SHIMADZU
Excellence in Science

Application News

No. P111

EPMA-8050G Electron Probe Microanalyzer

Analysis of Super Elastic Alloys and Shape-Memory Alloys

Titanium materials possess desirable mechanical properties such as corrosion resistance and heat resistance, and are widely used, including in the medical field, as they have excellent biocompatibility. Research and development of low-toxicity titanium alloys is underway.

Orthodontic wire with a super elastic property is used in treatment of dental malocclusions. Orthodontic wires with different transformation points are used appropriately depending on the patient's paradental condition and sensitivity to pain. In this study, three types of orthodontic wires with different transformation points were analyzed. As a result, the differences in the concentrations of additional trace elements and differences in the distribution of Ni and other elements were obtained, and the existence of multiple compound phases was confirmed.

This article introduces an example of analysis using an EPMA-8050G EPMA™ electron probe microanalyzer.

S. Yoshimi

Super Elastic Alloy

Alloys consisting of 50 % each of Ti and Ni by atomic ratio are called nickel titanium alloys (Nitinol), and are known to possess an excellent shape-memory property and super elastic property. Shape-memory alloys have the distinctive feature of returning to their original shape before deformation when heated to their transformation temperature (transformation point) or higher after deformation to an arbitrary shape, while super elastic alloys deform when a load is applied but then return to their original shape when the load is removed. The transformation temperature can be changed from 0 °C up to approximately 100 °C by modifying the alloying ratio of Ti and Ni, and it is also possible to change the properties of the alloy by adding 1 % or less of a third element (e.g. Cr, Co, Cu).

Fig. 1 shows the results of a mapping analysis and phase analysis of an orthodontic wire made from a super elastic alloy. A dispersion distributed microstructure consisting of multiple compound phases with a size of several μm in the TiNi alloy parent phase can be observed.

