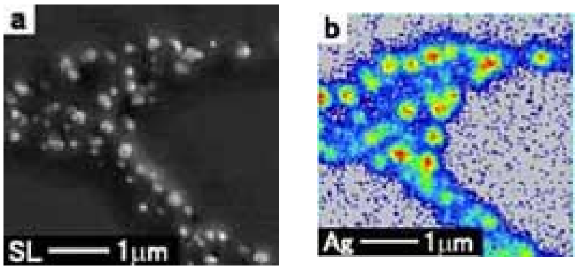
技術情報 Technical Information

Analyzing conditions for high spatial resolution X-ray images

Spatial resolution of X-ray imaging

Electron probe micro analyzers (EPMA) using LaB_6 and field emission (FE) electron sources can achieve higher spatial resolution than those with the conventional W filament.In general, it is expected that the smaller the electron source the higher the spatial resolution of the images or analyses.However, the spatial resolution is also influenced by the analytical conditions, and under some conditions the EPMA is unable to achieve its full potential.

Using Monte Carlo simulations for electron scattering within a sample, the optimum analyzing conditions were determined for variations in probe size, accelerating voltage, and probe current.A JXA-8100 with a LaB_6 gun was then used to test these optimized conditions.



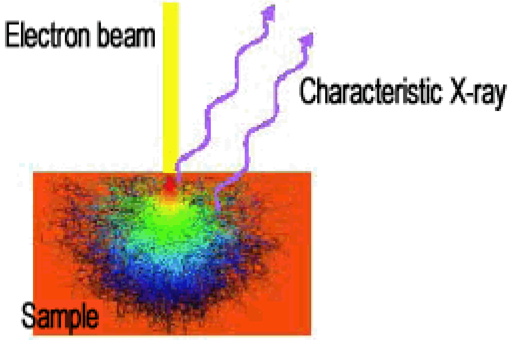
High magnification SE and X-ray images
(a) Secondary electron image
(b) X-ray image

Conditions:
Acelerating voltage 8 kV
Probe current 10 nA
Analytical range 5 µm×5µm

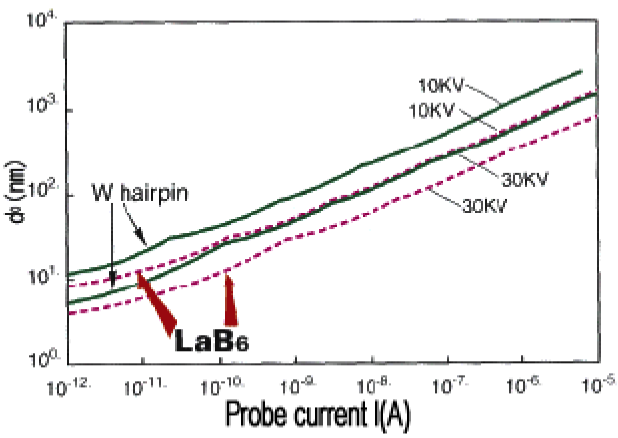
Calculating optimum accelerating voltage

The optimum accelerating voltage was determined by comparing the size of the electron scattering volume within a sample with the size of the electron probe itself projected.
The size of the electron probe was obtained from the design parameters of the EPMA, and Monte Carlo simulation was used to determine the volume of electron scattering within the sample.
Assuming that the X-ray emitting area is minimized when the probe diameter is equal to the size of electron scattering volume, at a constant probe current, the optimum accelerating voltage could be obtained.

The probe size is determined from the probe current and accelerating voltage.



The X-ray emitting area in a sample is determined from the accelerating voltage and sample properties (average density and atomic number).

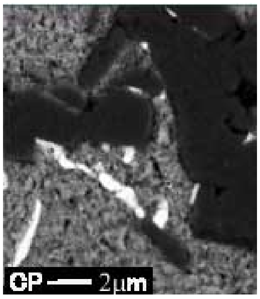


JXA-8100 and plot of the probe size versus probe current

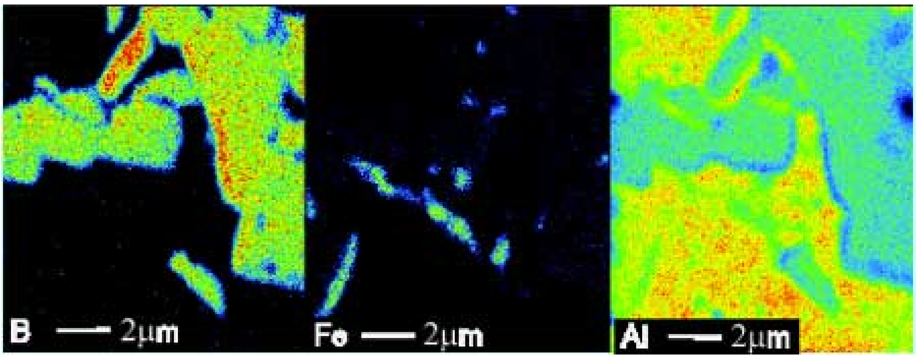
The vertical axis is beam size. The horizontal axis is probe current.The higher the probe current, the larger the beam diameter.Data discussed here was acquired using a JXA-8100 and LaB_6 unless otherwise noted.

