et al.: Metal-Metal Joining by Unusual Wetting on Surface Fine Crevice Structure Formed by Laser Treatment, *Mater. Trans.*, **56**, 1852, 2015.