» New Products

Development of Oxygen-free Copper Strips “GOFC” With Superior Heat-resisting Properties

1. INTRODUCTION

In recent years, the power output of power modules which perform automobile motor control, power conversion, etc. is increasing with the technological innovation of next-generation vehicles such as plug-in hybrid vehicles (PHVs) and electric vehicles (EVs), and of renewable energy such as wind power generation and photovoltaic power generation.

Under these circumstances, oxygen-free copper strips are used because their high electrical conductivity, their high thermal conductivity and their high heat dissipation are required for the power module substrates and the peripheral members whose thermal and electrical loads are rapidly increasing (Figure 1 shows the insulating substrate of an application example). The customers have been pointing out that in general oxygen-free copper strips (C1020R), the crystal grains are remarkably coarsened in the heat treatment process during the production of the power module substrates and the peripheral members, which generate various troubles in the following bonding process and in the bonding process with other parts. Therefore, development of an oxygen-free copper strip in which crystal grains do not coarsen had been required. Based on the C1020R, and applying our unique texture control technology without changing its component standard, we have developed a high-performance copper strip “GOFC (Grain growth control Oxygen-Free Copper)” in which the grain growth is restrained when heated. It had not been achieved with existing oxygen-free copper strips. The details are described below.

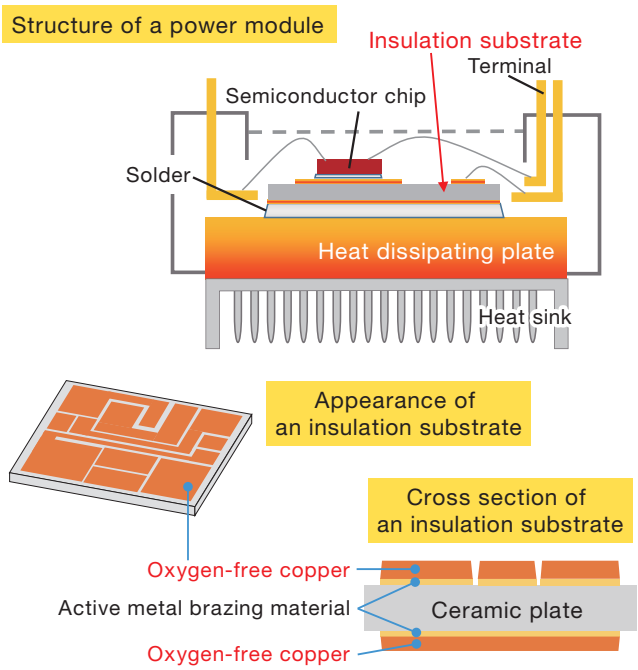

Figure 1 Application example of an oxygen-free copper strip to power module parts.

2. CHARACTERISTICS

Figure 2 shows the grain growth behavior of a general oxygen-free copper strip in the process of a high temperature heat treatment. It becomes a fine and uniform microstructure at 200 – 250°C (primary recrystallization), and becomes 1,000 μm and above in grain size, which is coarse and non-uniform (secondary recrystallization) at 600 – 650°C.

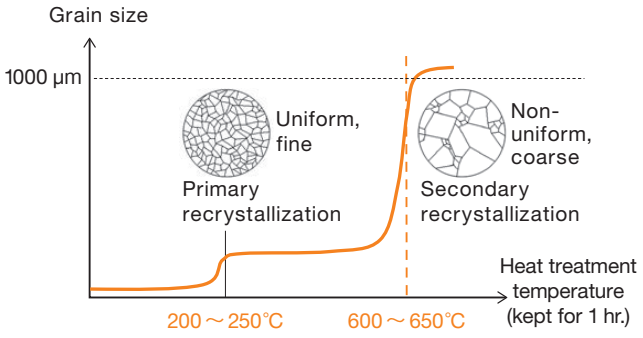

Figure 2 Grain growth behavior of a general oxygen-free copper strip.