X-ray images of Al alloy

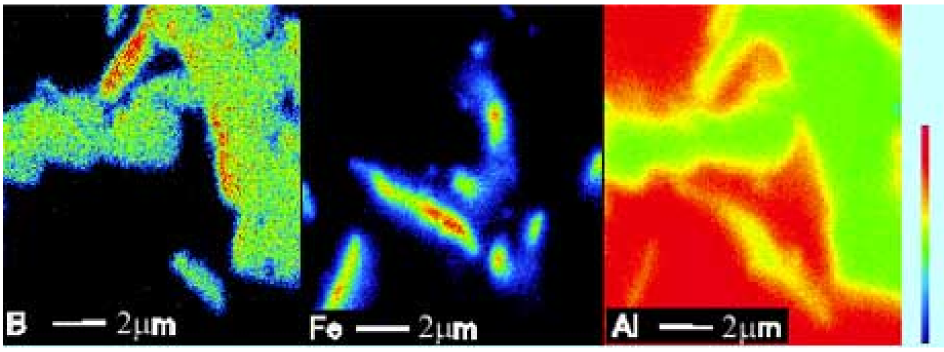
Using this approach, the optimum analyzing conditions determined for an Al alloy sample containing Fe and B, was 5 kV. A comparison of the optimum accelerating voltage (5 kV) and a higher voltage (15 kV) is shown below.
The results demonstrate that at 5 kV the spatial resolution is significantly improved over that at 15 kV.
The Fe distribution mapped at the optimum analyzing conditions is in excellent agreement with the white portion of the BE composition image shown to the right.



BE composition image

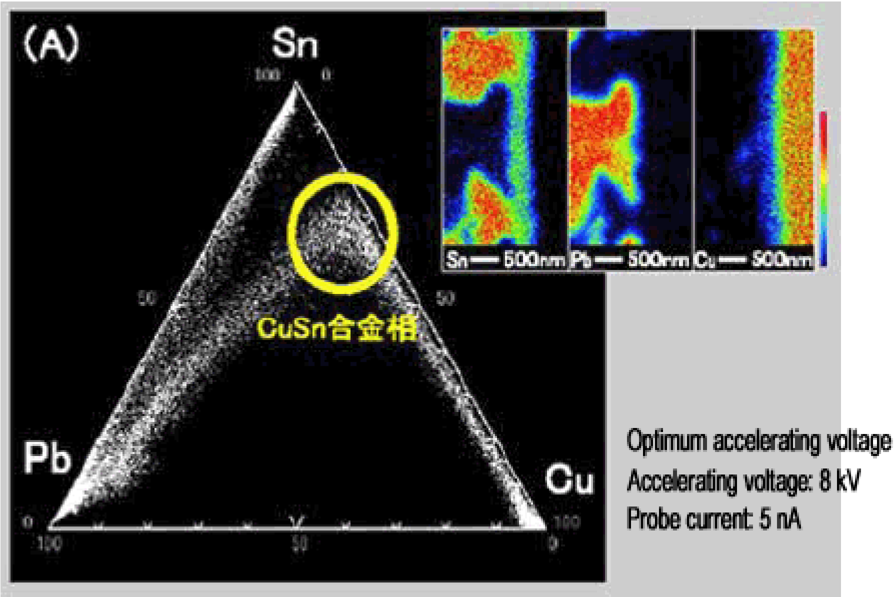


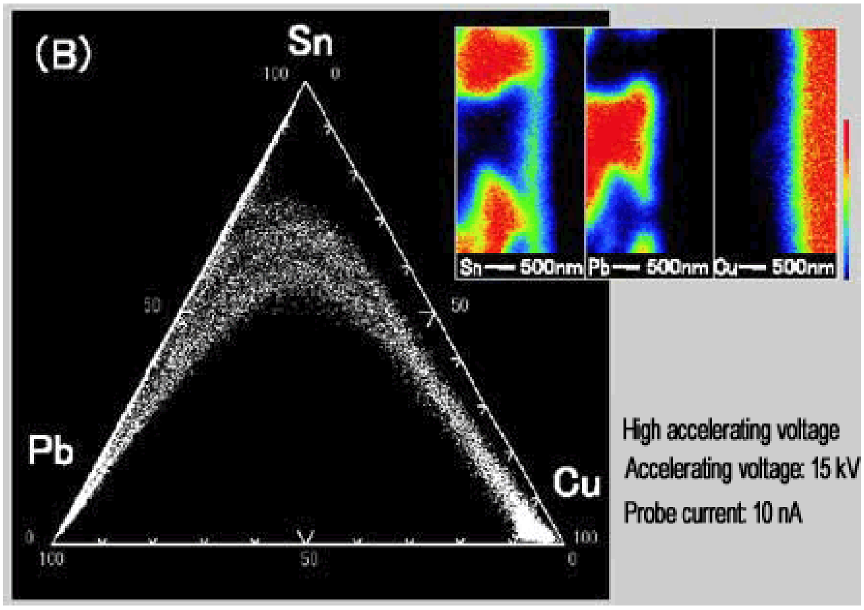
Optimum accelerating voltage – 5 kV; probe current 3 nA



High accelerating voltage – 15 kV; Probe current 20 nA

Phase analysis of CuSn alloy phase at solder-Cu interface





A CuSn alloy phase is present at the interface between the Cu substrate and Sn-rich solder shown above.The data in the above figures were acquired along this interface at two different accelerating voltages: (A) 8 kV (optimum) and (B) 15 kV (high). The Sn, Pb, and Cu compositions of each pixel were then plotted in the accompanying triangular diagrams.

At 15 kV, the triangular diagram does not show the compositional cluster representing the CuSn alloy phase.

However, the 8 kV data shows an inflection point between Cu and Sn phases.This inflection point is identified as the CuSn alloy phase.Furthermore, this alloy phase is in contact with the Pb phase, and not in direct contact with the solder phase.

These findings were made possible because of the fact that the optimized analytical conditions increased the spatial resolution, enabling a more accurate micro-area analysis.

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