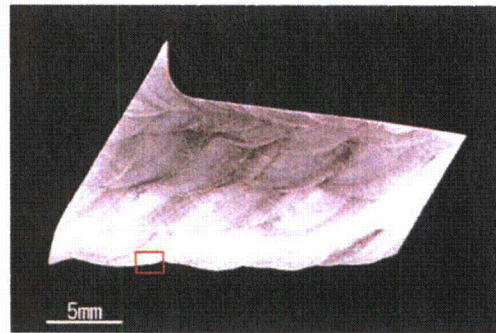
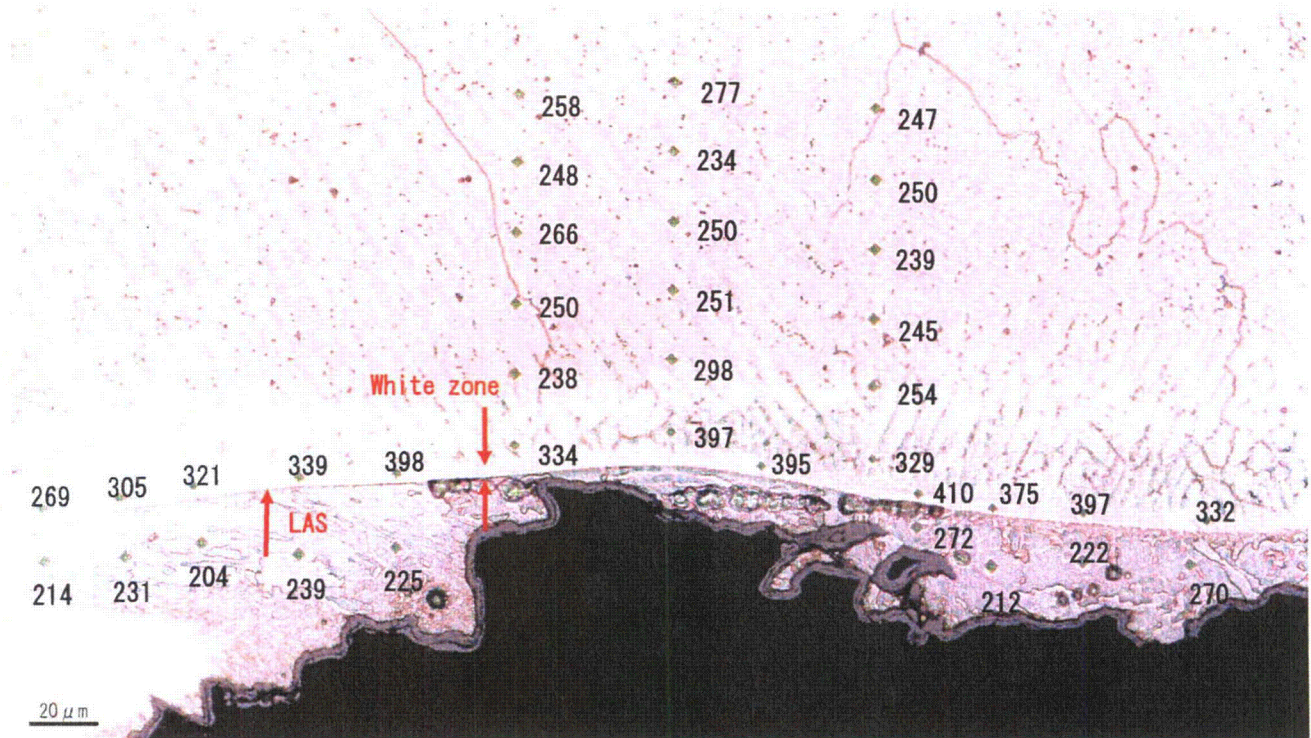


Fig. A.24(1) Vickers hardness of cross section of sample B (152 buttering)

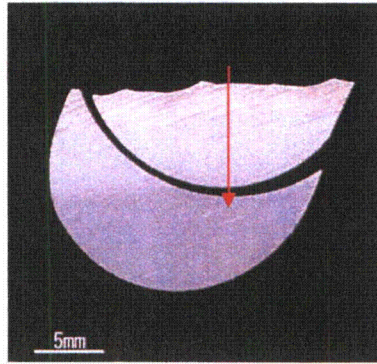


Enlarged

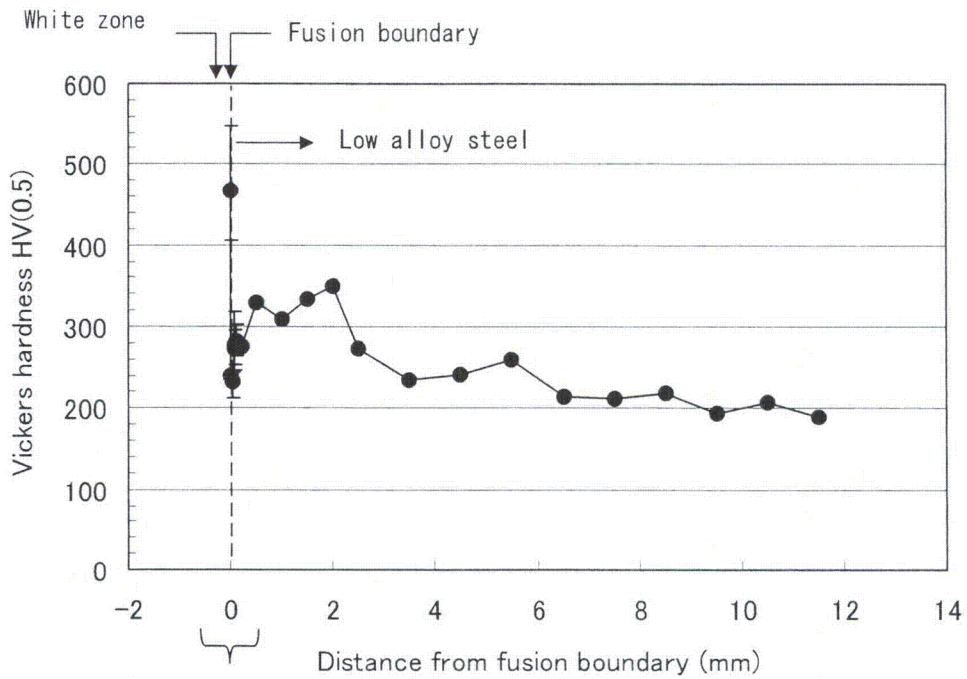


Load: 2g

Fig. A. 24(2) Vickers hardness of cross section of sample B (152 buttering) (Continued)

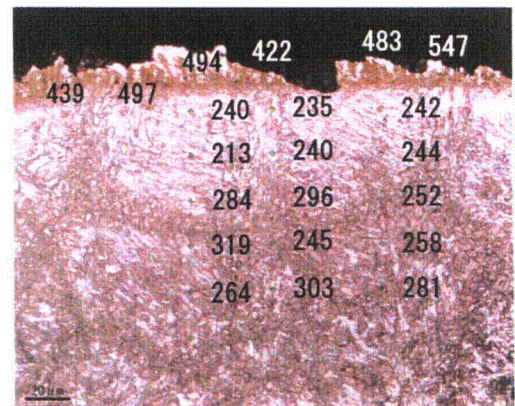
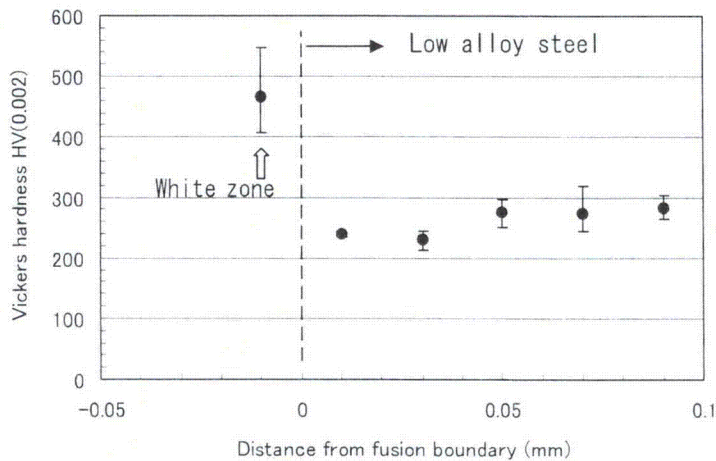


Measurement line of hardness



* Testing load is 2g at the distance between -0.05 to 0.15mm

Enlarged



Load: 2g

Fig. A.25 Vickers hardness of cross section of sample B (Low alloy steel channel head)

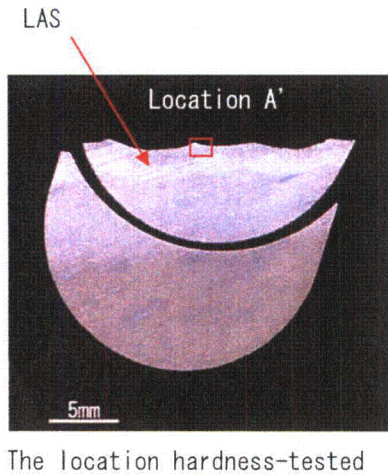
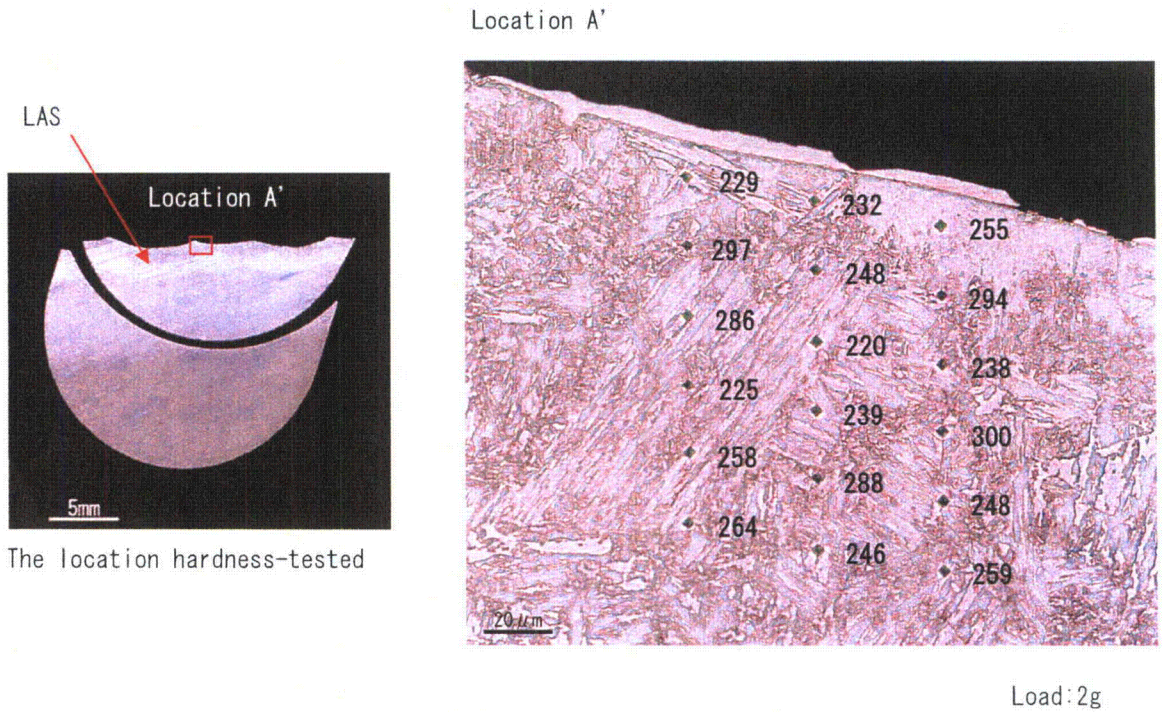
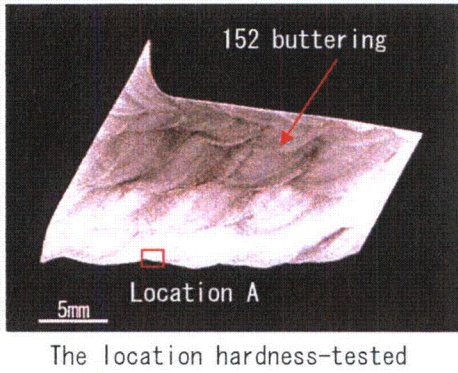
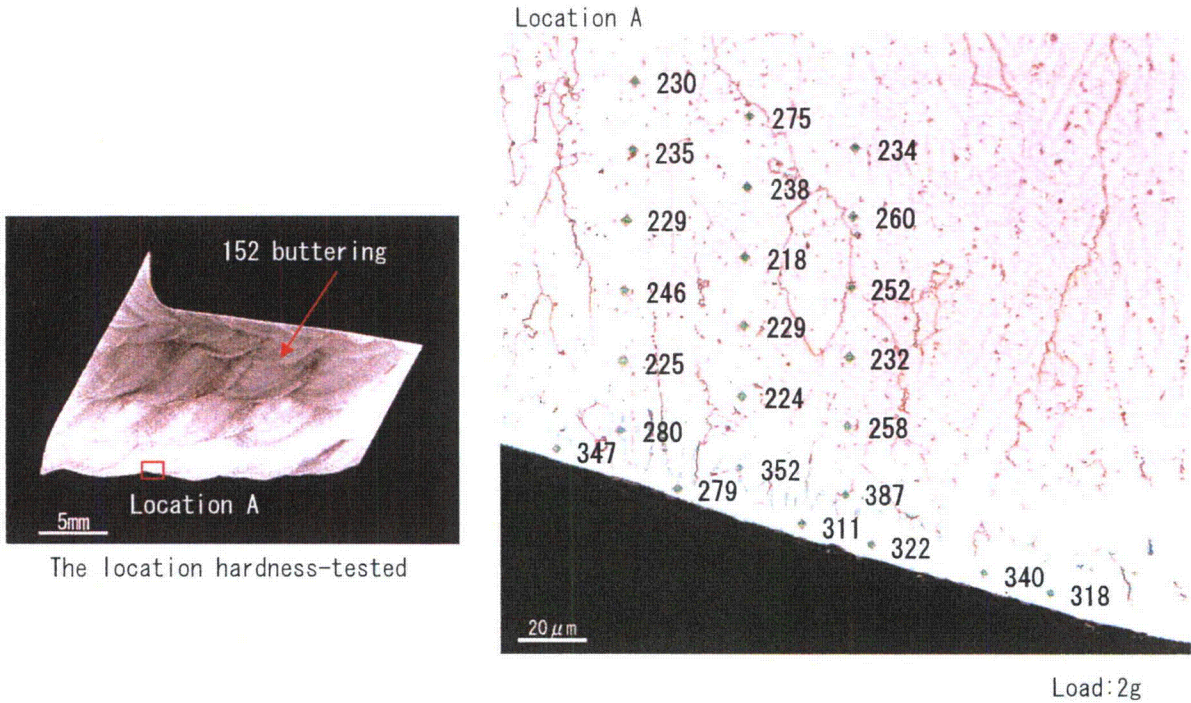
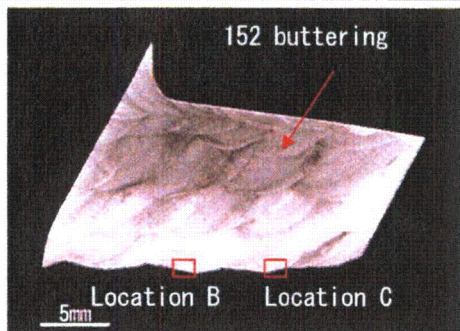
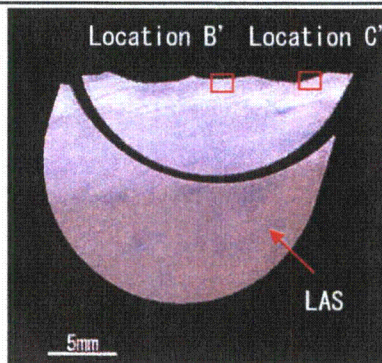


Fig. A. 26(1) Vickers hardness of cross section of sample B

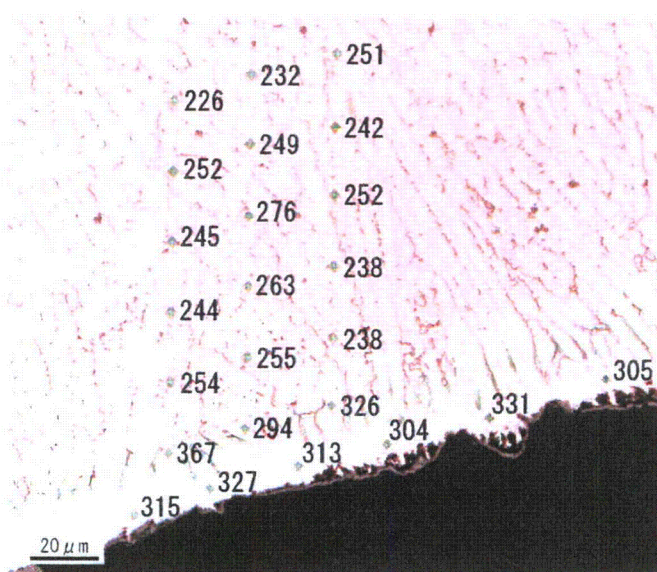
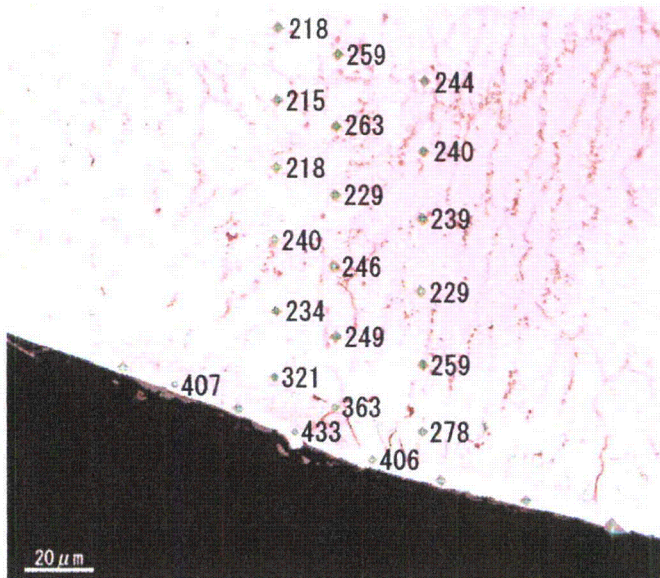


The location hardness-tested



The location hardness-tested Location C

Location B

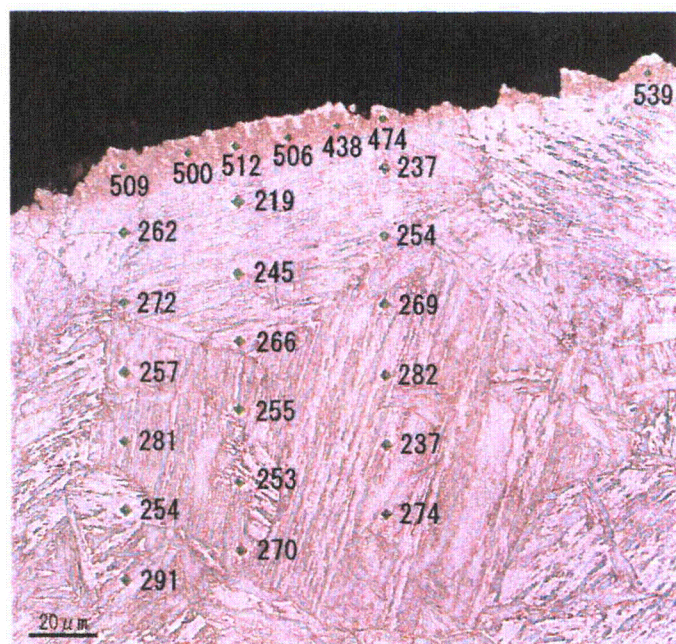
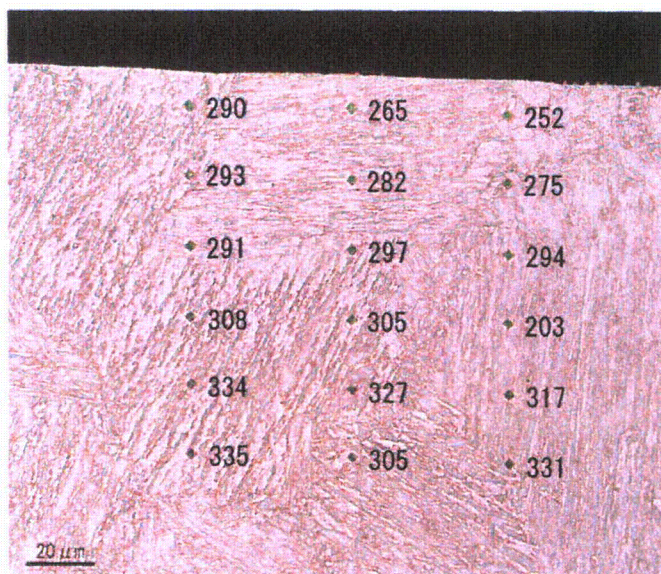


