Secondary Ion Characteristics of Al-Ni Intermetallic Compounds Sputtered by Ar Ion †

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The ion microanalyzer (IMA) has two faculties – to sputter secondary ions from a surface of the solid material and to analyze these through a mass spectrometer. It has been already mentioned by several investigators[1-3] that IMA has characteristics as follows; high sensitivity to detect light elements, an ability of analysis of sputtered ions from extremely thin solid surface and excellent depth profiling capability of elements in solid material in spite of the lack of a sufficiently quantitative technique.

From a view point of depth profiling, it is in progress using IMA in our laboratory to elucidate the oxidation process of some alloys[4] and the origin of the joint defect in diffusion welding.[5] This note reports the secondary ion characteristics of Al-Ni intermetallic compounds formed in diffusion welding of mild steel – nickel interlayer – aluminum.

When the nickel interlayer is used in diffusion welding between mild steel and aluminum, two kinds of intermetallic layers in the weld are formed which are identified to be Al_3Ni_2 and Al_3Ni by X-ray diffraction measurement[5]. The fracture of the welded joint occurs often in Al_3Ni_2 layer.

Figure 1 shows the yields of the various secondary ions on the fracture of mild steel and aluminum sides, respectively. The experimental conditions of IMA are as follows;

primary ion source	: Ar^+
primary ion beam diameter	: 1mm
accelerating voltage	: 10KV
sample current	: 2μA

It is observed that iron and aluminum diffuse into the opposite sides through the nickel layer. Nickel also

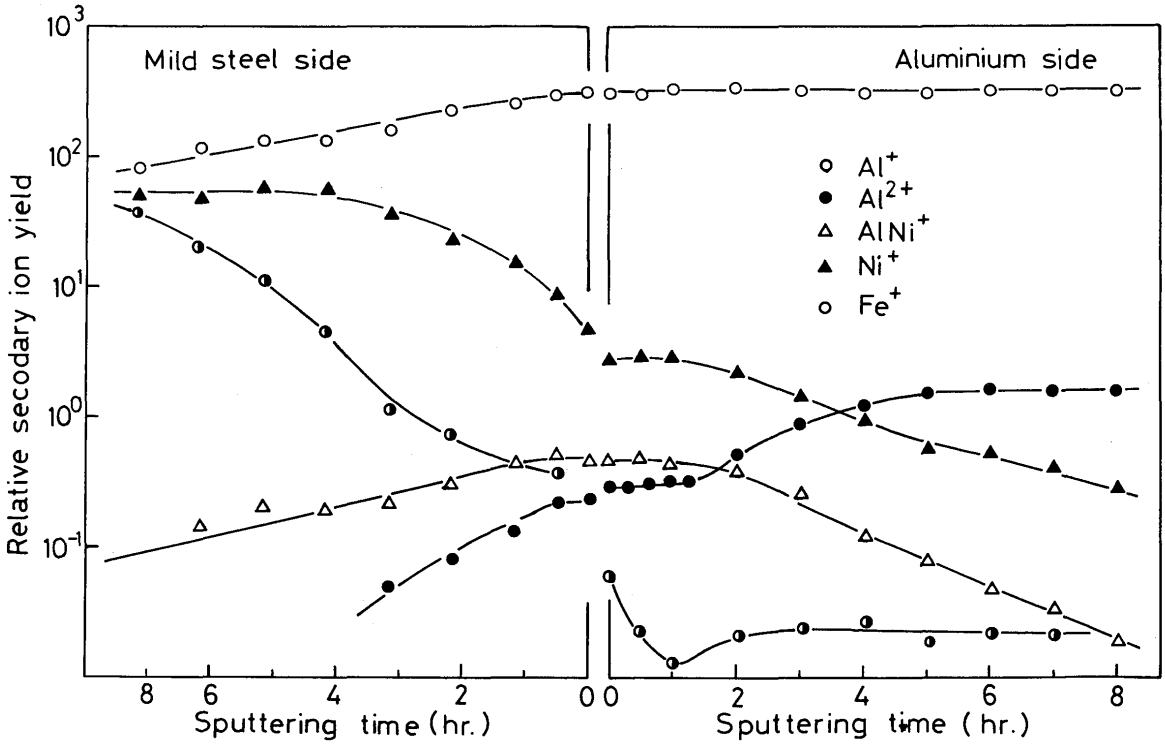

Fig. 1 Relative secondary ion yield of various elements on fracture surface vs. sputtering time.

