Laser Metallization of Ceramics†

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The laser technology makes the materials processing more effective, whereas the technology realizes new processing which is not performed by other conventioal processes.

Ceramics because of its superior mechanical properties has, in recent years, expands the paractical engineering application such as a turbocharger in a automobile. The worse workability and inherent brittleness of ceramics necessitate the joining of ceramics to metals, which possess the high reliability in the practical application.

The present work tries to metallize the ceramics, which is covered with Ni-Ti alloy powder, by laser irradiation, and clarifies the condition of laser power to form the metallized layer. Further, the ceramic/metal joint is directly formed by melting the metal part by laser irradiation.

KEY WORDS: (Laser Metallization) (Laser)(Alumina) (Titanium) (Kovar) (Spinel Oxide)

1. Metallization of ceramics with laser irradiation

Figure 1 shows the laser irradiation system. The specimen which is preheated in the furnace is laser-irradiated from the upper path and the spcimen is moved with the furnace. The laser beam from the maximum power of 15 kW contanious CO_2 laser heat souce is focused by convex lens and mirror plate. The specimen, which size is 20 mm long, 20 mm wide and 2 mm thick, is covered with Ni-50 mass% Ti powder of 1 mm thickness. The powder was prepared by mixing Ni and Ti powder. The specimen was preheated up to 1473 K.

In the low laser power condition of 0.5 kW and 1.7×10^{-2} m/s the metallized alloy in **Fig. 2** does't sufficiently wet Al_2O_3 ceramics, and separates from the ceramics after cooling down. **Fig. 3** represents the microstructure of specimen laser-irradiated in the higher power condition of 1.5 kW and 1.7×10^{-2} m/s. The laser beam overheats the metallized alloy, and then alumins cermics reacts and dissolves into the alloy. The detailed distrbution of Ti of the metallized specimen shows the formation of $Al_2O_3\cdot TiO_2$ intermediate spinel oxide at the interface of Al_2O_3 and Ni-50Ti alloy in **Fig. 4.**

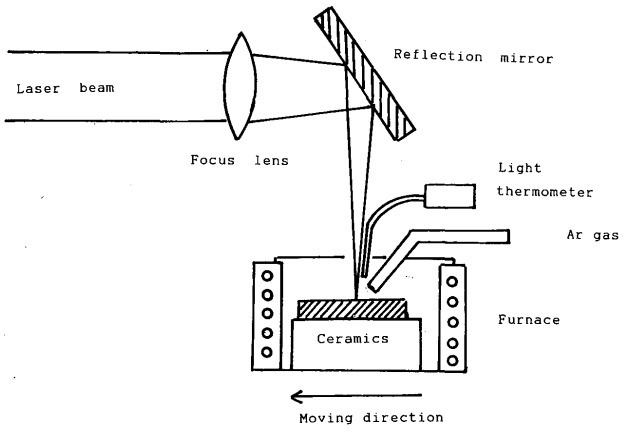

Fig. 1 Laser irradiation system.

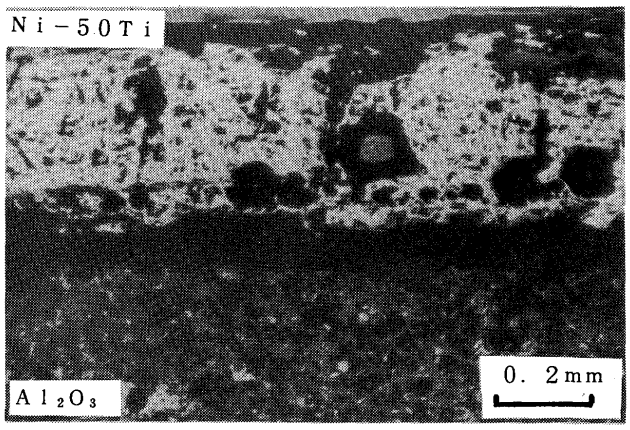

Fig. 2 Microstructure of laser-metallized Al_2O_3 with Ni-50Ti alloy.

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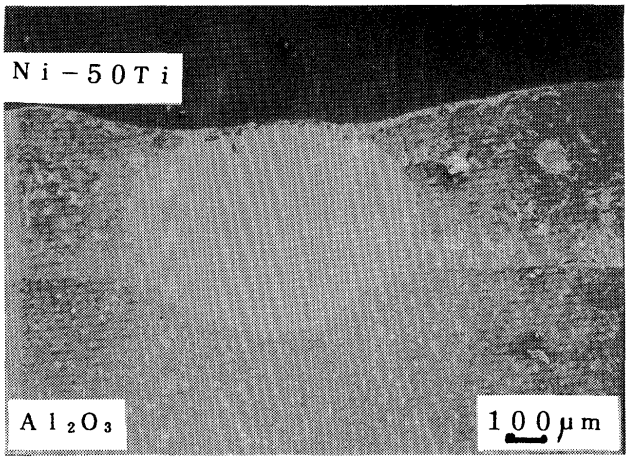

Fig. 3 Microstructure of laser-metallized Al_2O_3 with ni-50Ti alloy.