The results of hardness test (152 buttering side)

Load:2g

Location B'

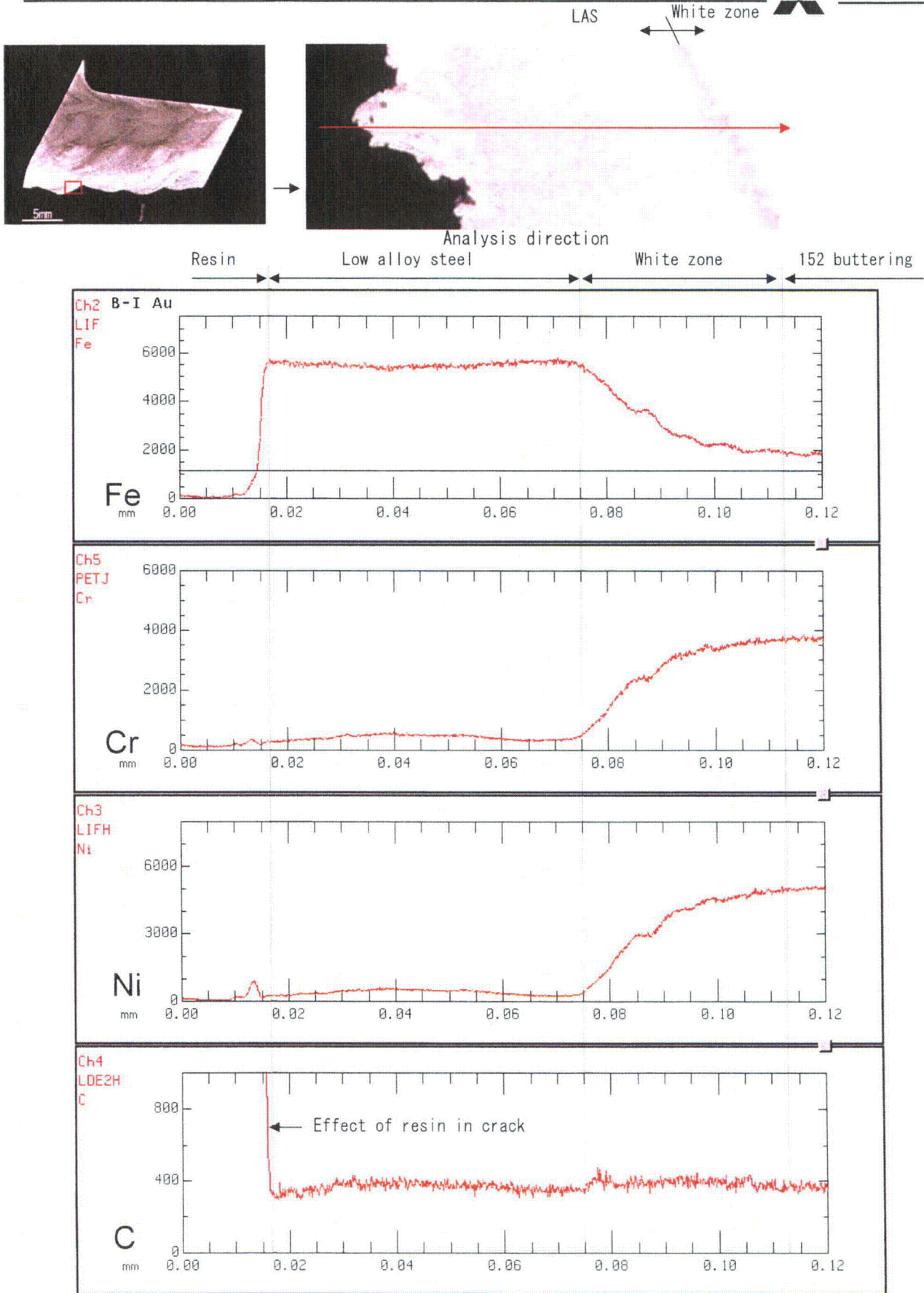
Location C'



The results of hardness test (LAS Channel head side)

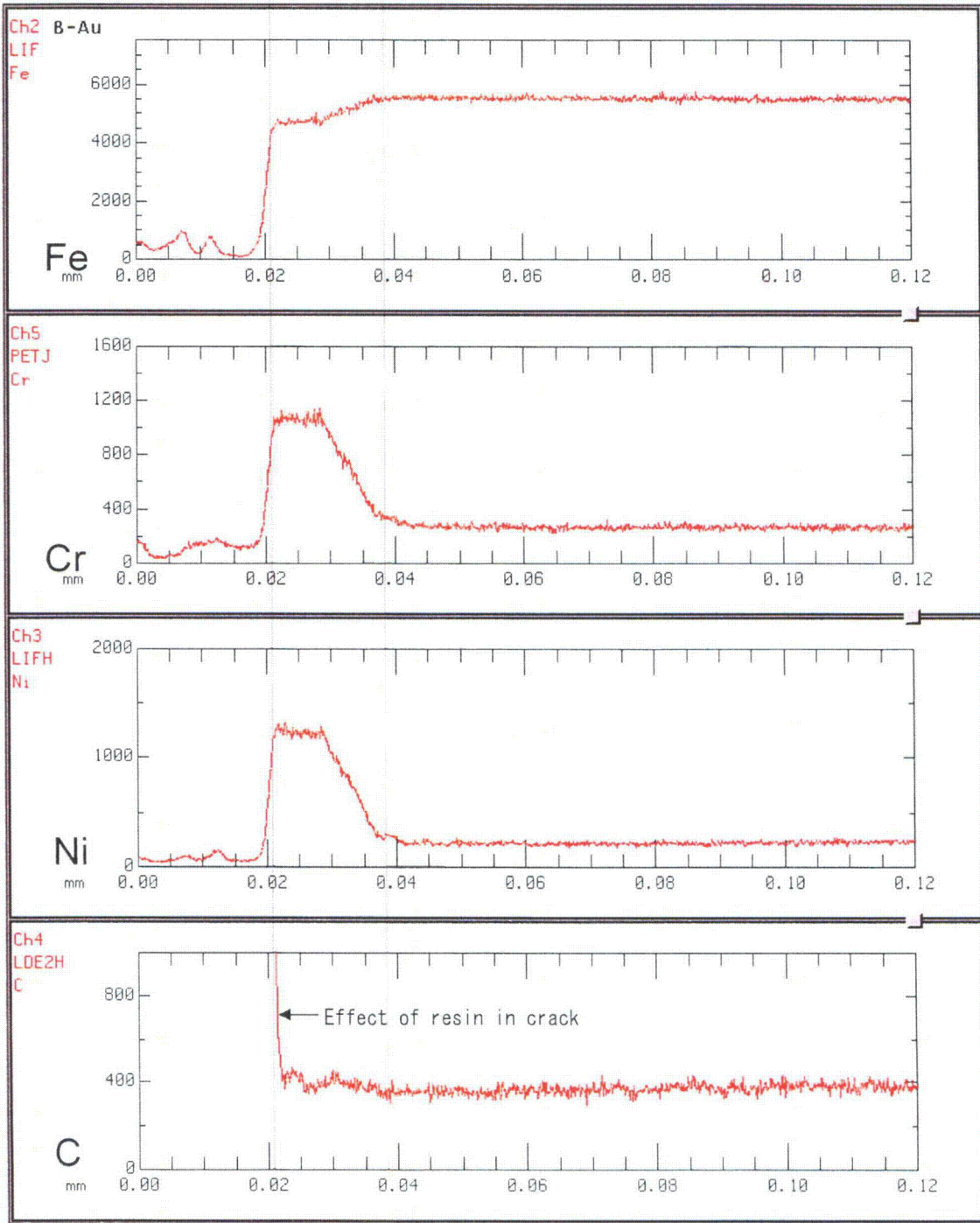
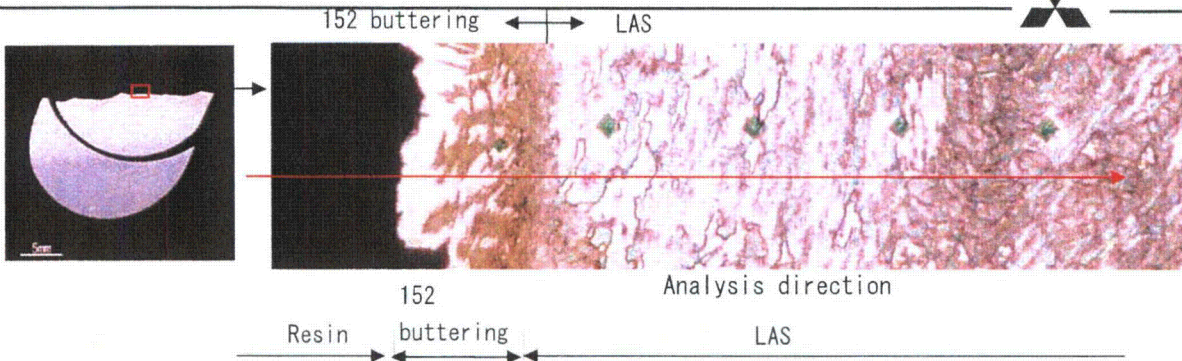
Load:2g

Fig. A.26(2) Vickers hardness of cross section of sample B (Continued)



The result of C is for reference. The sample was evaporation coated with Au.

Fig. A.27 EPMA line analysis of cross section of sample B (152 buttering)



The result of C is for reference. The sample was evaporation coated with Au.

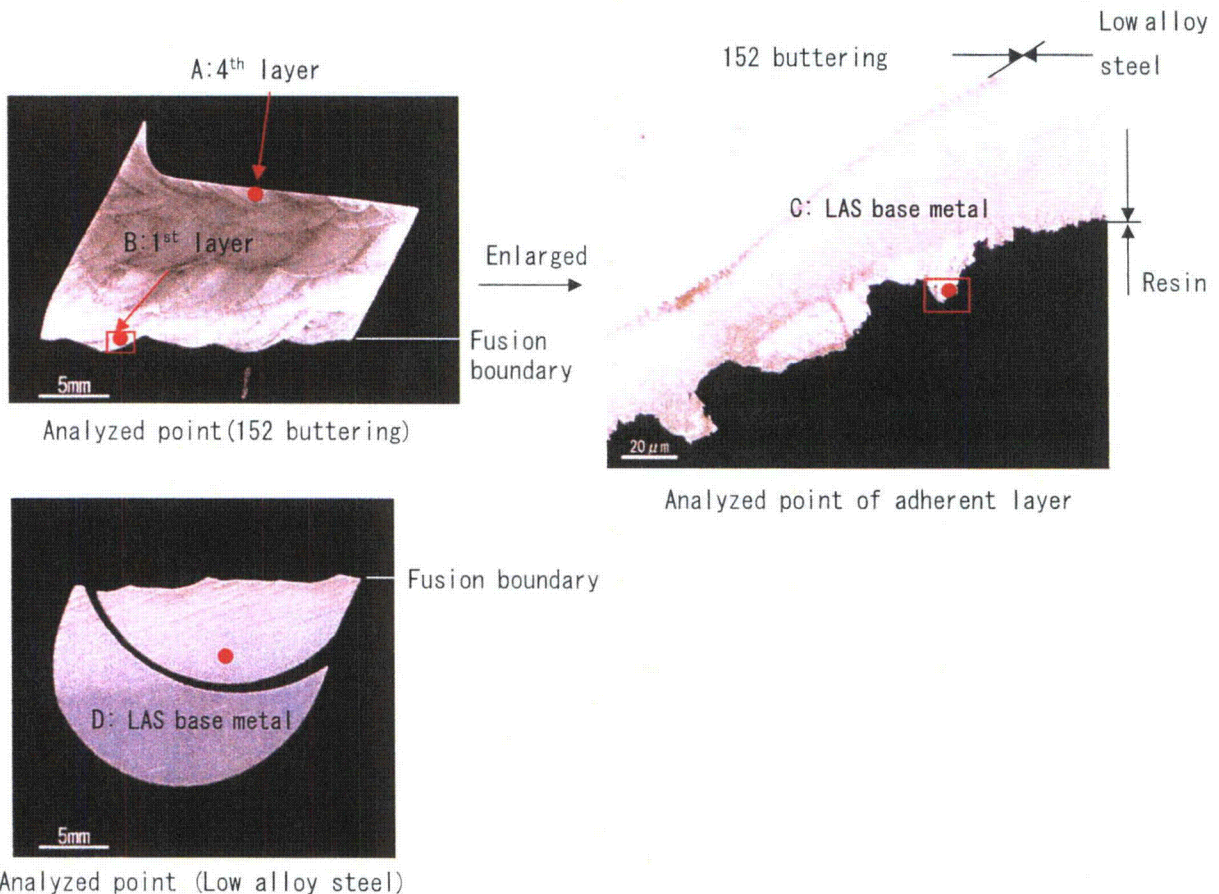
Fig. A.28 EPMA line analysis of cross section of sample B (Low alloy steel channel head)

Table A.4 The results of EPMA semi-qualitative analysis (wt.%)

		Al	Si	Ti	Cr	Mn	Fe	Ni	Nb	Mo
Sample B (152 buttering)	A: 4 th layer	0.2	0.4	-	30.1	4.7	8.8	54.6	1.3	-
	B: 1 st layer	0.3	0.4	0.2	23.1	3.7	30.3	41.0	1.0	-
	C: LAS base metal	-	0.3	-	0.5	1.4	96.9	1.0	-	-
152 weld metal** (A,B)		0.11	0.27	0.1	29.57	0.27	10.1	59.6	1.61	0.01
Sample B (Low Alloy Steel)	D: LAS base metal	-	0.3	-	0.3	1.8	95.8	1.1	-	0.7
Low alloy steel**		-	0.24	-	0.19	1.38	Bal.	0.88	-	-

* The value obtained by semi-quantitative analysis was for reference because the effect of background and superposition X-ray were not considered.

** The values in certification sheet of the material.



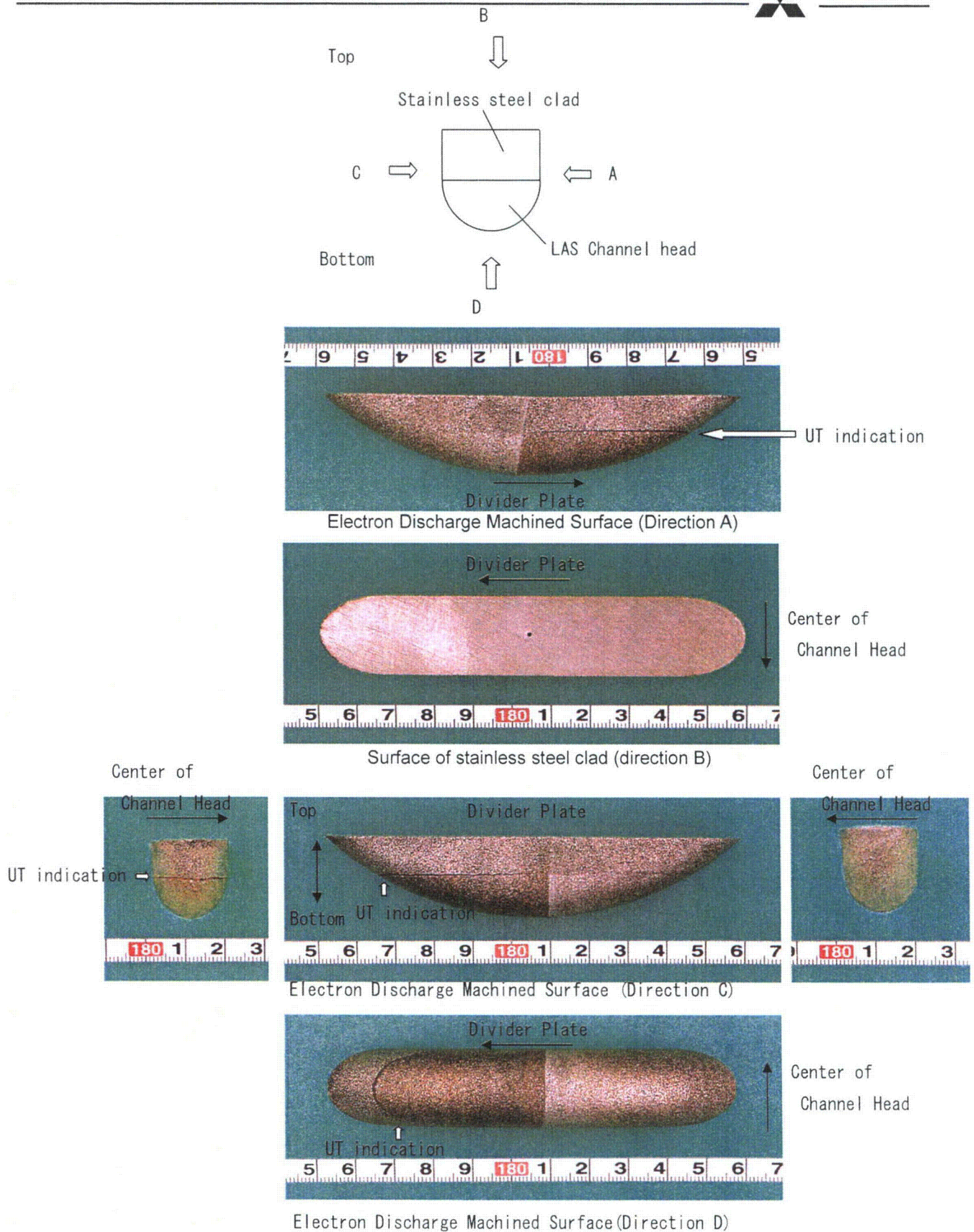


Fig.A.29 Appearance of sample C

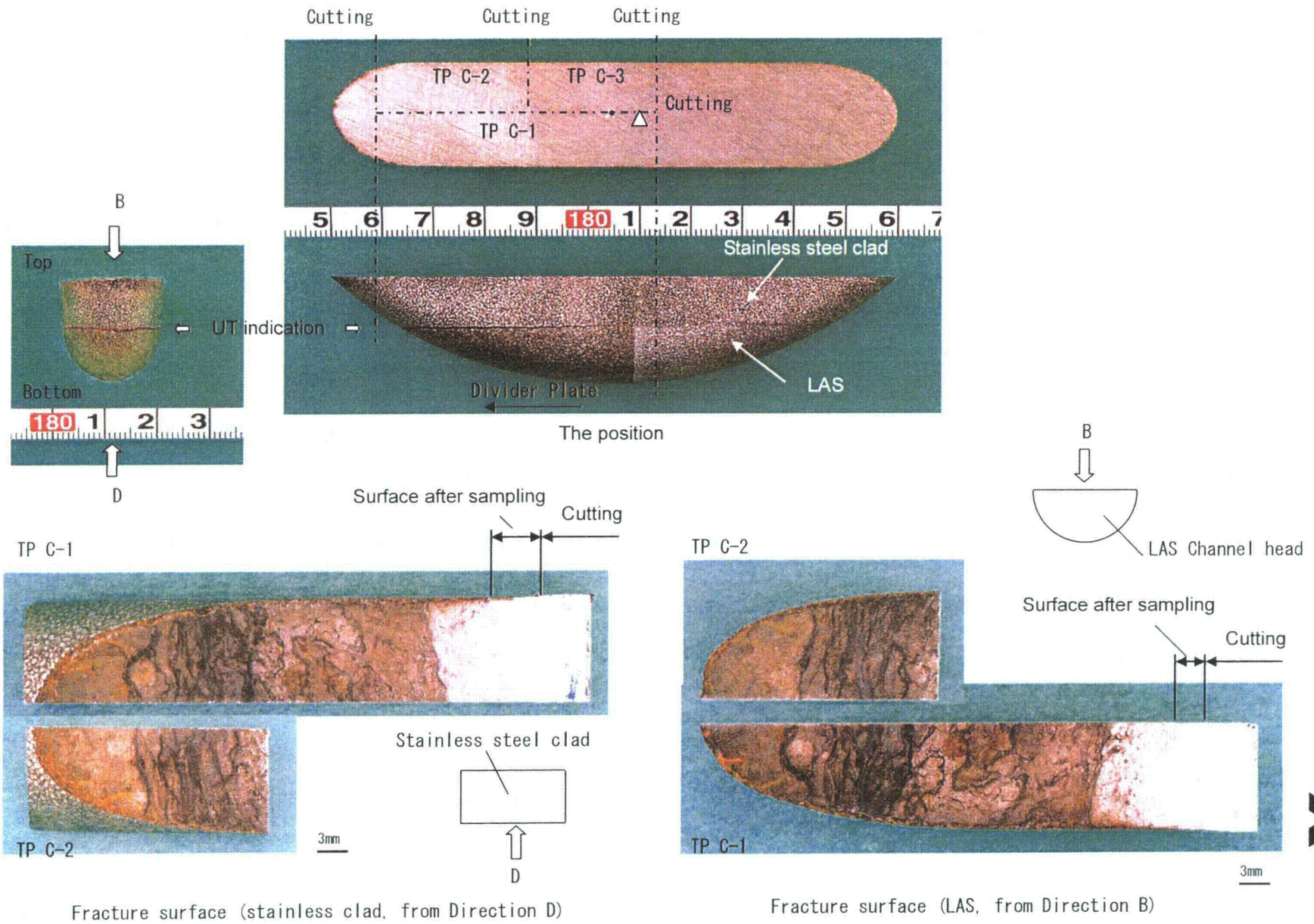
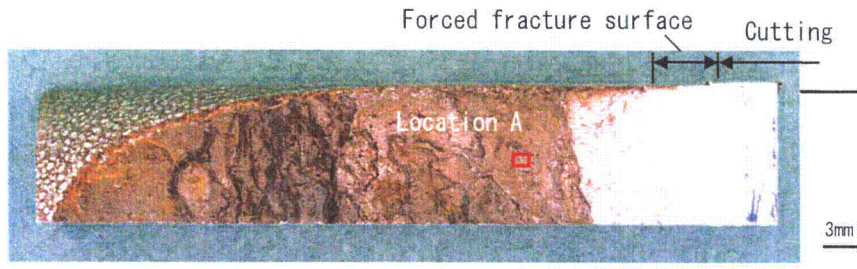
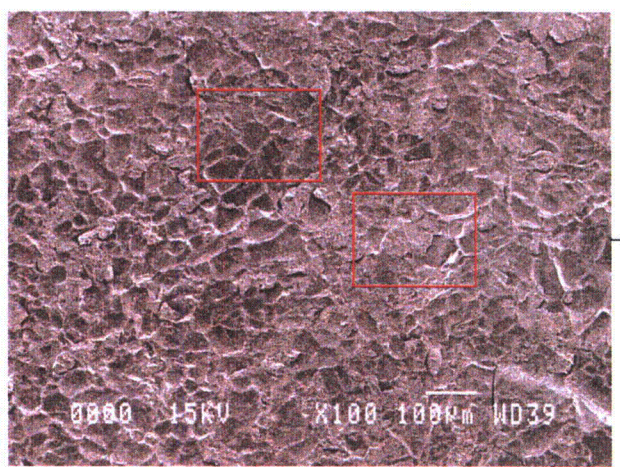