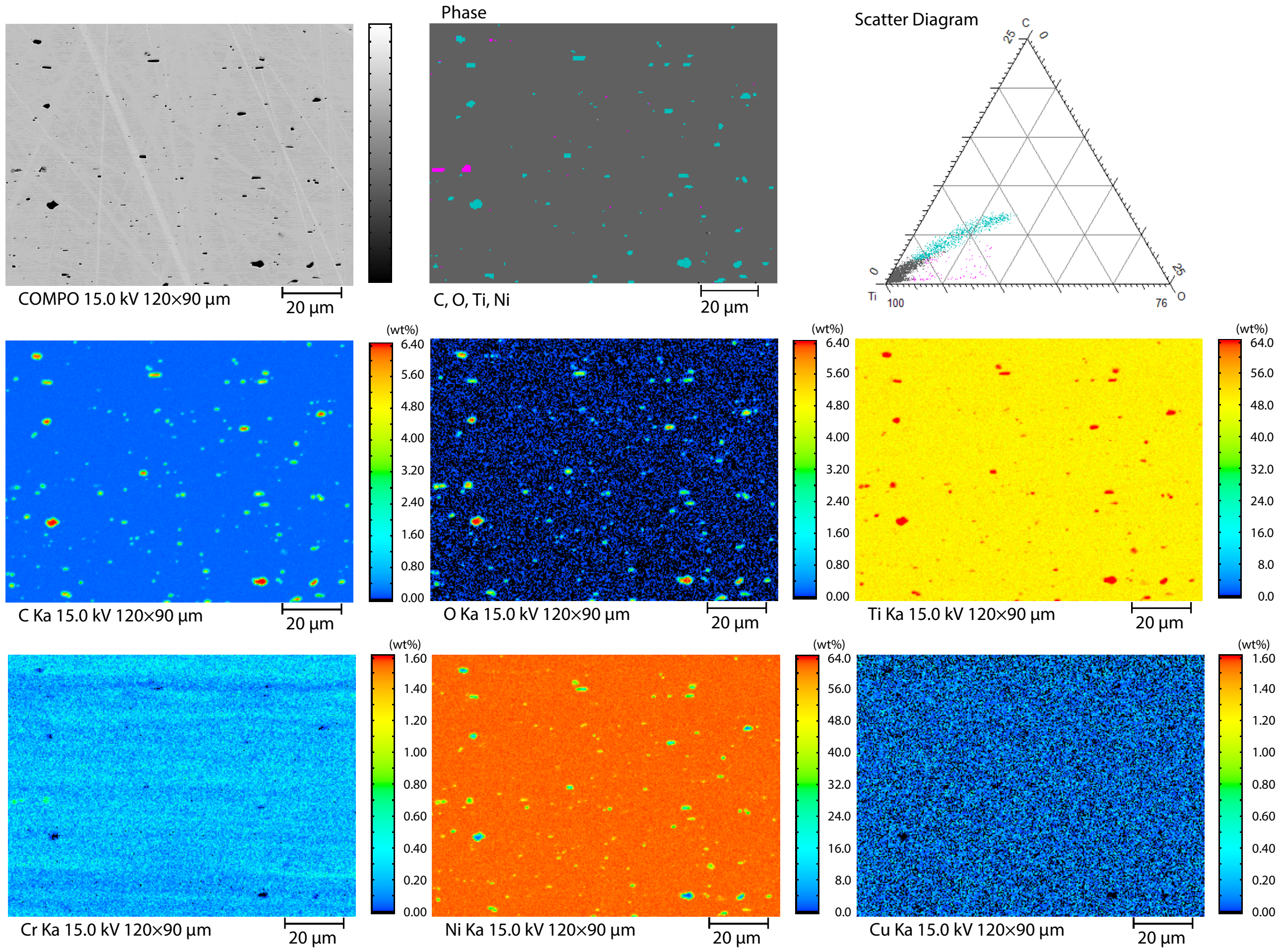

Fig. 1 Mapping Analysis and Phase Analysis of Orthodontic Wire

Quantitative Analysis of TiNiCu Shape-Memory Alloy

Three types of orthodontic wires with different transformation points were examined. The temperature at which orthodontic force acts differs in each of these alloys. (Af27 displays a comparatively strong orthodontic force at the temperature in the oral cavity, Af35 has a relatively weak orthodontic force, and Af40 shows orthodontic force when the temperature in the oral cavity is 40 °C or higher). Table 1 shows the results of a quantitative analysis of these three types of orthodontic wires, indicating that there are slight differences in the amount of addition of no more than 1 % Cr.

Mapping Analysis of TiNiCu Shape-Memory Alloy

Fig. 2 shows the results of a mapping analysis of the orthodontic wires with different transformation temperatures in Table 1. Differences in concentration can be recognized in the Cr distribution images, and the distributions of the microstructures in which Ni is replaced with Cr and Cu are also different. Fig. 3 shows the enlarged mapping analysis and phase diagram results for the orthodontic wire with the Af point temperature of 27 °C, and reveals the existence of multiple compound phases.

Table 1 Results of Quantitative Analysis of Orthodontic Wires Af27, Af35, and Af40

Unit (wt%)

Sample \ Element	C	O	Ti	Cr	Ni	Cu	Sum
Af27	0.80	0.38	43.98	0.32	48.44	5.99	99.91
Af35	0.86	0.40	43.98	0.21	48.38	6.00	99.82
Af40	0.82	0.38	43.92	0.18	48.60	5.93	99.82

Conclusion

As shown in this article, the quantitative analysis of trace elements, including light elements, and differences in element distribution images and the size, type, and dispersion state of fine compound phases can be confirmed by using EPMA, and based on the results, it is possible to identify differences in material characteristics due to additional elements.