Figure 3 shows the behavior of the secondary recrystallization of a general oxygen-free copper strip and the GOFC. In the general oxygen-free copper strip, the grain rapidly grows in the heat treatment at 600°C and above. On the other hand, in the GOFC, the grain growth is restrained because the secondary recrystallization does not occur until the heat treatment temperature reaches 800°C. Figure 4 shows the microstructure of the GOFC and the general oxygen-free copper strip after a heat treatment at 800°C for one hour. Compared to the general oxygen-free copper strip, the GOFC has confirmed to be the recrystallization structure which is extremely fine without cracks. Also, as the Figure 5 shows, the crystal grains of the general oxygen-free copper strip after the heat treatment stated above is coarse and non-uniform,

which can be clearly confirmed visually, but the GOFC has a fine and uniform crystal structure. Therefore, in addition to being able to contribute to the improvements in bonding properties and solving problems in bonding processes with other parts, it can also meet the customers' demands for improved appearance such as irregular reflection prevention and good appearance.

In addition, the GOFC has an electrical conductivity and a thermal conductivity equivalent to those of the C1020R.

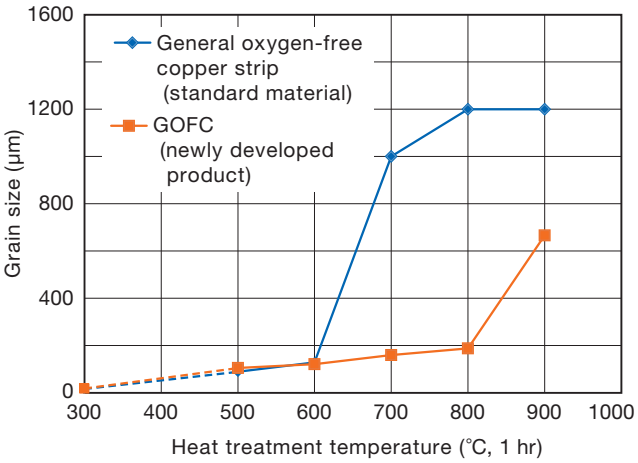

Figure 3 Grain growth behavior of the general oxygen-free copper strip and the GOFC kept at each temperature for one hour (in an argon gas atmosphere).

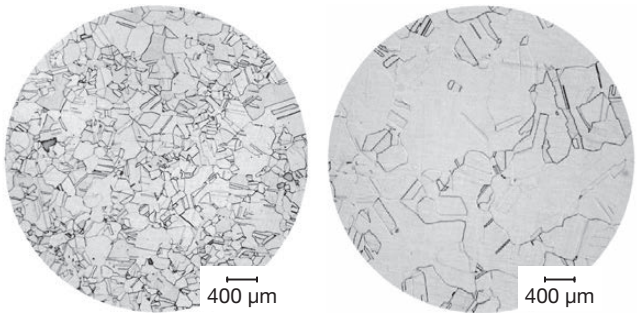

Figure 4 Microscopic photos of the structure kept at 800°C for one hour (in an argon gas atmosphere) (The quality classification is 1/2 H before the heat treatment in both samples.).

Figure 5 Appearance of the crystal structures kept at 800°C for one hour (in an argon gas atmosphere).

3. CONCLUSION

We have succeeded in developing an oxygen free copper strip GOFC with an improved heat resistance compared to the general oxygen free copper strip as a material for power module substrates and peripheral components. The GOFC can contribute to the improvement of the bonding property and the problem solving in the bonding process with other parts in the power module substrates and the peripheral members which require a high-temperature heat treatment when manufacturing, because the crystal grains of the oxygen-free copper become fine. We have already established a mass production process and have commercialized it for the use as a bonding material of insulation substrates for power modules.

By expanding the GOFC to a wider range of users in the future, we will contribute in solving the problems of the changes in shape and appearance at high temperature during manufacturing of power modules, and in improving the functionality of power modules.

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