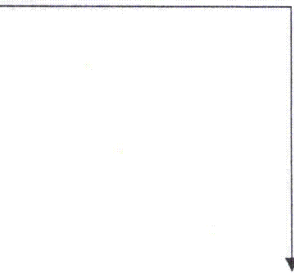
Fig.A.30 Appearance of fracture surface of TP C-1 and C-2 sample C



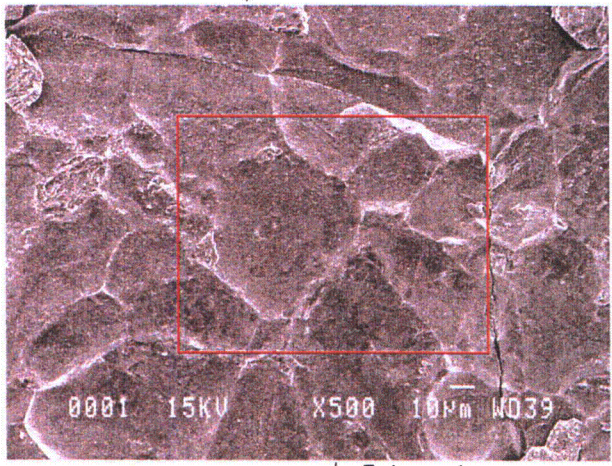
Detail observation of Location A



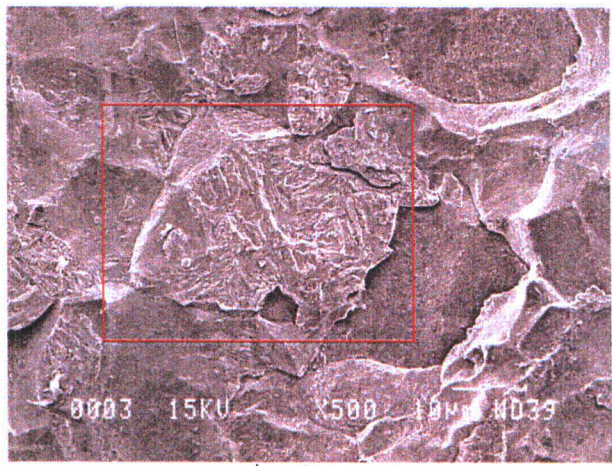
Enlarged



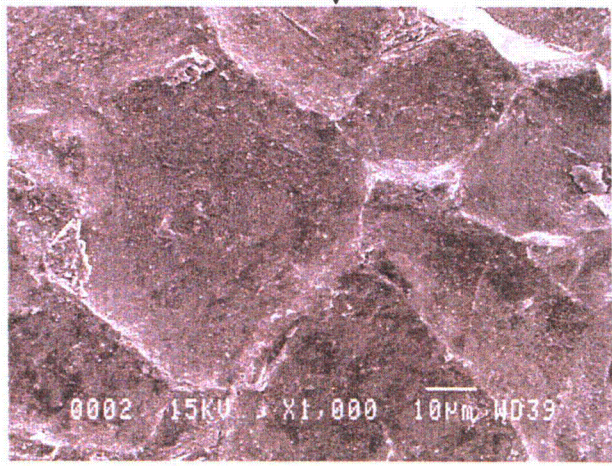
Enlarged



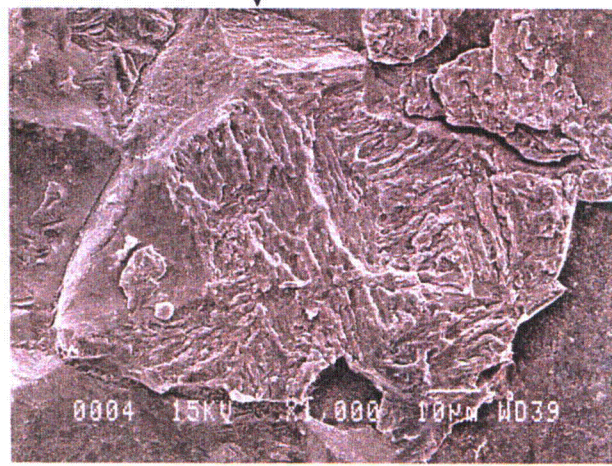
Enlarged



Enlarged

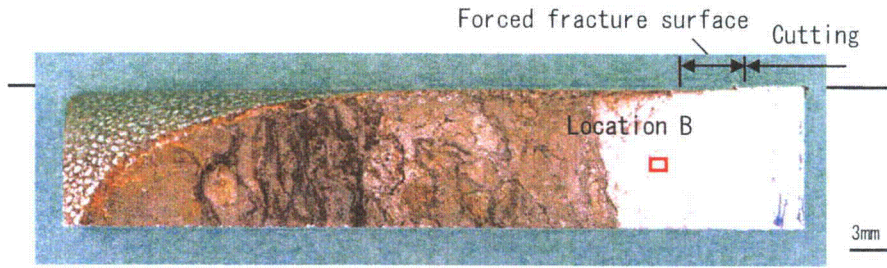


Dendrite-boundary-like pattern

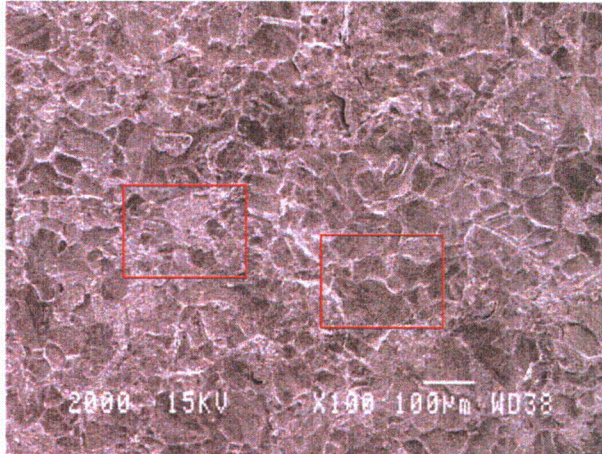


Quasi-cleavage fracture surface

Fig. A. 31(1) SEM observation of fracture surface of TP C-1 (sample C)

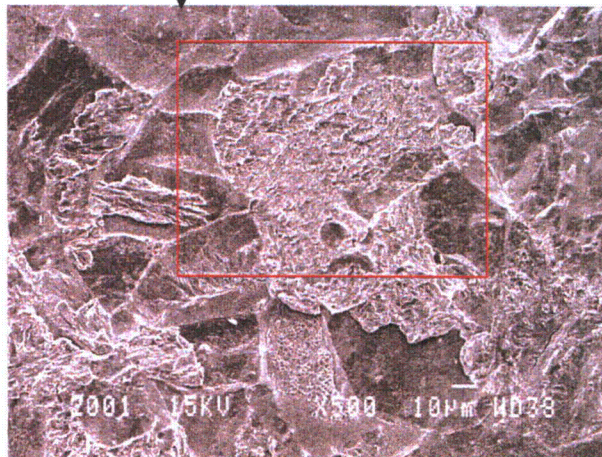


Detail observation of Location B



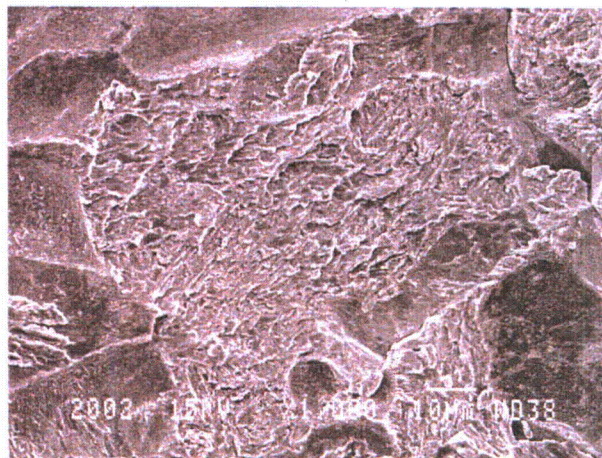
Enlarged

Enlarged

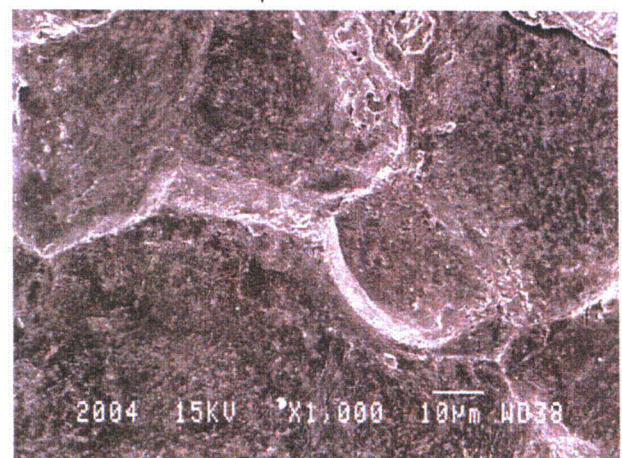
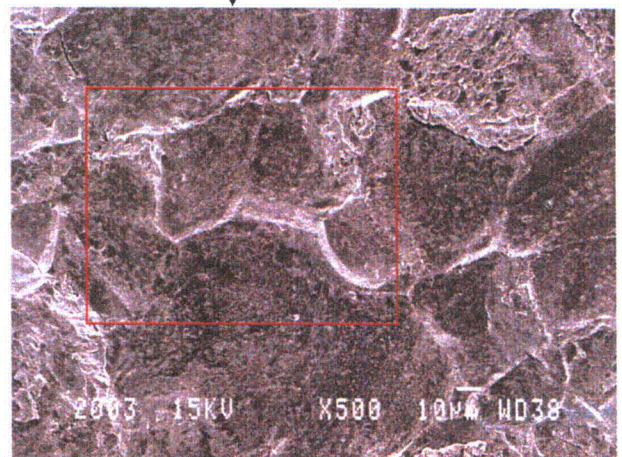


Enlarged

Enlarged



Quasi-cleavage fracture surface



Dendrite-boundary-like pattern

Fig. A.31(2) SEM observation of fracture surface of TP C-1(sample C) (Continued)

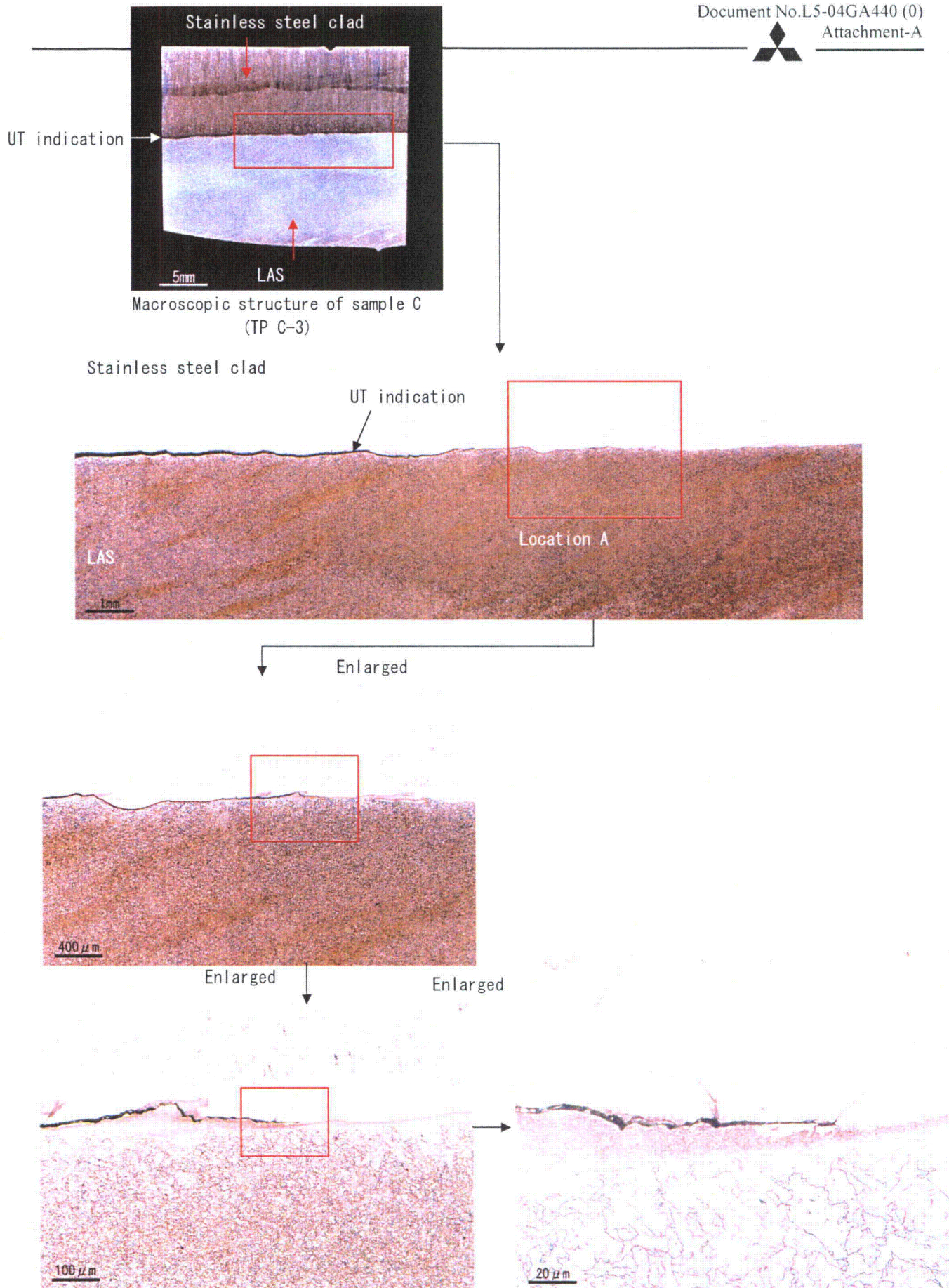


Fig. A.32(1) Micro-structure observation of cross section of sample C

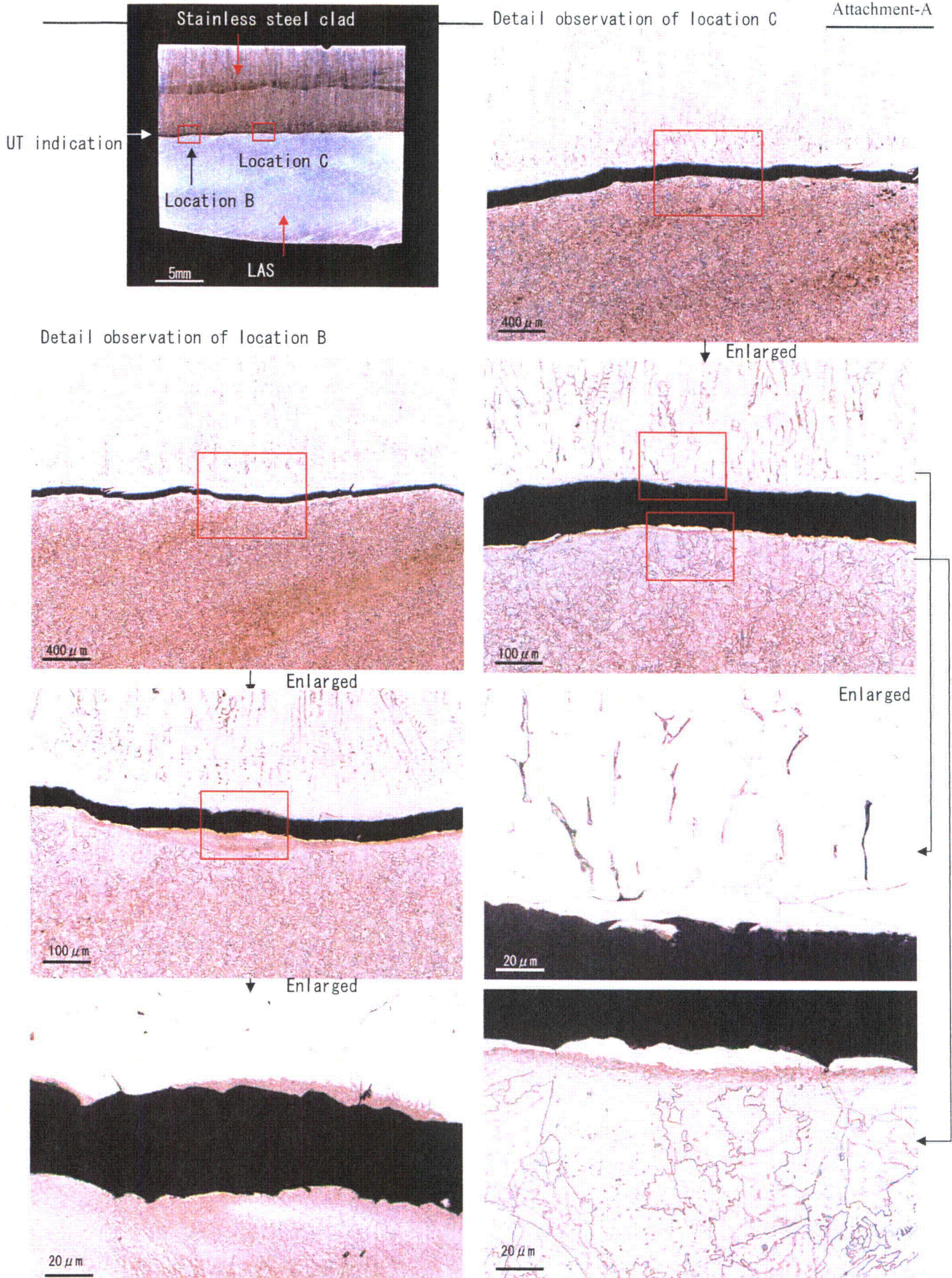
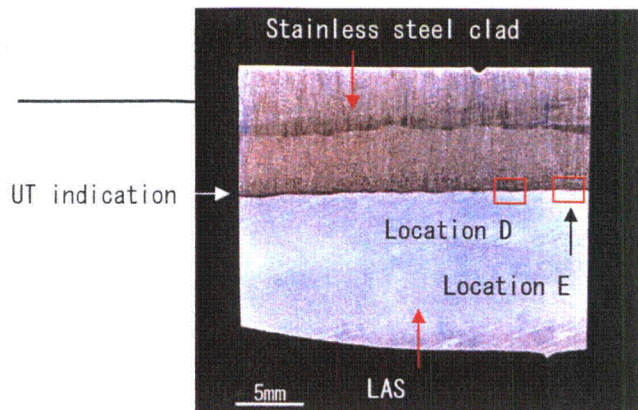
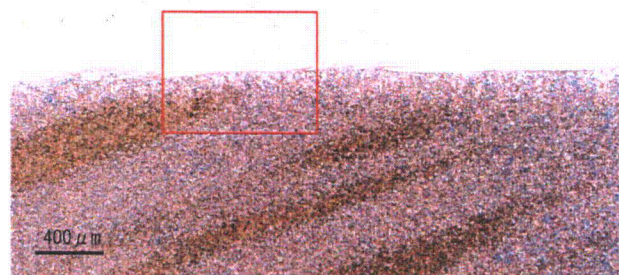
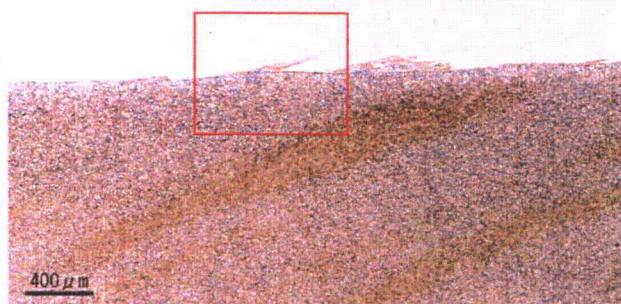