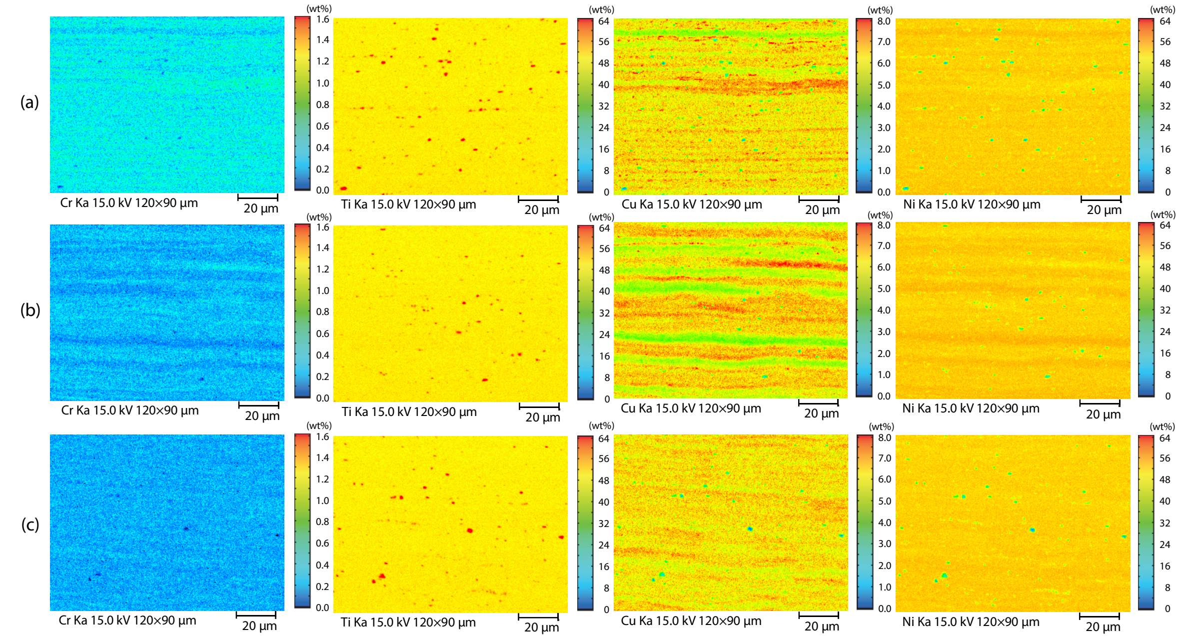

Fig. 2 Mapping Analysis of Orthodontic Wires (a) Af27, (b) Af35, and (c) Af40

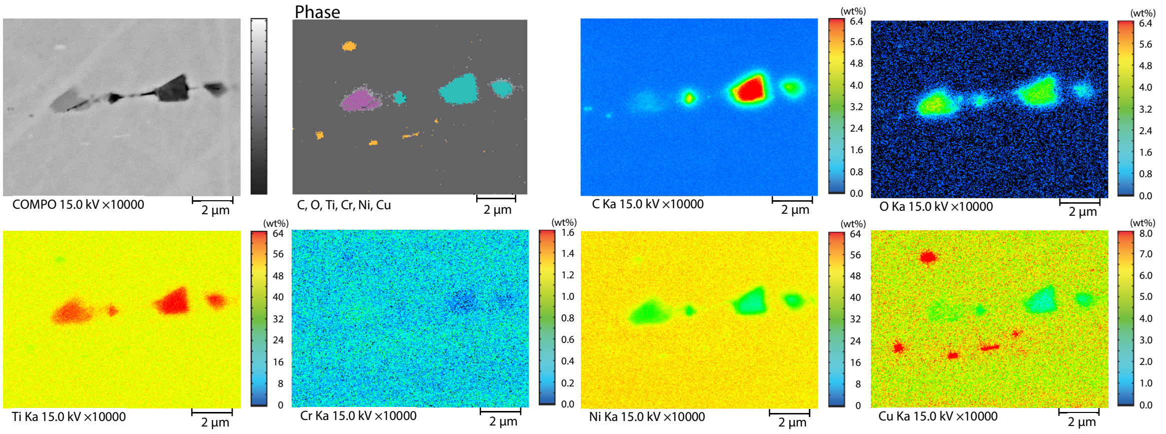

Fig. 3 Compound Phases of Orthodontic Wire Af27

<Reference>
The Japan Titanium Society, Metal materials used at the site series: Titanium (2007)
EPMA is a trademark of Shimadzu Corporation in Japan and/or other countries.

First Edition: Jul. 2020

Related Products Some products may be updated to newer models.

EPMA-8050G

Electron Probe Microanalyzer

Related Solutions

Electronics

Hydrocarbon Processing Industry (Petrochemical, Ch

Price Inquiry

Product Inquiry

Technical Service / Support Inquiry

Other Inquiry