# Ion Beam Etching of Metal Composites using Gatan's PECS

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## Introduction

In general it's not possible to reveal the structure of all phases in a composite simultaniously by conventional etching methods if the components differ in their chemical properties. Ion Beam Etching Techniques however work in many of these cases. So one of the more important applications for this method in metallography is etching of metal combinations with extreme difference in chemical potential. This work presents composite materials from various manufacturing processes that were etched by ion beam. Application examples include build-up welds made out of Nickel containing weld material on plain steel or GGG40, welds with a Ni interface layer, and corrosion or wear protection layers produced by powder metallurgical processes. The differences in chemical composition between substrate and surface layer are demonstrated by corresponding Electron Microprobe profiles.

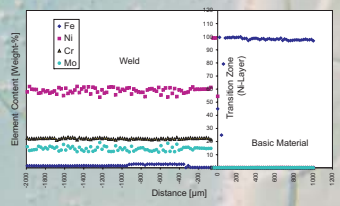
## Test Pocedure and Results

The ion beam etching was performed in a Gatan PECS (**P**recision **E**tching and **C**oating **S**ystem). The broad beam ion source in this system generates a 10 mm beam diameter at vertical incidence to the sample, depending on the ion gun parameters (ion gun voltage and ion gun current). By tilting the specimen, i.e. by altering the incident angle, the etch mark can be enlarged further if the specimen is rotated during the process.

Although the chemical compositions of the metals that build up the composites are very different, ion beam etching reveals the structure of both compounds equally and simultaniously. DIC (**D**ifferential **I**nterference **C**ontrast) should be used to enhance the characteristic contrast that stems from the etching due to ion bombardment. Perlitic and martensitic textures should be treated with Nital after ion beam etching to further enhance the contrast.

**Example 1:**
Dissimilar Steel Joint, Hastelloy on Plain Steel with Ni Interface Layer
Etch Parameters:
6kV/405µA/16min/30°, rot.

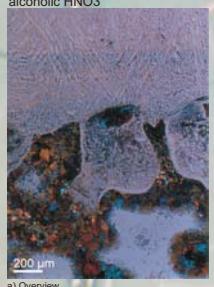
a) Overview



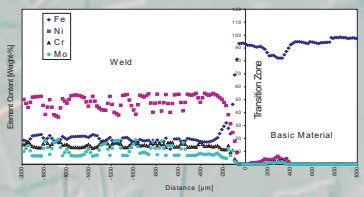
b) Electron-Microprobe

c) Nickel Layer at higher Magnification

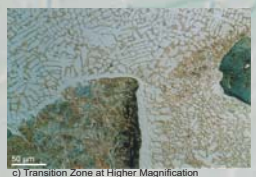
**Example 2:**
Plasma Hot Wire Build-up Weld (Ni Alloy on GGG40)
Etching Parameters:
6kV/405µA/30min/45°, rot.
Subsequent etching with 2% alcoholic HNO3



a) Overview



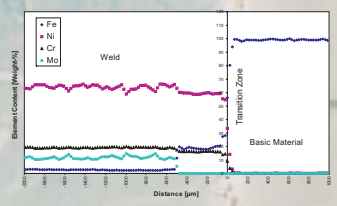
b) Electron Microprobe Profile



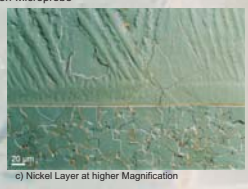
c) Transition Zone at Higher Magnification

**Example 3:**
Plasma Hot Wire Build-up Weld (Ni Alloy on Steel) S-NiCr20Mo15 on Boiler Plate HII
Etching Parameters:
6kV/405µA/8min/vertical

a) Overview



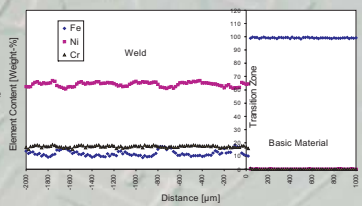
b) Electron-Microprobe



c) Nickel Layer at higher Magnification

**Example 4:**
Plasma Hot Wire Build-up Weld (Ni Alloy on Boiler Plate HII) rolled after welding
Etching Parameters:
6kV/405µA/8min/vertical incidence

a) Overview

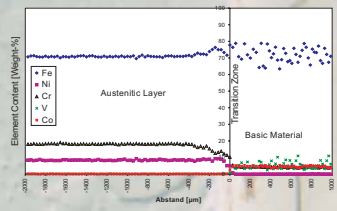


b) Electron-Microprobe

c) Transition Zone at Higher Magnification

**Example 5:**
Austenitic Protective Layer on PM Steel
(HIP)
(X5CrNi189 on Supermet 65)
Etching Parameters:
6kV/405µA/8min/30°, rot.

a) Overview

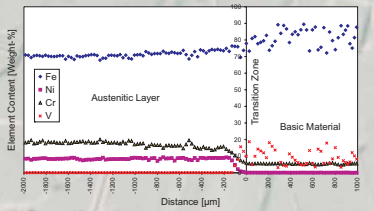


b) Electron-Microprobe

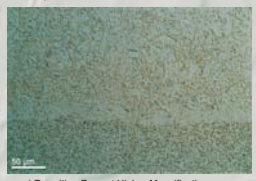
c) Transition Zone at Higher Magnification

**Example 6:**
Austenitic Protective Layer on PM Steel
(HIP)
(X5CrNi189 on Supermet 69)
Etching Parameters:
6kV/405µA/8min/30°, rot.

a) Overview



b) Electron-Microprobe



c) Transition Zone at Higher Magnification

## Closing Remark

Sputtering yields of the individual compounds plays an important role in optimizing ion beam etching of composite materials. Although the chemical characteristics of surface layer and substrate reveal enormous differences the sputtering yields are similar. Both compound partners could be etched simultaniously and equally.

## Acknowledgement

I like to thank Gatan GmbH for lending the PECS, Leica GmbH for lending the DMR optical microscope.

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