Fig. A. 32 (2) Micro-structure observation of cross section of sample C (Continued)



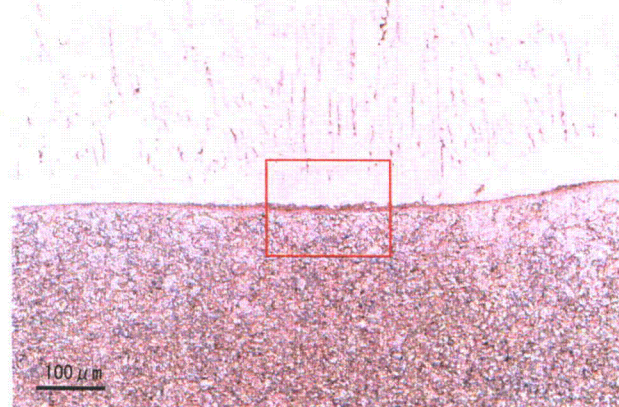
Detail observation of location D

Detail observation of location E



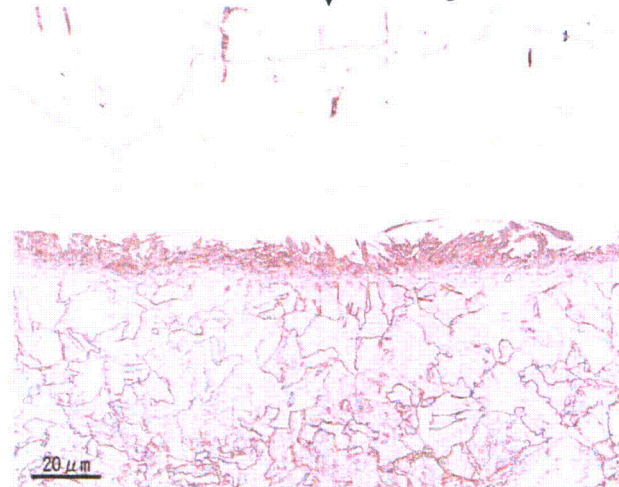
↓ Enlarged

↓ Enlarged



↓ Enlarged

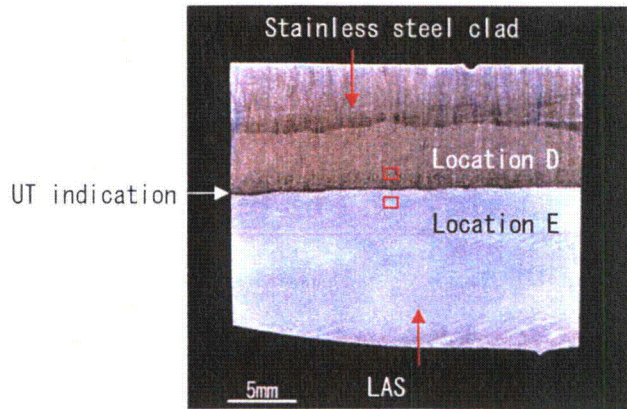
↓ Enlarged



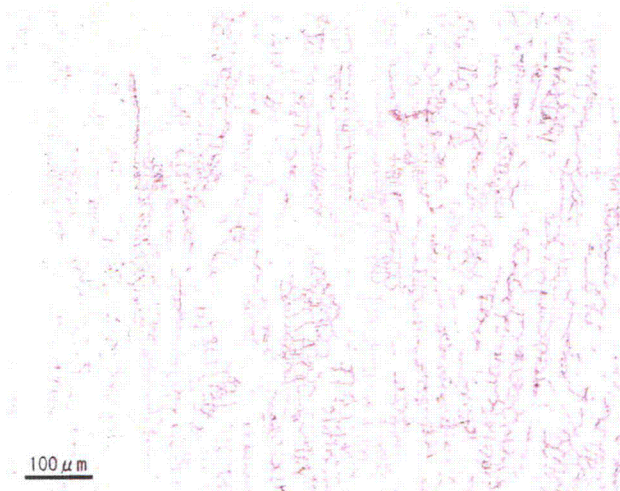
20 μm

20 μm

Fig. A.32(3) Micro-structure observation of cross section of sample C (Continued)



Detail observation of location D
(Stainless steel weld metal)



Detail observation of location E
(LAS)

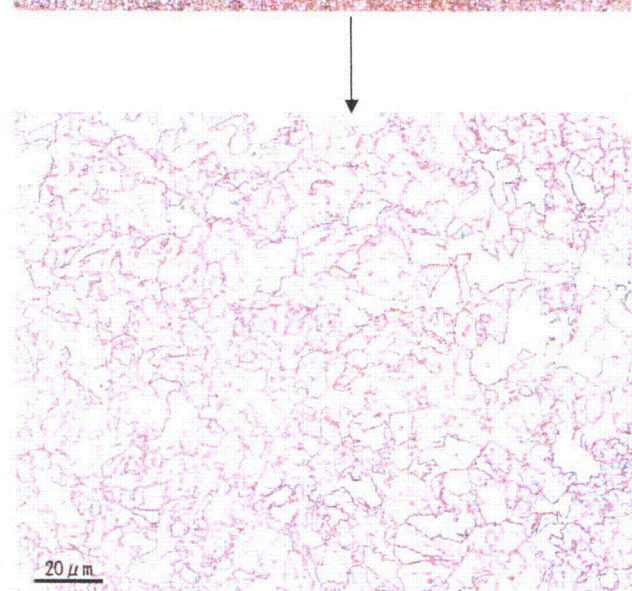
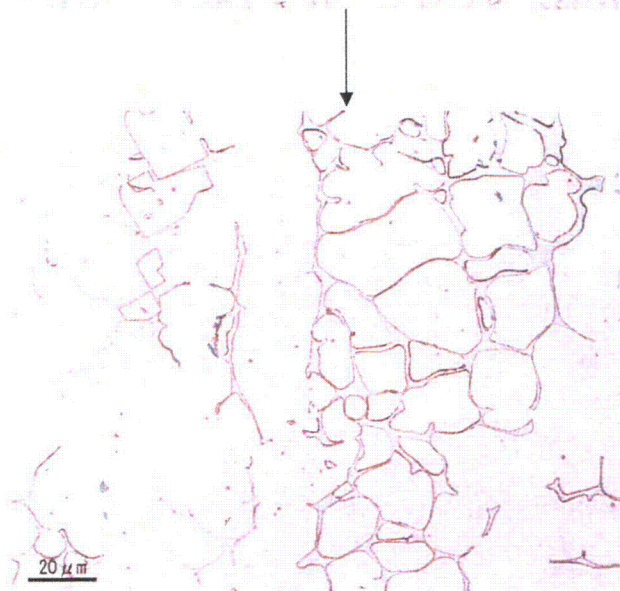
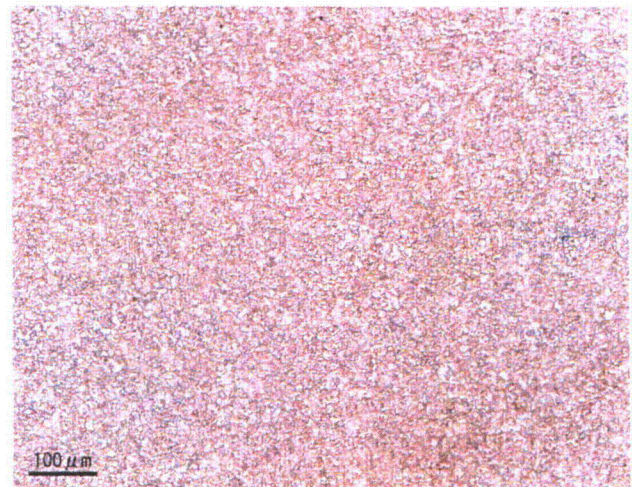


Fig. A.32(4) Micro-structure observation of cross section of sample C (Continued)

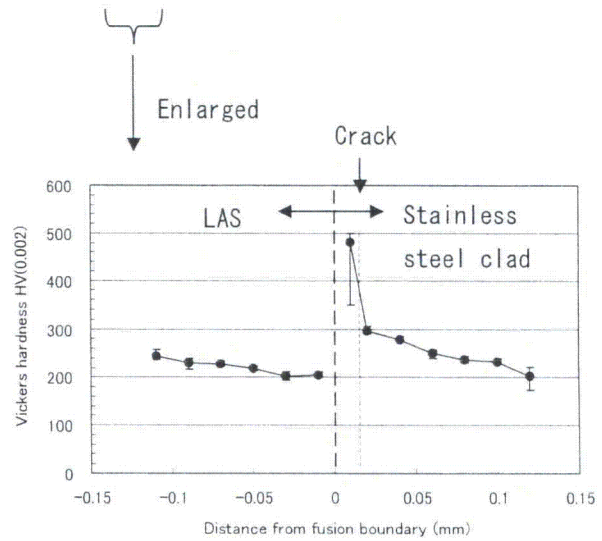
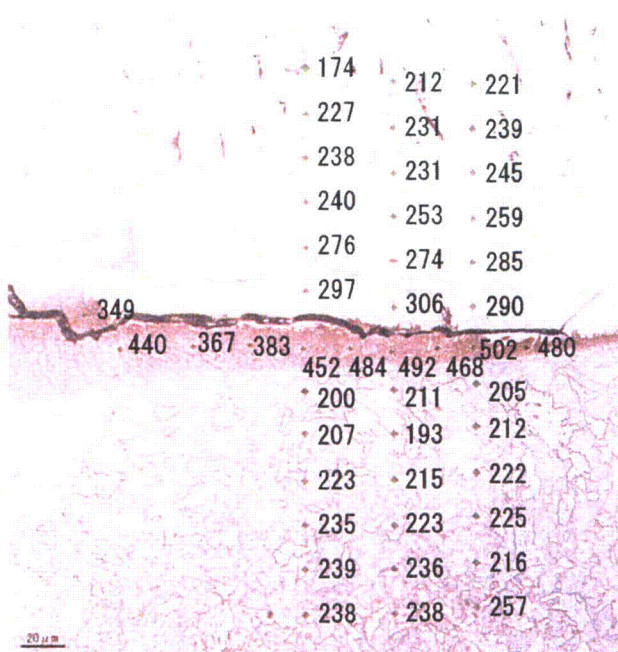
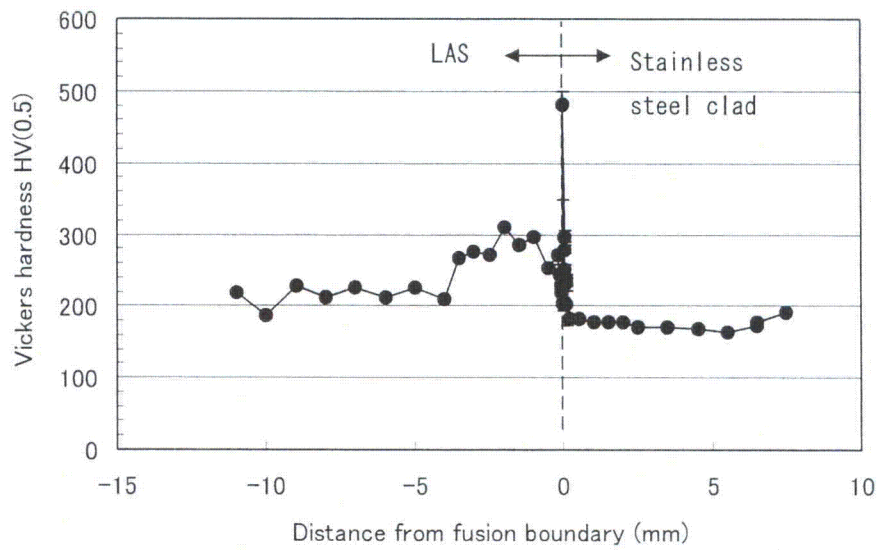
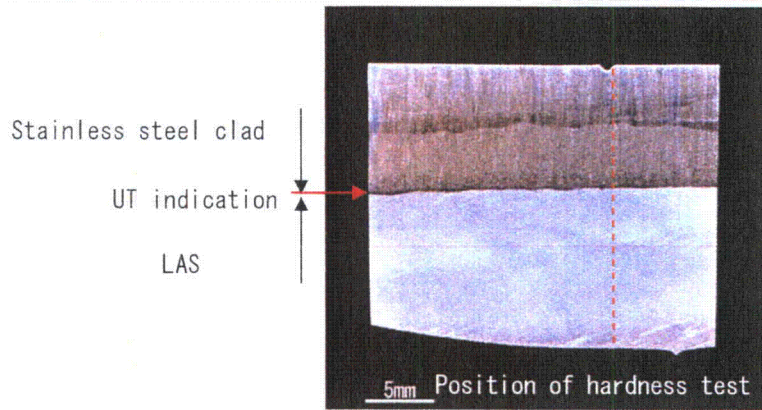