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distributes into aluminum but has a plateau in vicinity of the fracture. The molecular ion of $AlNi^+$ has maximum yield at the fracture. In the aluminum sides, multiply charged ion of Al^{2+} shows the plateaus both in the outer and inner sides. The yield in the former is about one third as large as that in the latter. The inner and outer sides would probably correspond to Al_3Ni and Al_3Ni_2 intermetallic layers, respectively.

It is difficult to interpret theoretically above mentioned features of various ions. It will be, therefore, important to investigate the standard specimens of Al_3Ni_2 and Al_3Ni intermetallic compounds. Their specimens were prepared as follows. Analytical grade powder reagents of aluminum and nickel were weighed and mixed to be ratio of stoichiometry. After they were pressed to disks ($14mm\phi \times 2mm^t$), they were sintered at 600°C for 3 days in argon atmosphere. They were checked to be Al_3Ni_2 and Al_3Ni intermetallic compounds with X-ray diffraction means.

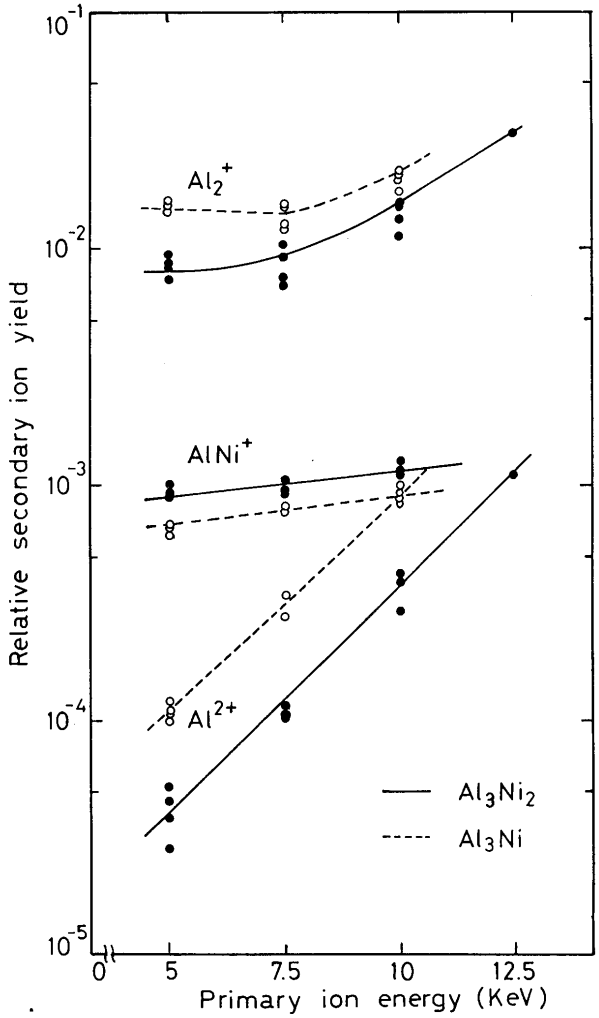

Fig. 2 Relative secondary ion yield of Al_3Ni_2 and Al_3Ni.

Relative secondary ion yields of Al_3Ni_2 and Al_3Ni versus to the energy of primary argon ion are shown in Fig. 2. The secondary ion species observed are Al^{2+}, Al^+, Al_2^+ and $AlNi^+$. The ordinate shows the ratio of intensities between each secondary ion and Al^+ ion. Solid and broken lines correspond to the results of Al_3Ni_2 and Al_3Ni, respectively. All ion yields increased monoclinally with the voltage of primary ion such as in the case of oxide materials.[6] The gradients in Al_3Ni_2 were almost as large as those in Al_3Ni. The tendency was remarkable for Al^{2+} The Al^{2+} ion yield of Al_3Ni_2 is one third as that of Al_3Ni. It is very interesting that this value is same as that in Fig. 1.

It is considered that these phenomena would be probably due to the bonding force between the atoms in the specimens and also suggest possibility of the state analysis of various materials. If it is so, it is necessary to investigate not only single charged matrix ions but also complex ions such as multiply charged and molecular ions. However, it remains difficulty to discuss the details of the relation between the all of the secondary ion yields and the bonding force because of the occurence of complex ionization process.

Further studies using IMA on the secondary ion yield of various elements are in progress.

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