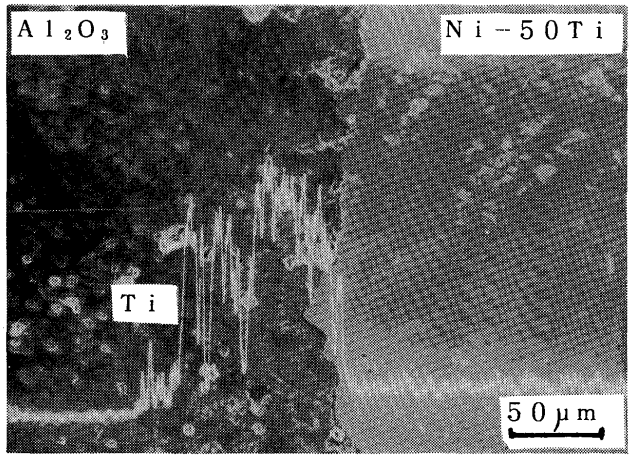

Fig. 4 Element analysis of laser-metallized Al_2O_3 with Ni-50Ti alloy.

2. The joining of ceramics with metal by laser irradiation

Although the metallization process with laser irradiation is the main method to produce the ceramic/metal joint, the metal may directly join to metal by heating with laser irradiation. The present paper also tries the ceramics to metal by melting the active element foil such as Ti by laser irradiation.

The Ti foil 10 mm dai. and 50 μm thick was inserted between kovar alloy 10 mm dia. and 3 mm thick and Al_2O_3 15 mm dai. and 3 mm thick. The Ti foil and alloy in the upper part of the lapped spcimen was irradiated by the laser power of 3 kW and 5×10^{-3} m/s. **Figs. 5** and **6** represents the line analyses of elements in the specimen.

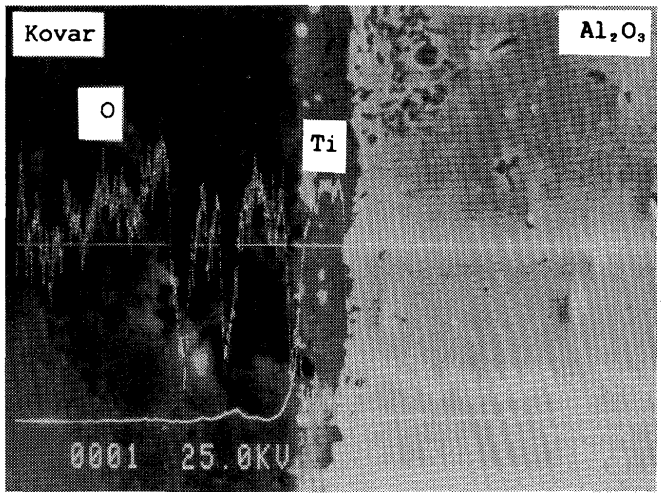

Fig. 5 Element analysis of Al_2O_3/Kovar joint joined by laser irradiation.

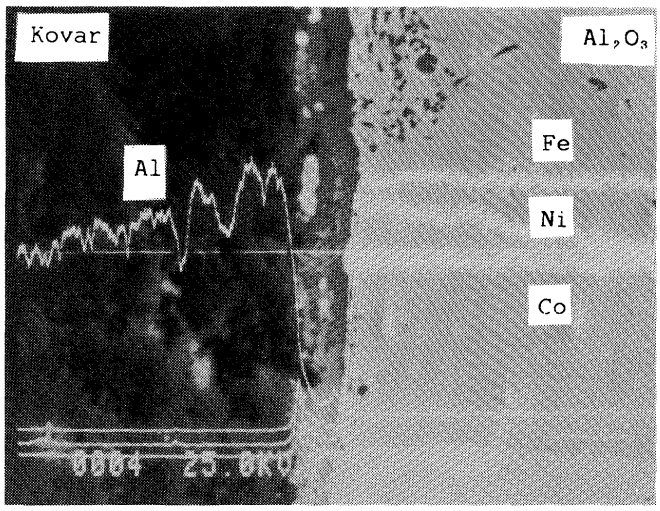

Fig. 6 Element analysis of Al_2O_3/Kovar joint joined by laser irradiation.

The sound joint of Al_2O_3/kovar joint is formed without any crack. The main part of Ti reacts with Al_2O_3 and forms the $Al_2O_3 \cdot TiO_2$ intermediate spinel oxide of 15 μm thickness at the interface of Al_2O_3 and alloy, though the part of Ti dissolves into kovar alloy.

In conclusion, the ceramics was metallized by laser irradiation of metallic powder layer, and the ceramics was directly joined to alloy by melting the alloy part by laser irradiation. The ceramic reacts with Ti in alloy and forms the spinel oxide at alumina/alloy interface during laser irradiation. The authors thank Dr. H. Oda in Reserach Center for Ultra High Energy Density Heat Source of Welding Reserach Institute in Osaka University for operating the laser heat source.