Fig. A.33(1) Vickers hardness of cross section of sample C



Stainless steel clad
 UT indication
 LAS

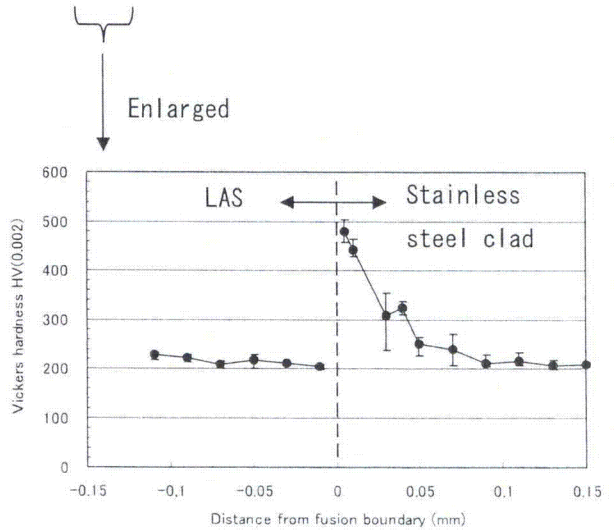
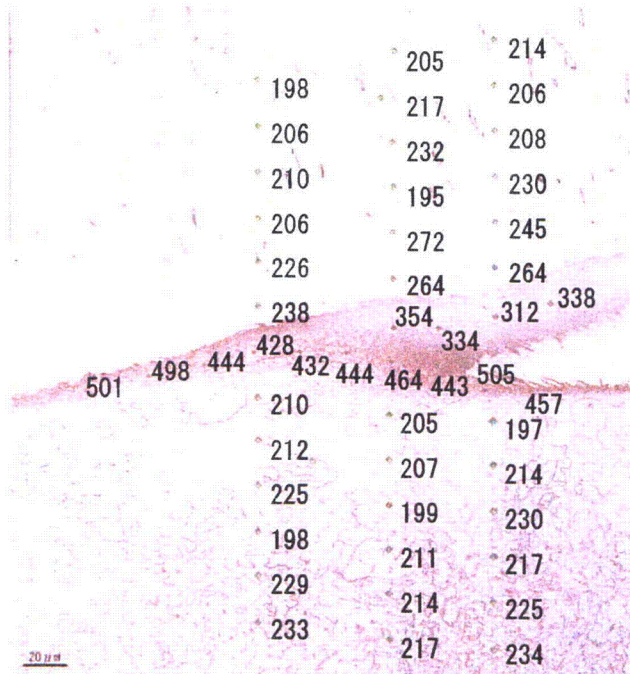
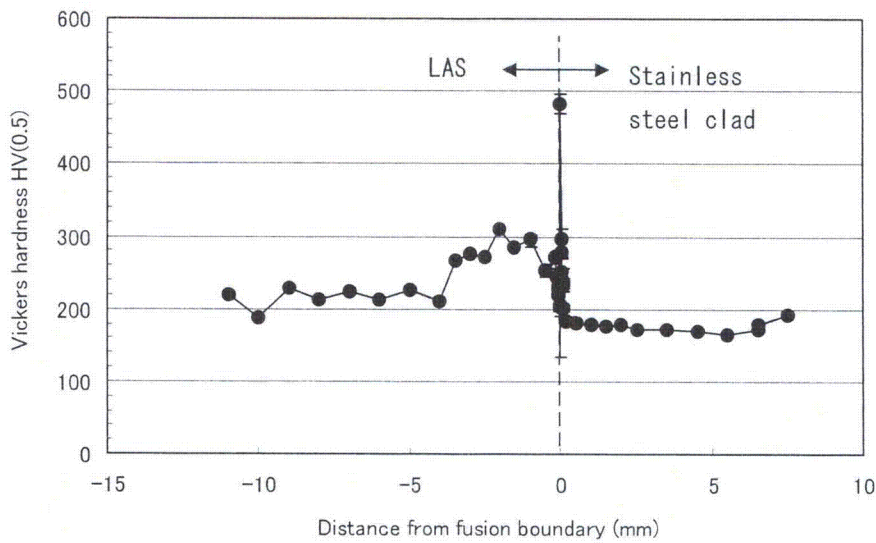
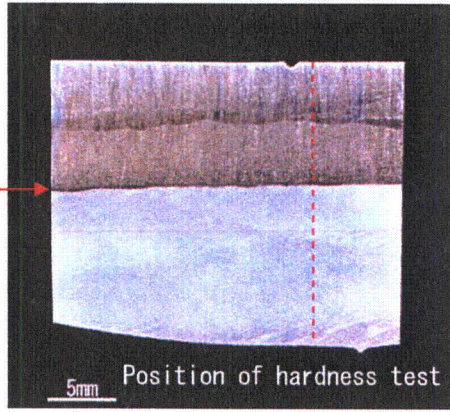
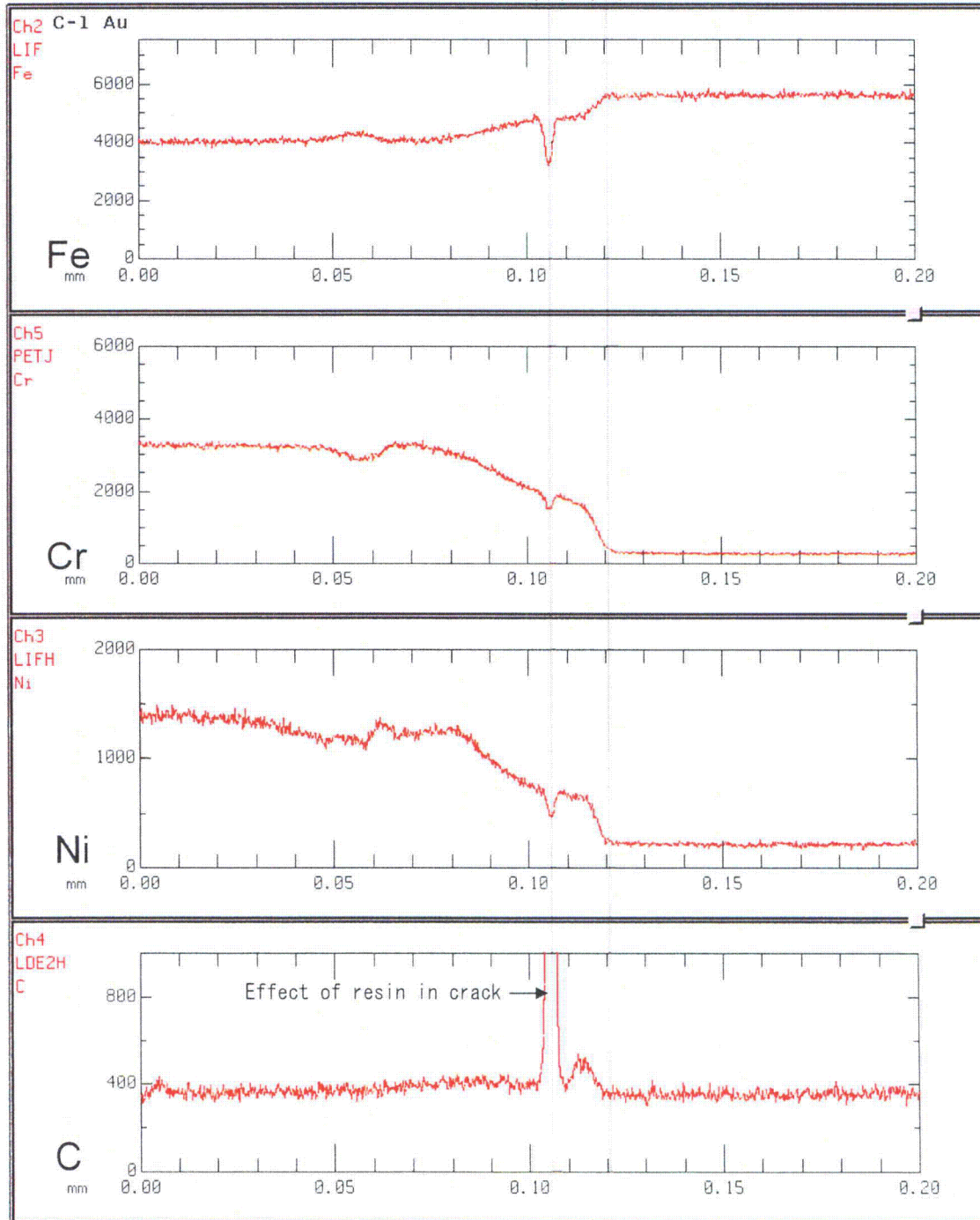
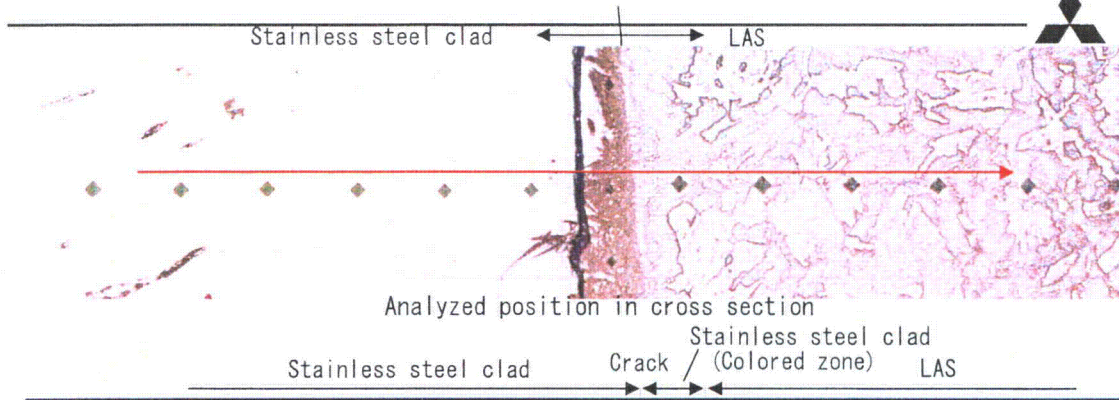
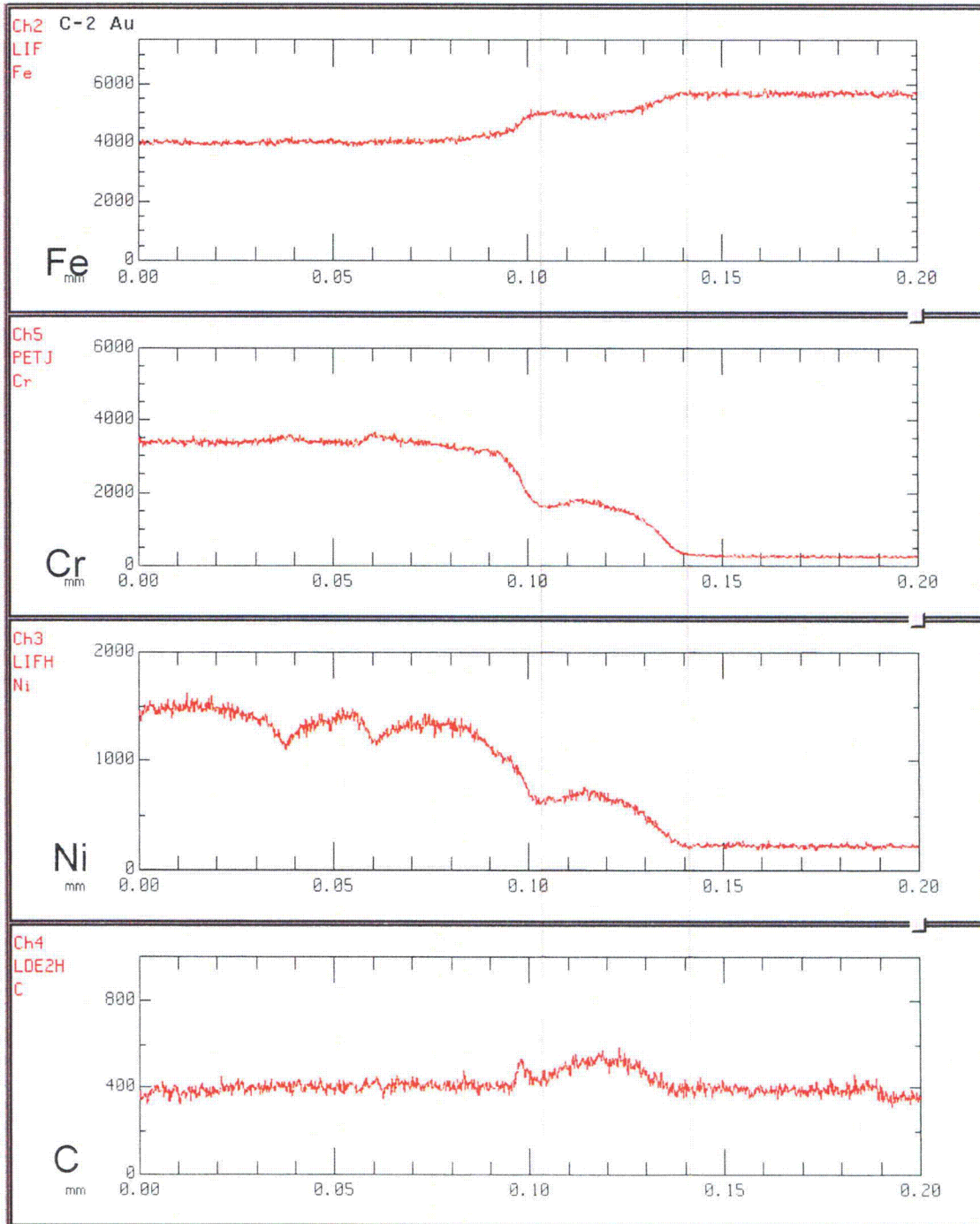
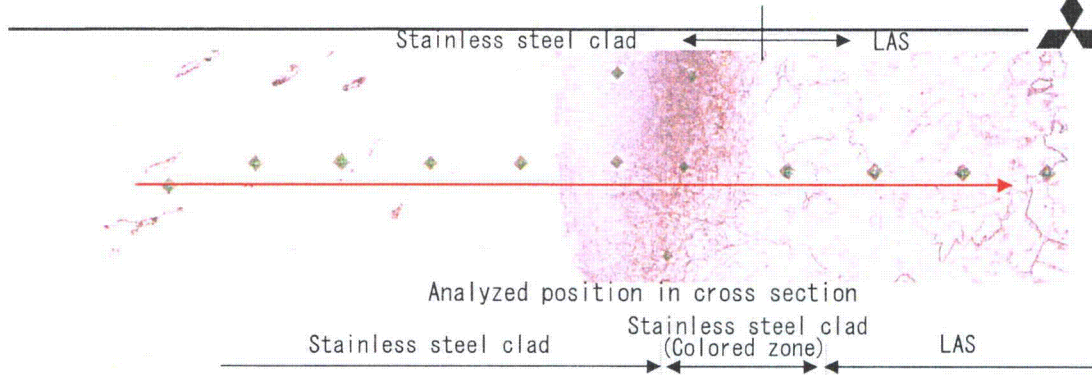


Fig. A.33(2) Vickers hardness of cross section of sample C (Continued)



The result of C is for reference. The sample was evaporation coated with Au.

Fig.A.34(1) EPMA line analysis of Cross Section of sample C



The result of C is for reference. The sample was evaporation coated with Au.

Fig.A.34(2) EPMA line analysis of Cross Section of sample C (Continued)

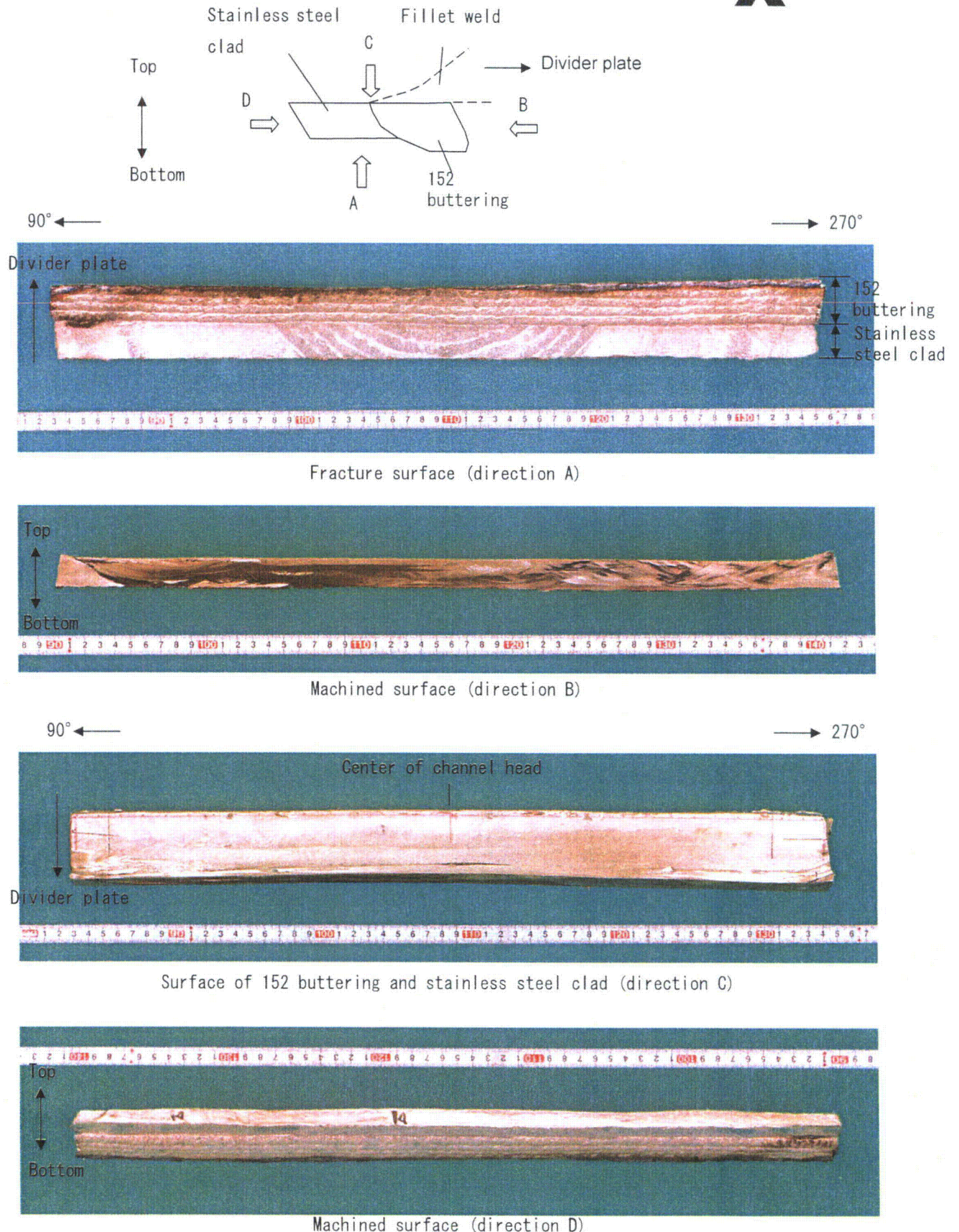
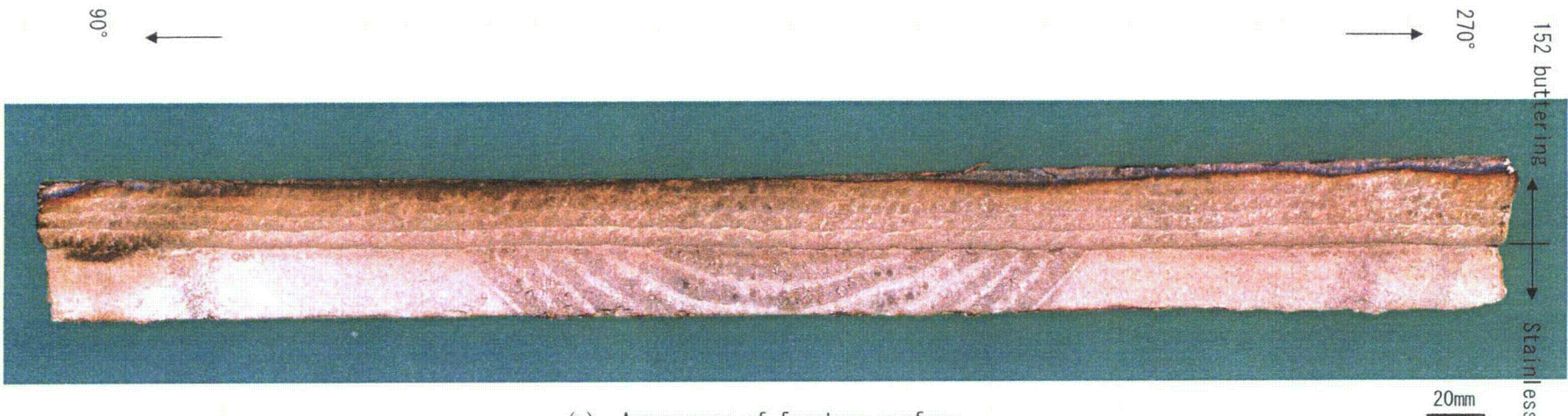
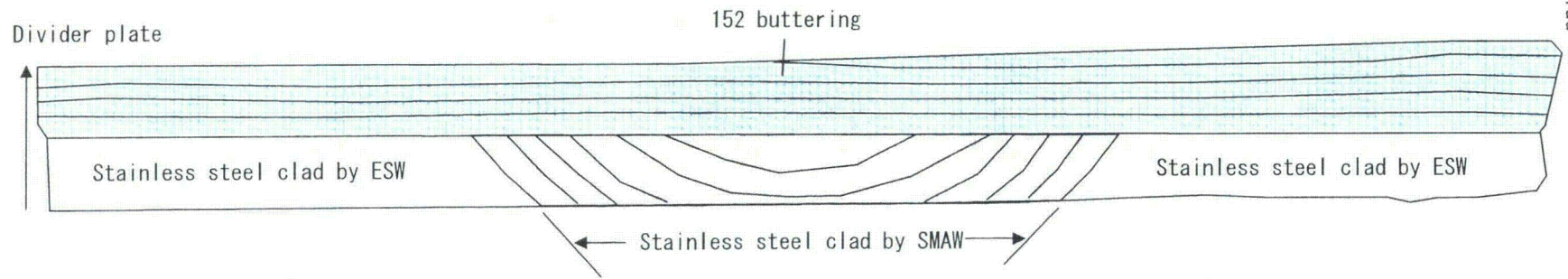


Fig.A.35 Appearance of sample D



(a) Appearance of fracture surface



(b) Schematic illustration of fracture surface

Fig.A.36(1) Appearance of fracture surface (Schematic illustration)



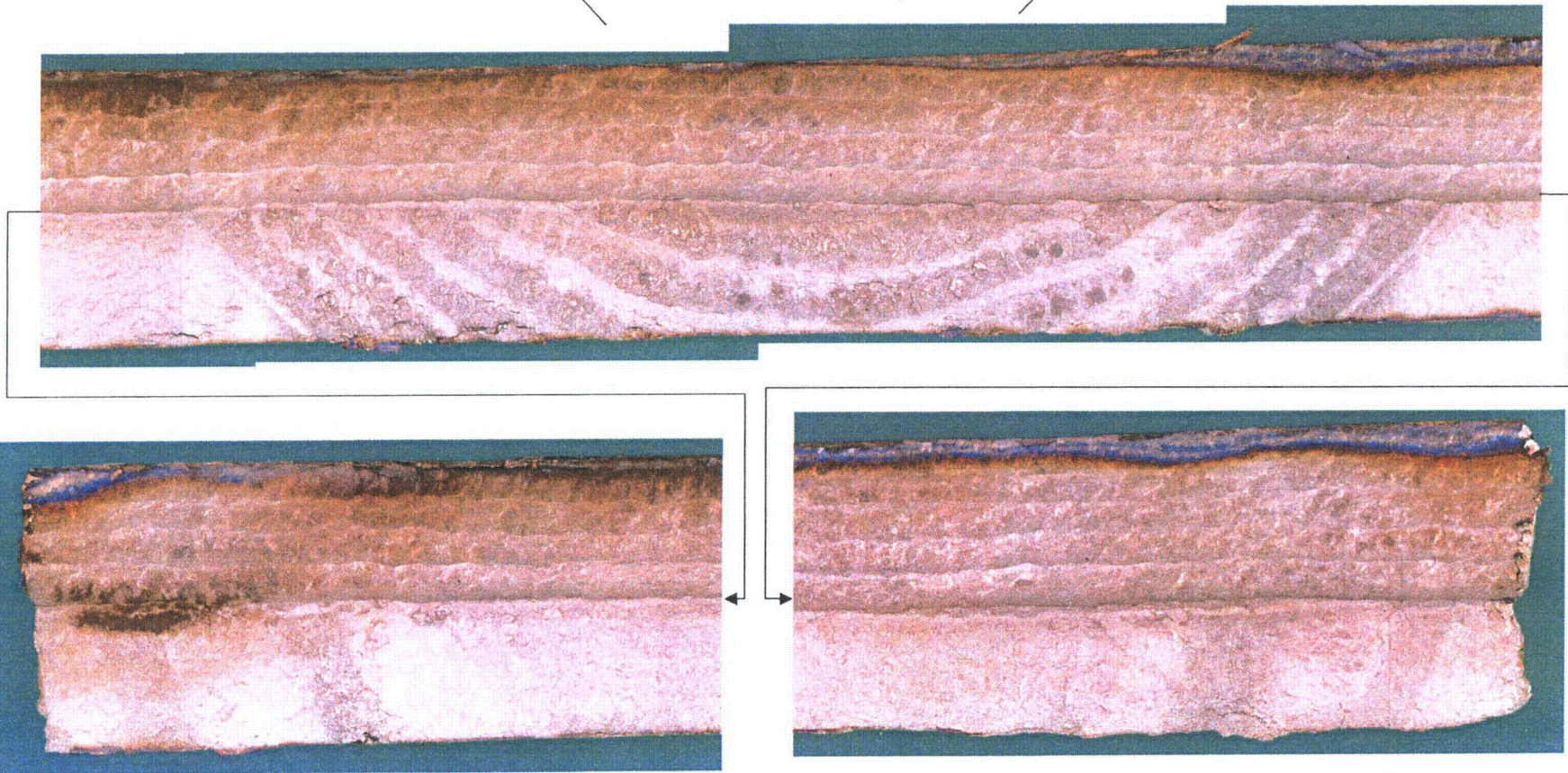
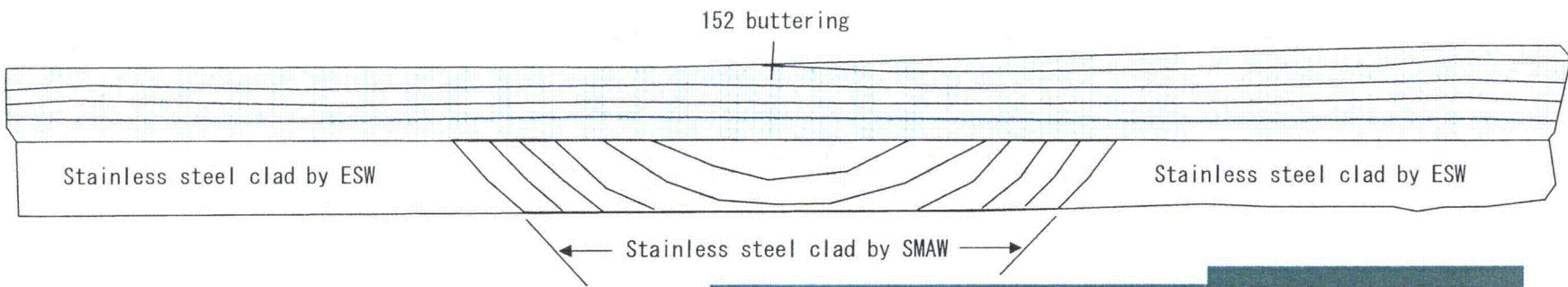
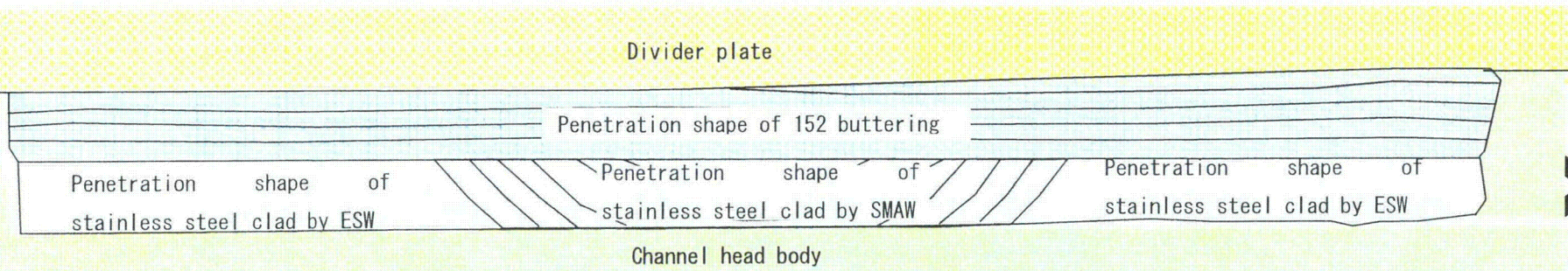
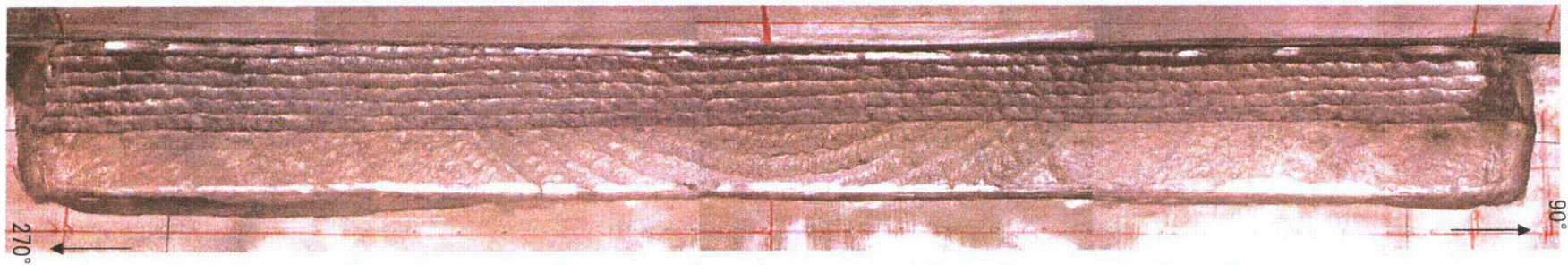
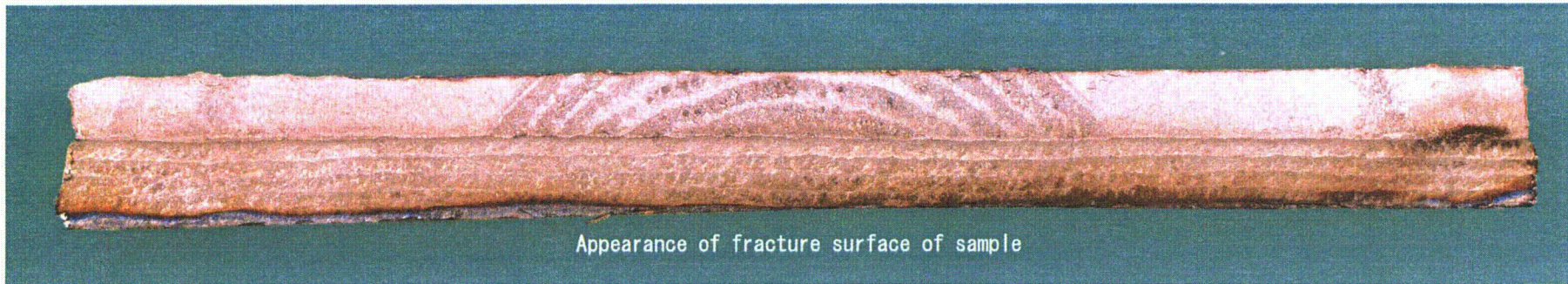


Fig.A.36(2) Appearance of fracture surface

10mm



(c) Schematic illustration channel head body after removal of sample

Fig.A.37(1) Appearance of fracture surface of channel head body after removal of sample

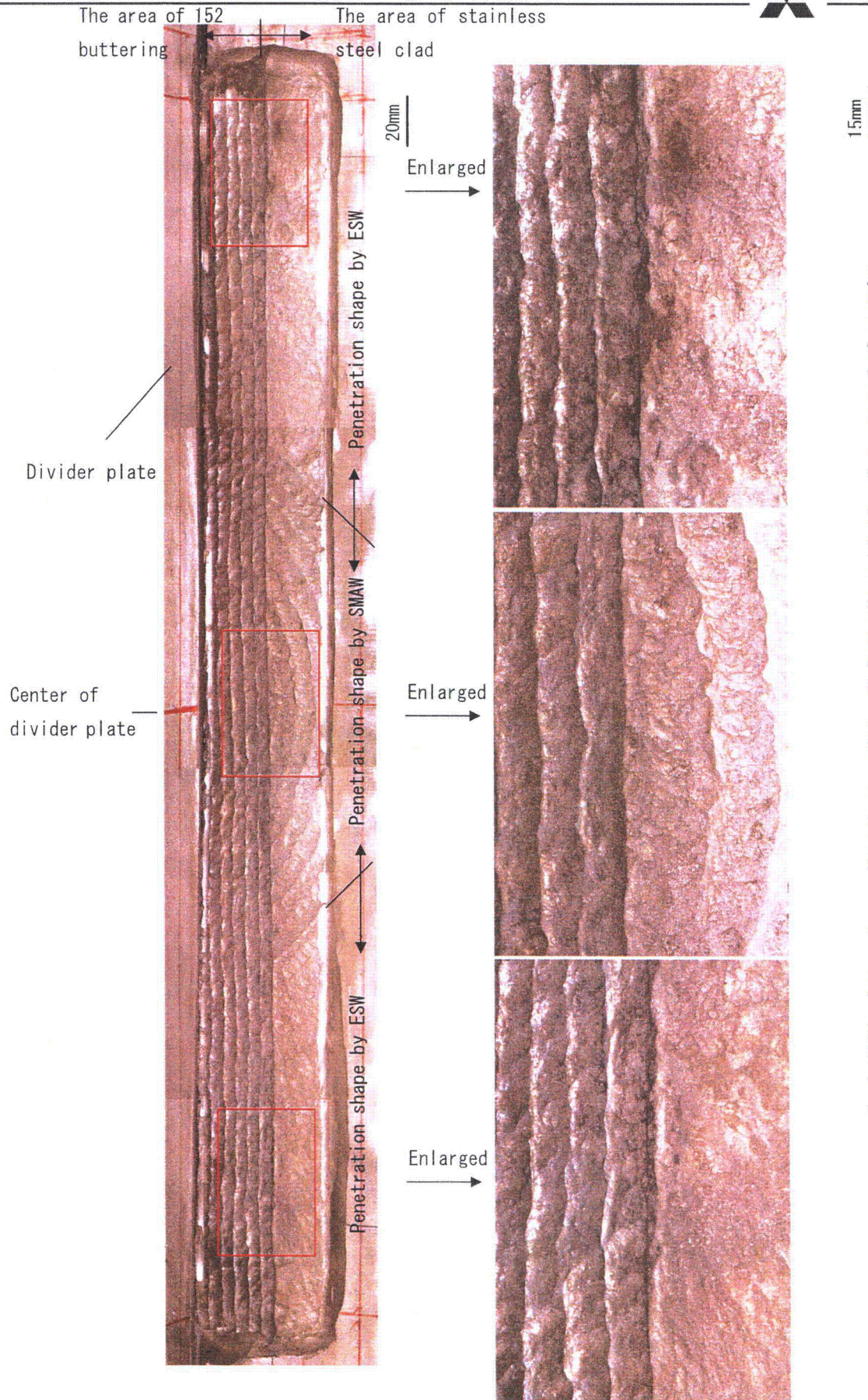
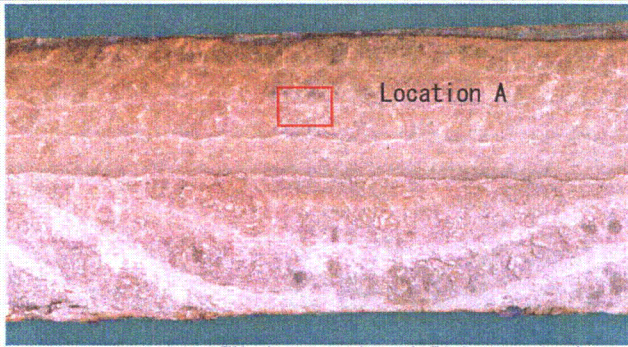
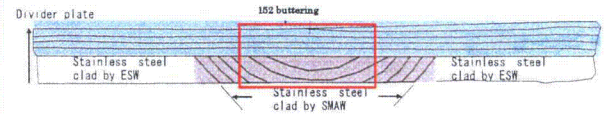


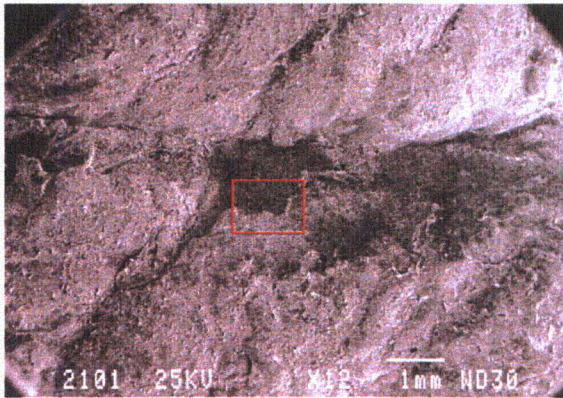
Fig.A.37(2) Appearance of fracture surface of channel head body after removal of sample



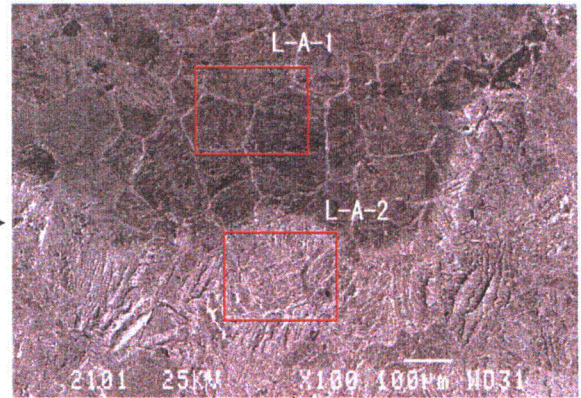
Location for SEM observation (152 buttering)



Detail observation of location A



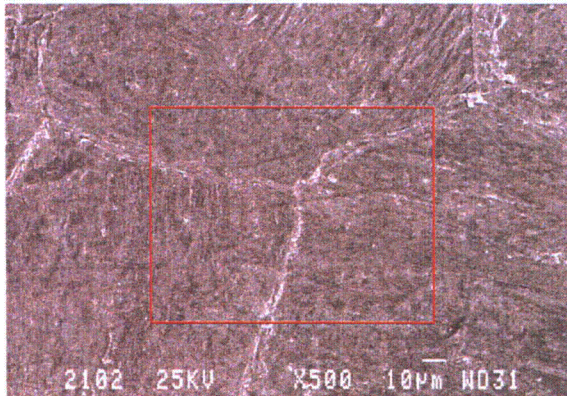
Enlarged



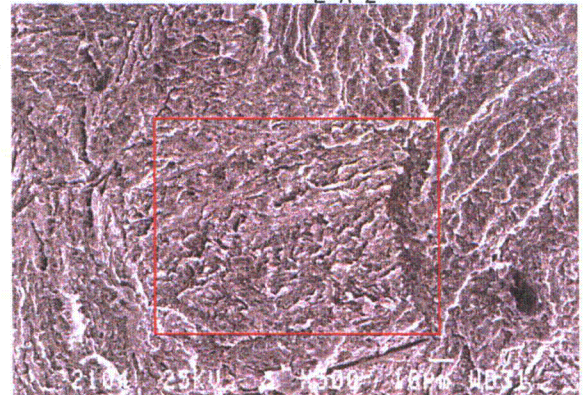
Enlarged

L-A-1

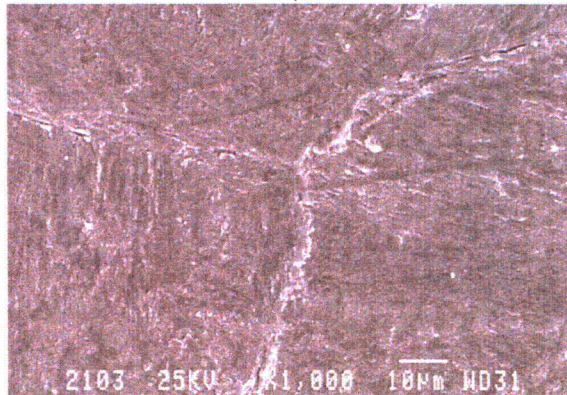
L-A-2



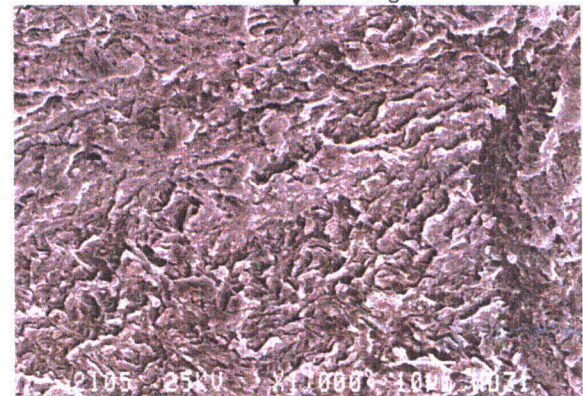
Enlarged



Enlarged

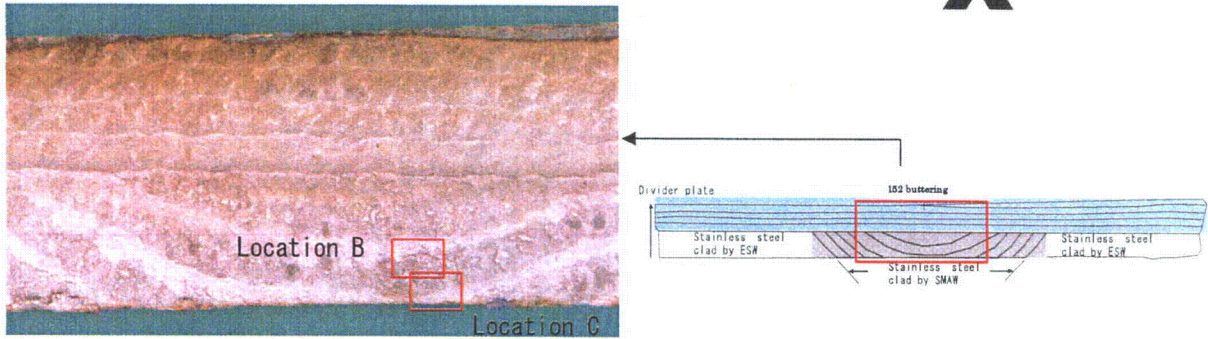


Dendrite boundary like or grain boundary like pattern



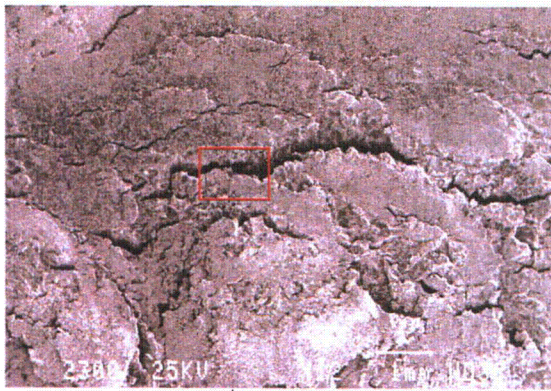
Quasi-cleavage fracture surface

Fig.A.38(1) SEM observation of fracture surface of sample D (152 buttering)

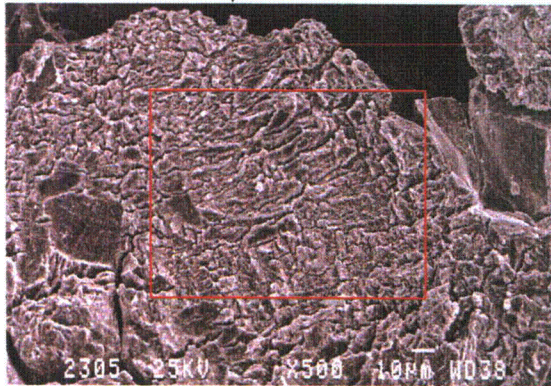


Location for SEM observation (stainless steel clad by SMAW)

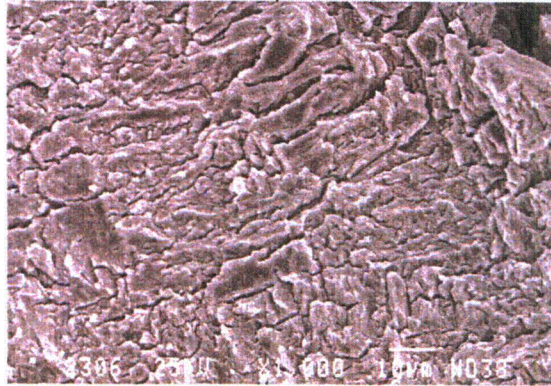
Detail observation of location B



↓ Enlarged



↓ Enlarged

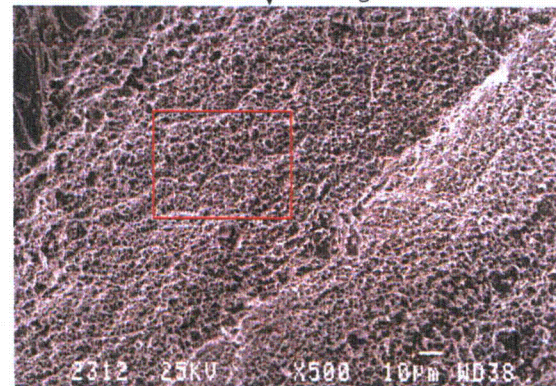


Quasi-cleavage fracture surface

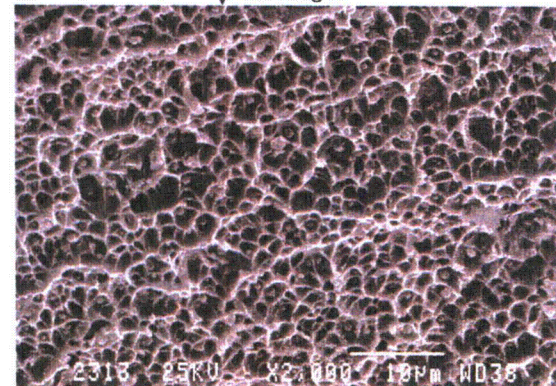
Detail observation of location C



↓ Enlarged

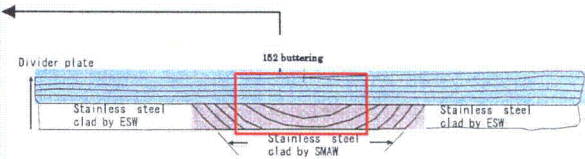
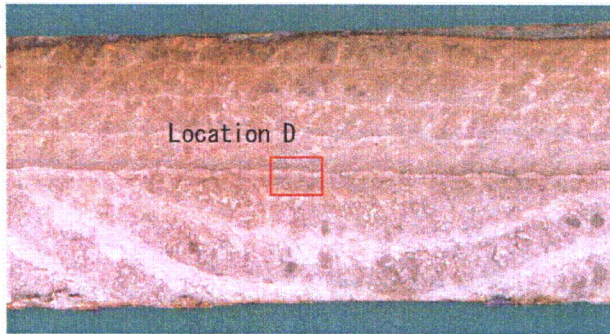


↓ Enlarged



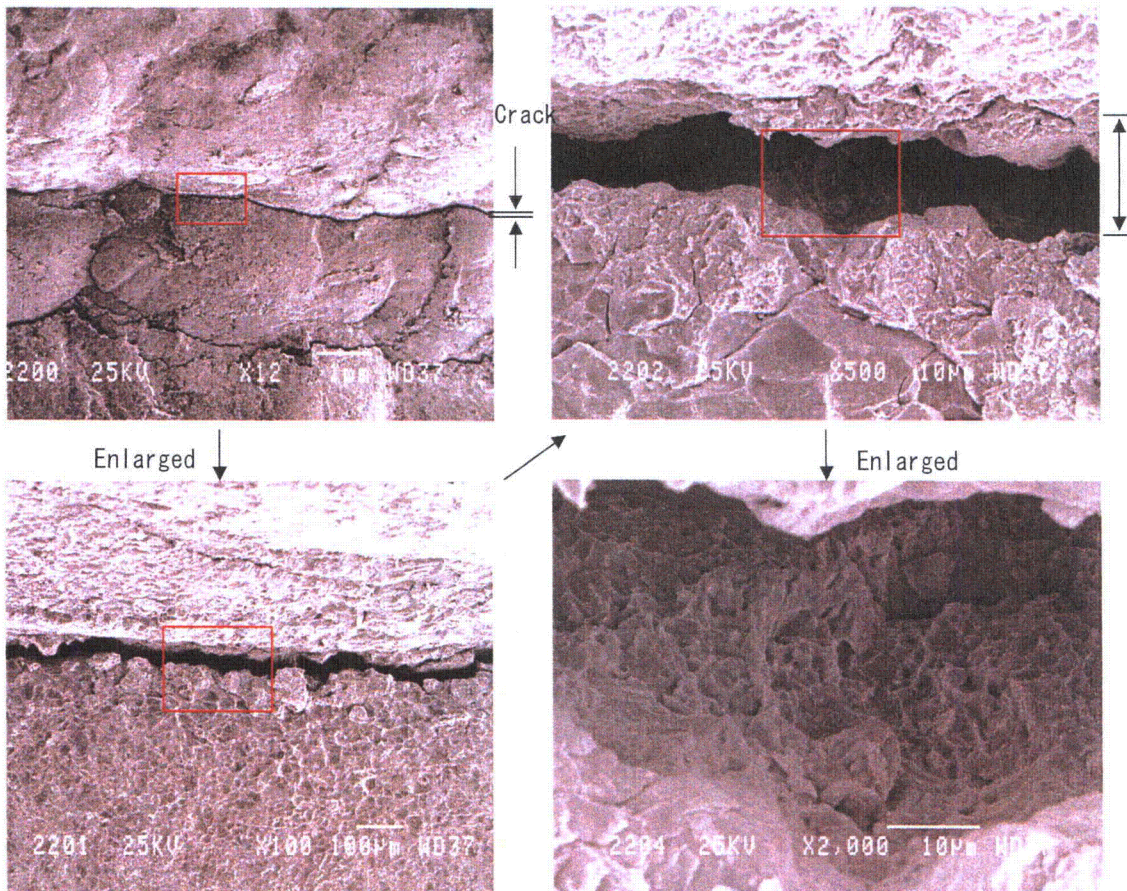
Ductile fracture surface

Fig.A.38(2) SEM observation of fracture surface of sample D (Stainless steel clad by SMAW)



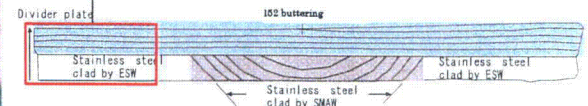
Location for SEM observation (boundary between 152 buttering and stainless steel clad)

Detail observation of location D



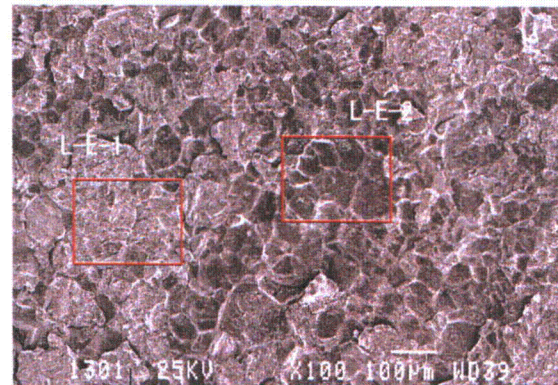
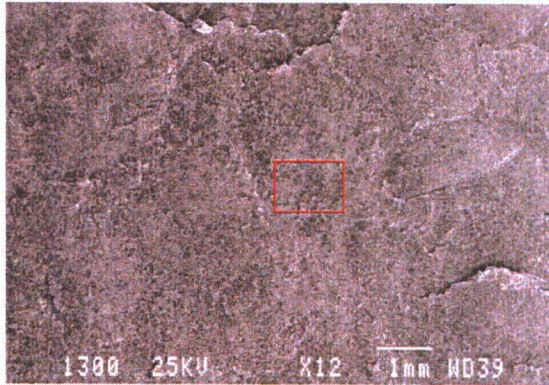
Ductile fracture surface

Fig.A.38(3) SEM observation of fracture surface of sample D (boundary between 152 buttering and stainless steel clad by SMAW)



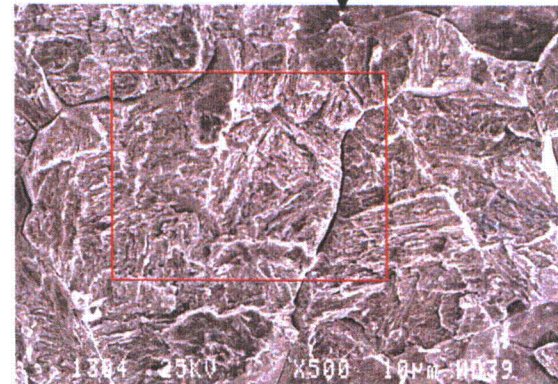
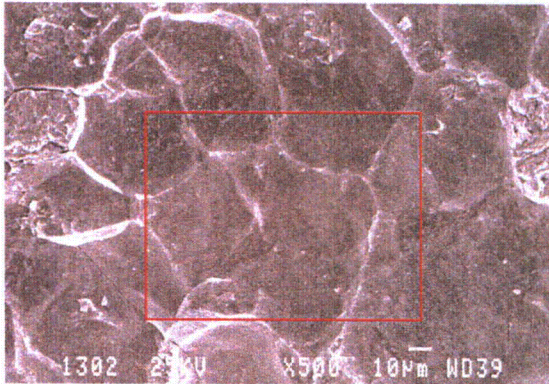
Location for SEM observation (stainless steel clad by ESW)

Detail observation of location E



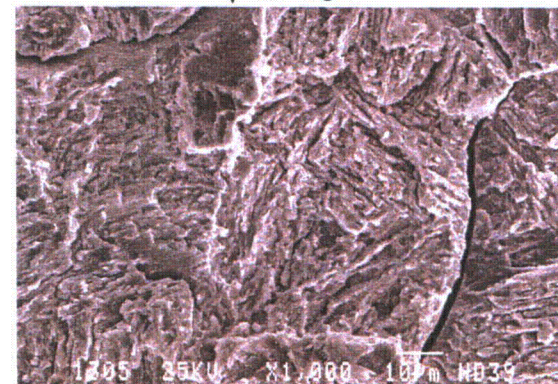
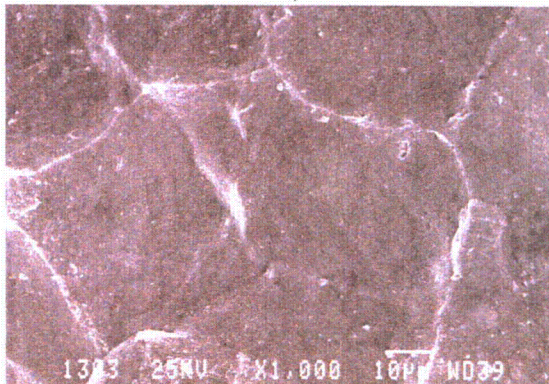
L-E-1 Enlarged

L-E-2 Enlarged



Enlarged

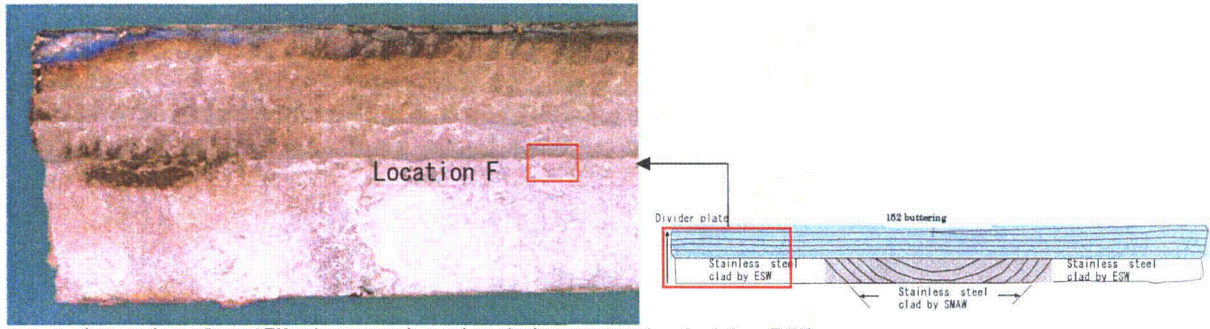
Enlarged



Dendrite boundary like or grain boundary like

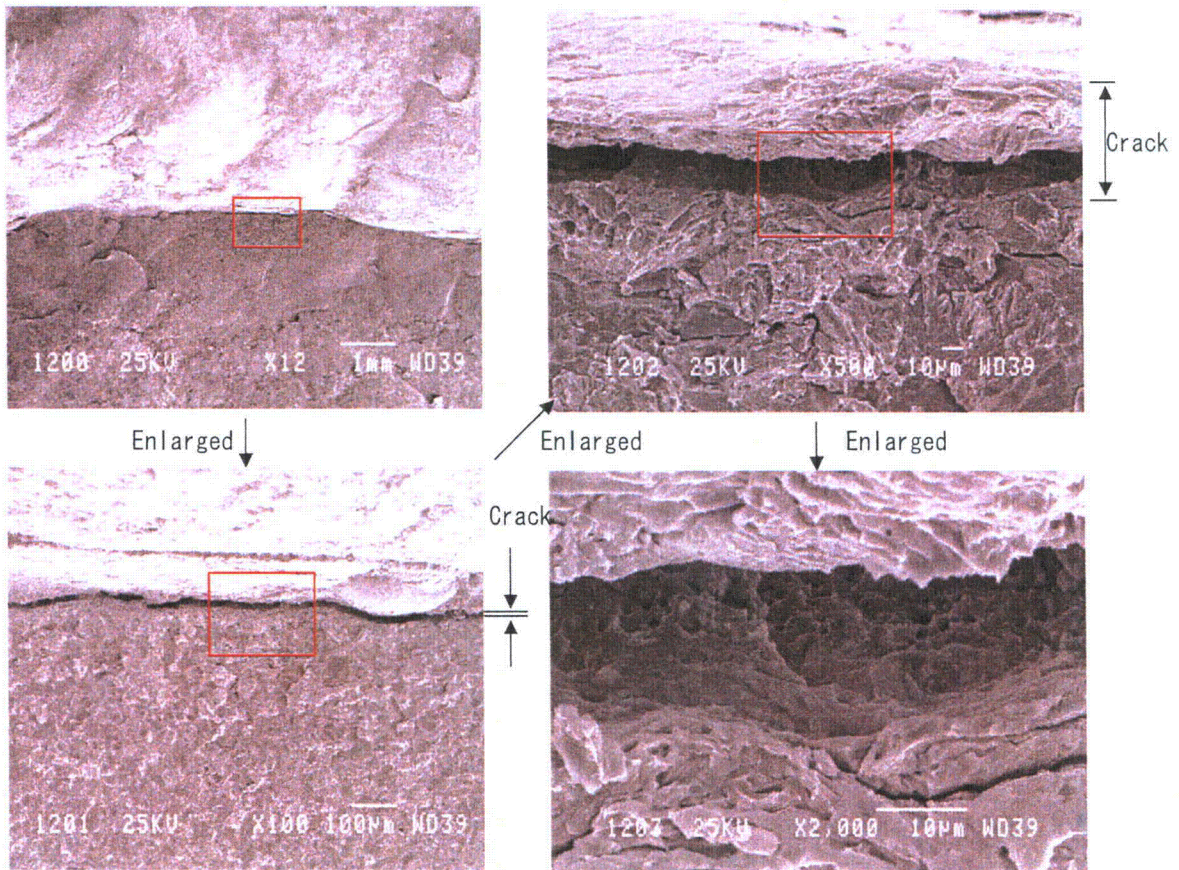
Quasi-cleavage fracture surface

Fig.A.38(4) SEM observation of fracture surface of sample D (Stainless steel clad by ESW)



Location for SEM observation (stainless steel clad by ESW)

Detail observation of location F



Ductile fracture surface

Fig.A.38(5) SEM observation of fracture surface of sample D (boundary between 152 buttering and stainless steel clad by ESW)

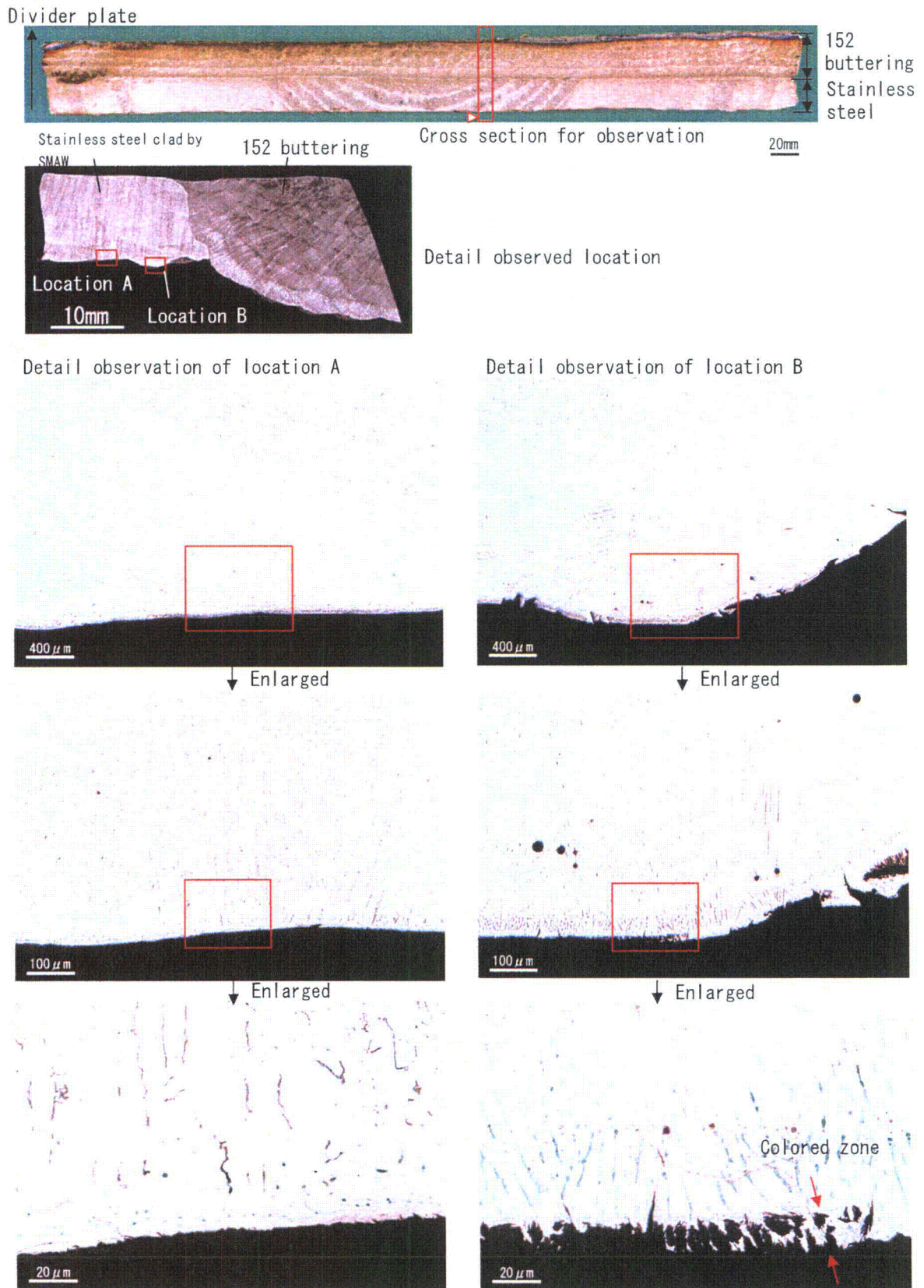
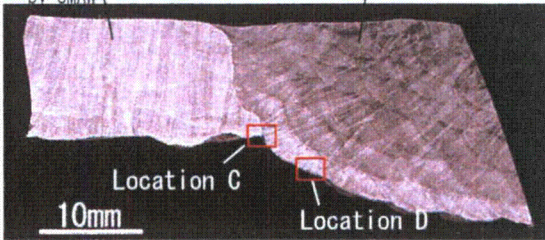
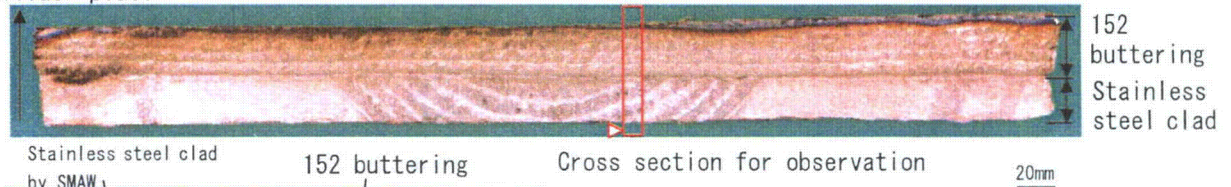


Fig.A.39(1) Microstructure observation of cross section of sample D (Stainless steel clad by SMAW)

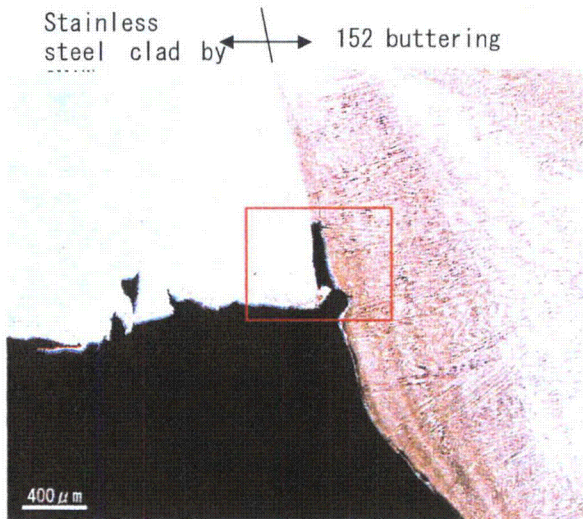


Divider plate



Detail observed

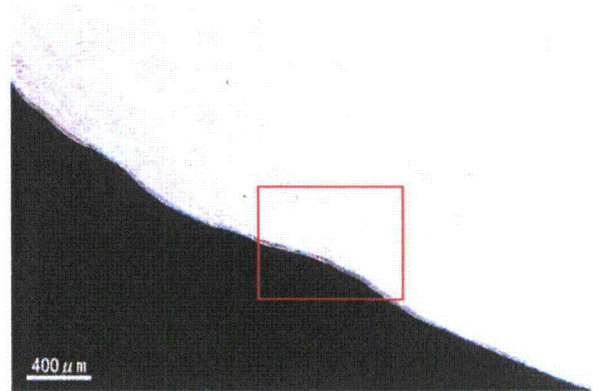
Detail observation of location C



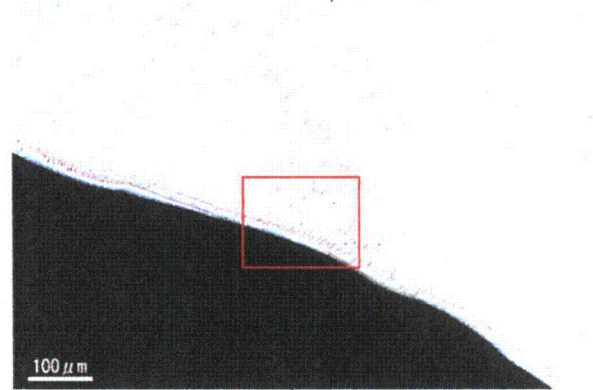
↓ Enlarged



Detail observation of location D



↓ Enlarged



↓

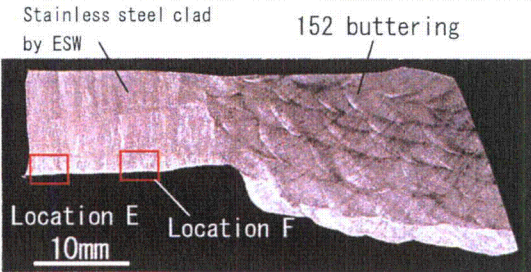
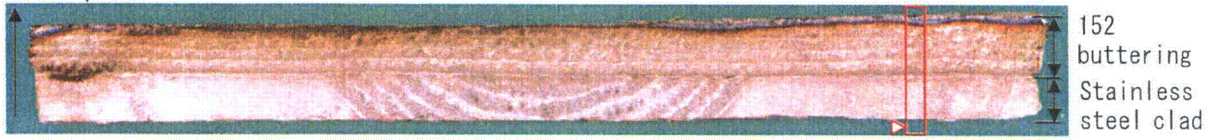


- Crack propagated near boundary between 152 buttering and stainless steel clad.
- Crack opened widely.

Fig.A.39(2) Microstructure observation of cross section of sample D
 (152 buttering and boundary between 152 buttering and stainless steel clad)



Divider plate

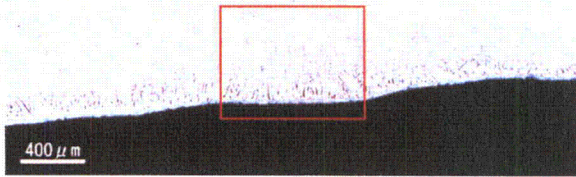


Cross section for observation 20mm

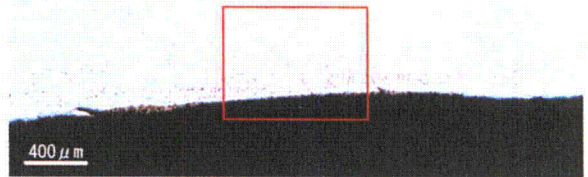
Detail observed

Detail observation of location E

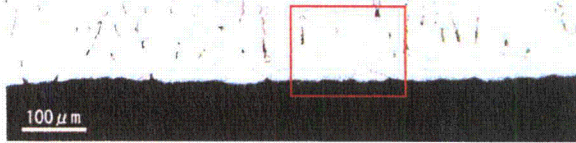
Detail observation of location F



↓ Enlarged



↓ Enlarged



↓ Enlarged



↓ Enlarged

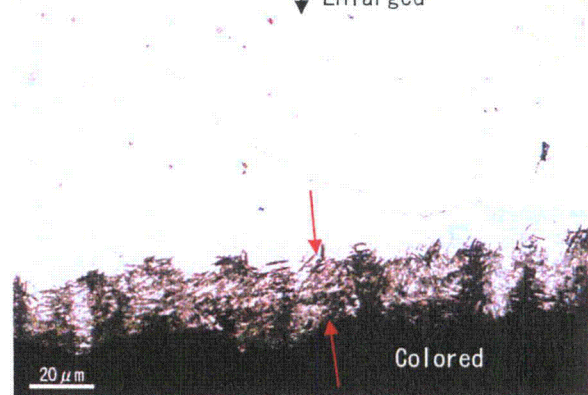


Fig.A.39(3) Microstructure observation of cross section of sample D
 (Stainless steel clad by ESW)

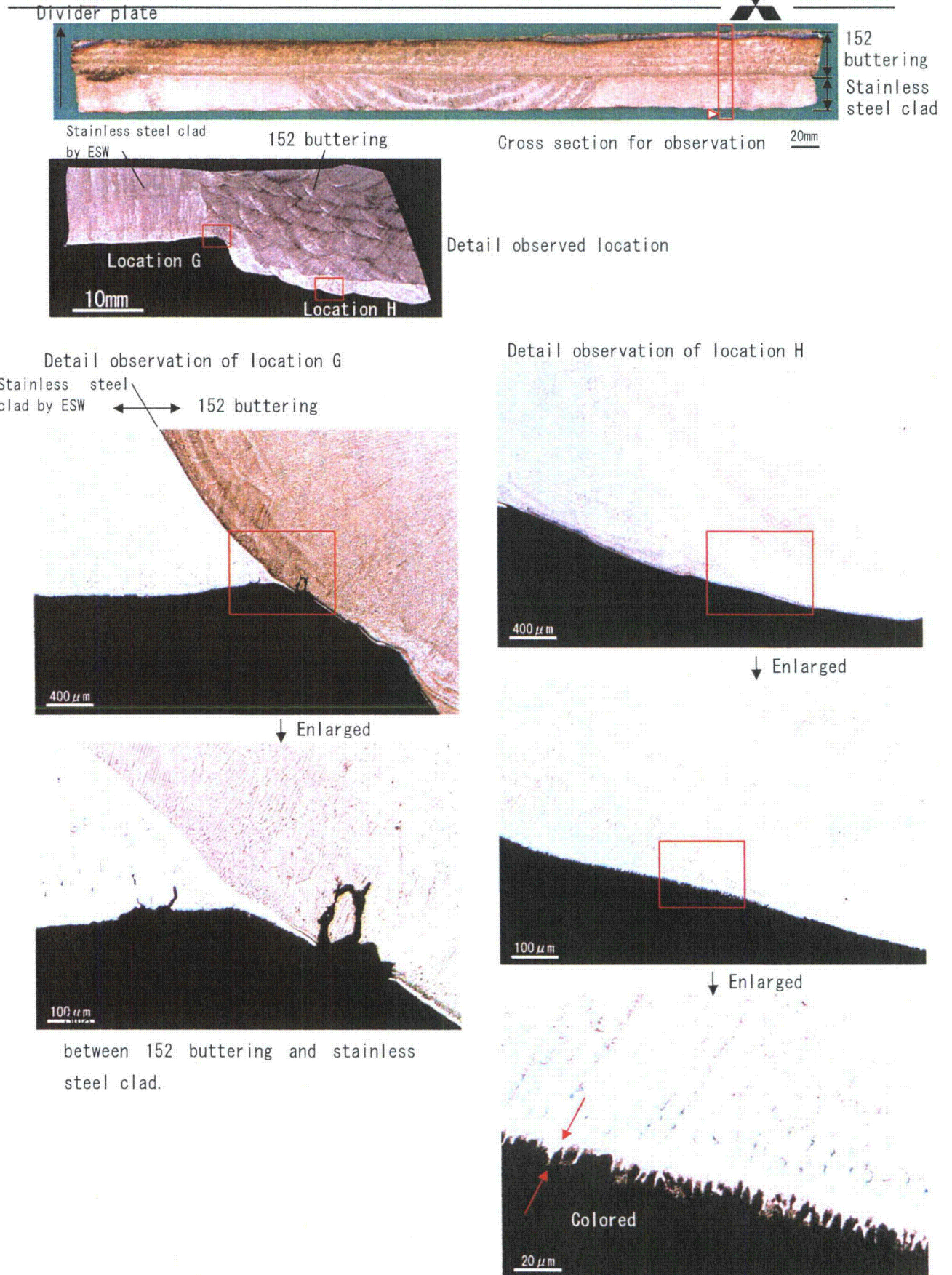


Fig.A.39(4) Microstructure observation of cross section of sample D
 (152 buttering and boundary between 152 buttering and stainless steel clad)

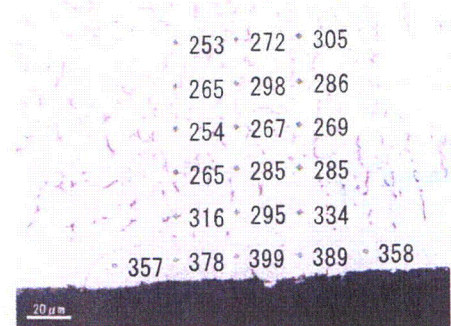
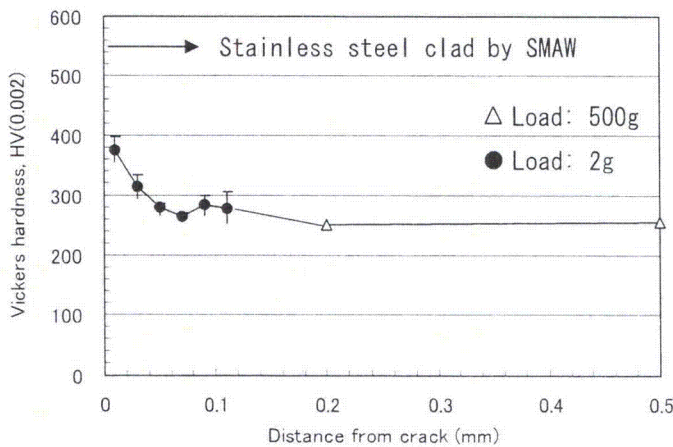
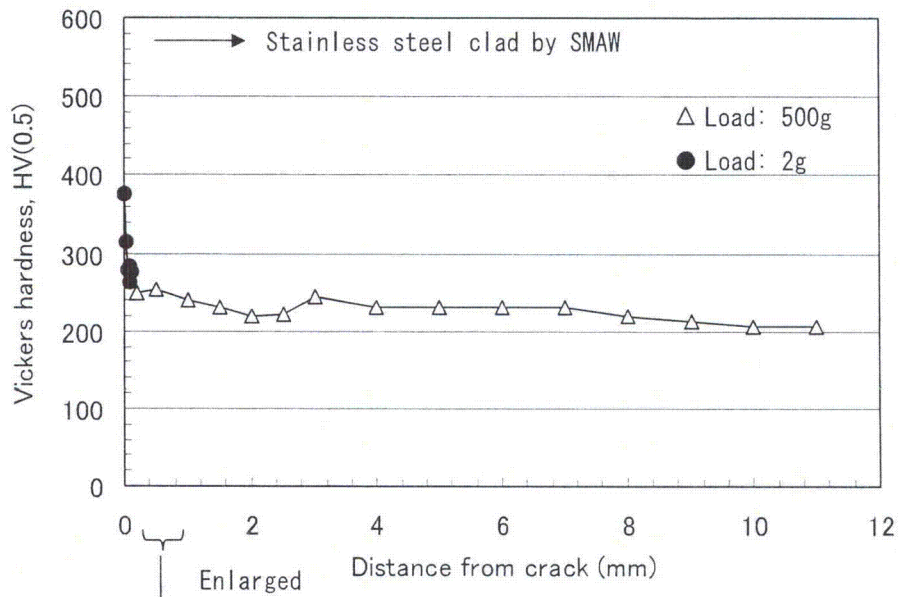
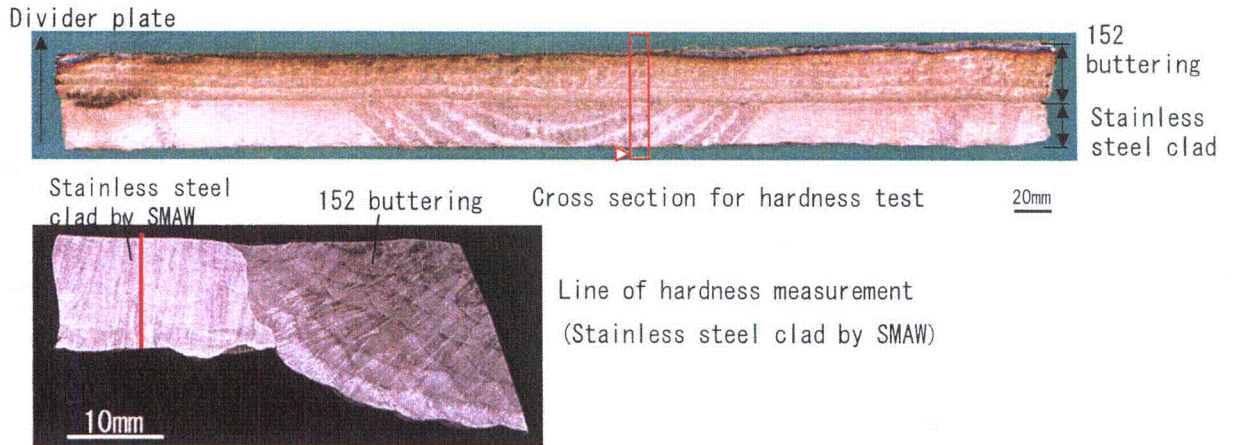
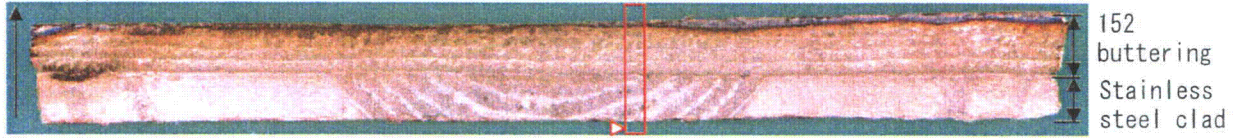


Fig.A.40(1) Vickers hardness of cross section of sample D (Stainless steel clad by SMAW)



Divider plate

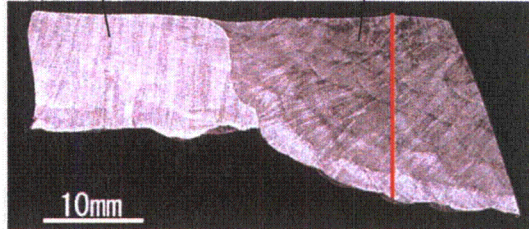


Stainless steel clad by SMAW

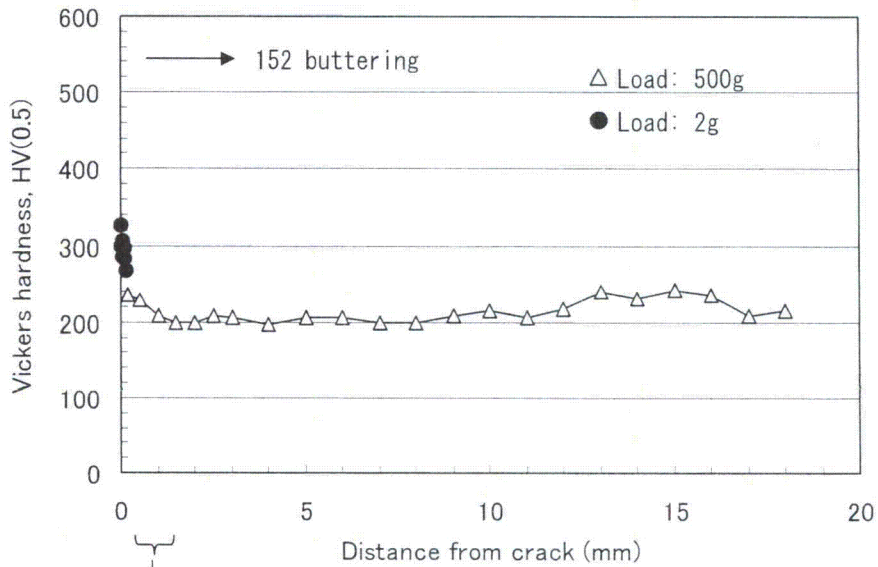
152 buttering

Cross section for hardness test

20mm



Line of hardness measurement
 (152 buttering)



Enlarged

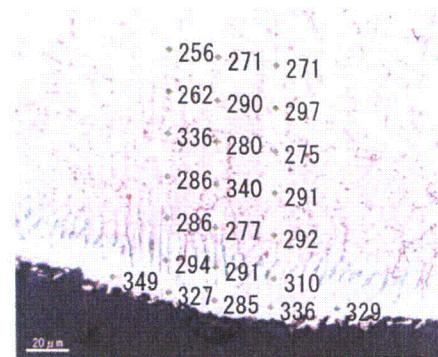
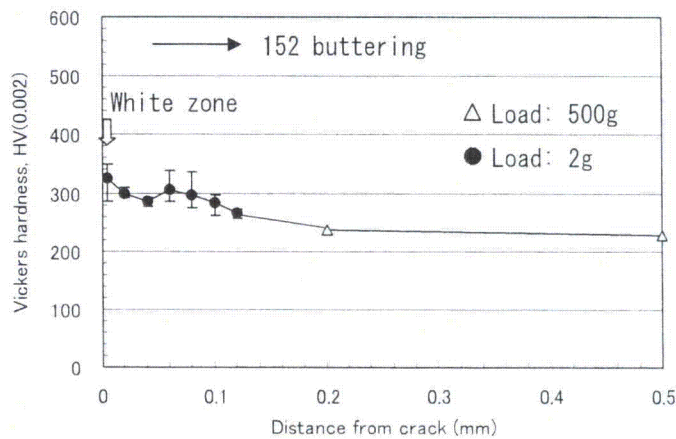
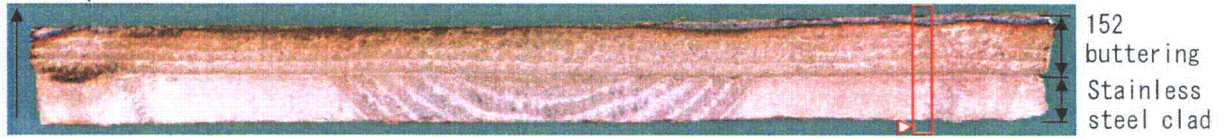


Fig.A.40(2) Vickers hardness of cross section of sample D (152 buttering)

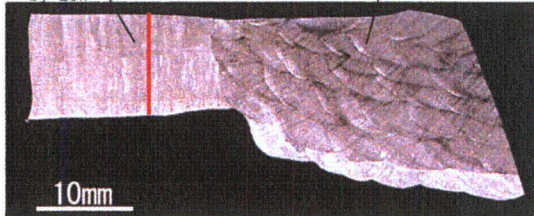


Divider plate



Stainless steel clad by ESW 152 buttering

Cross section for hardness test 20mm



Line of hardness measurement
 (Stainless steel clad by ESW)

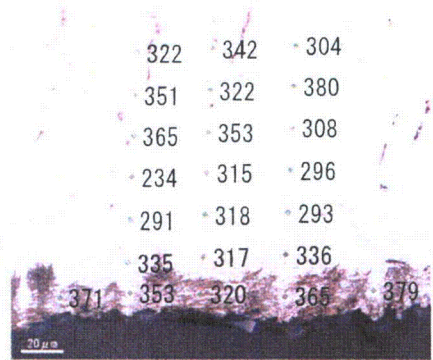
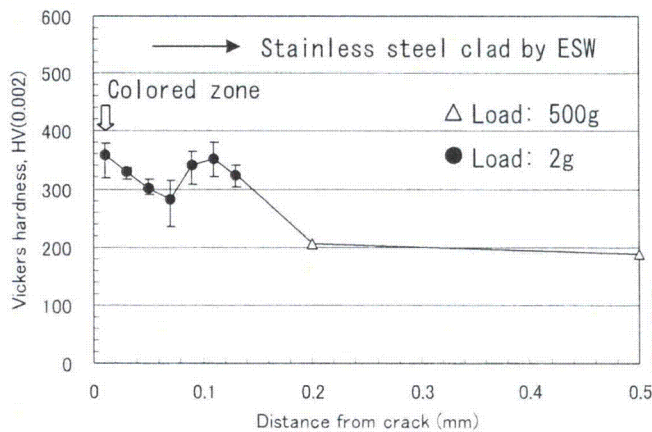
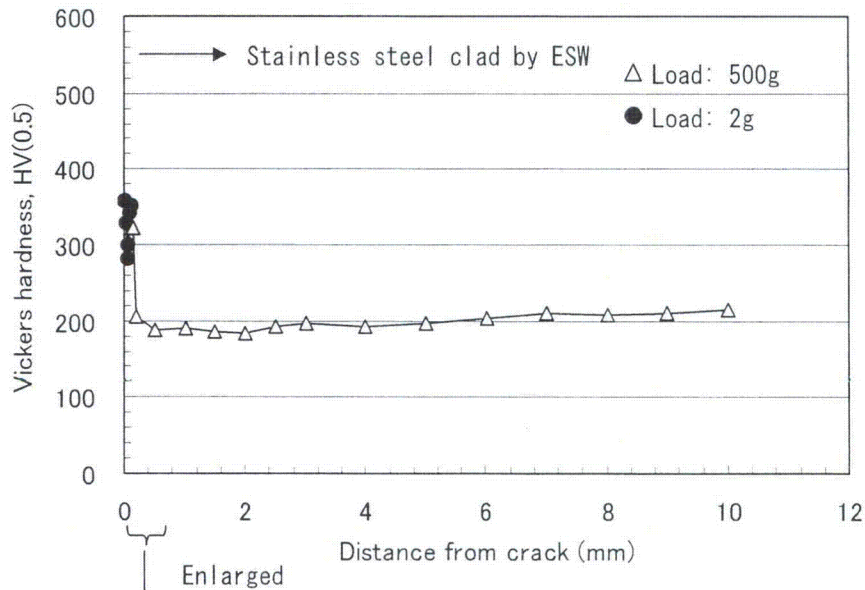


Fig.A.40(3) Vickers hardness of cross section of sample D (Stainless steel clad by ESW)

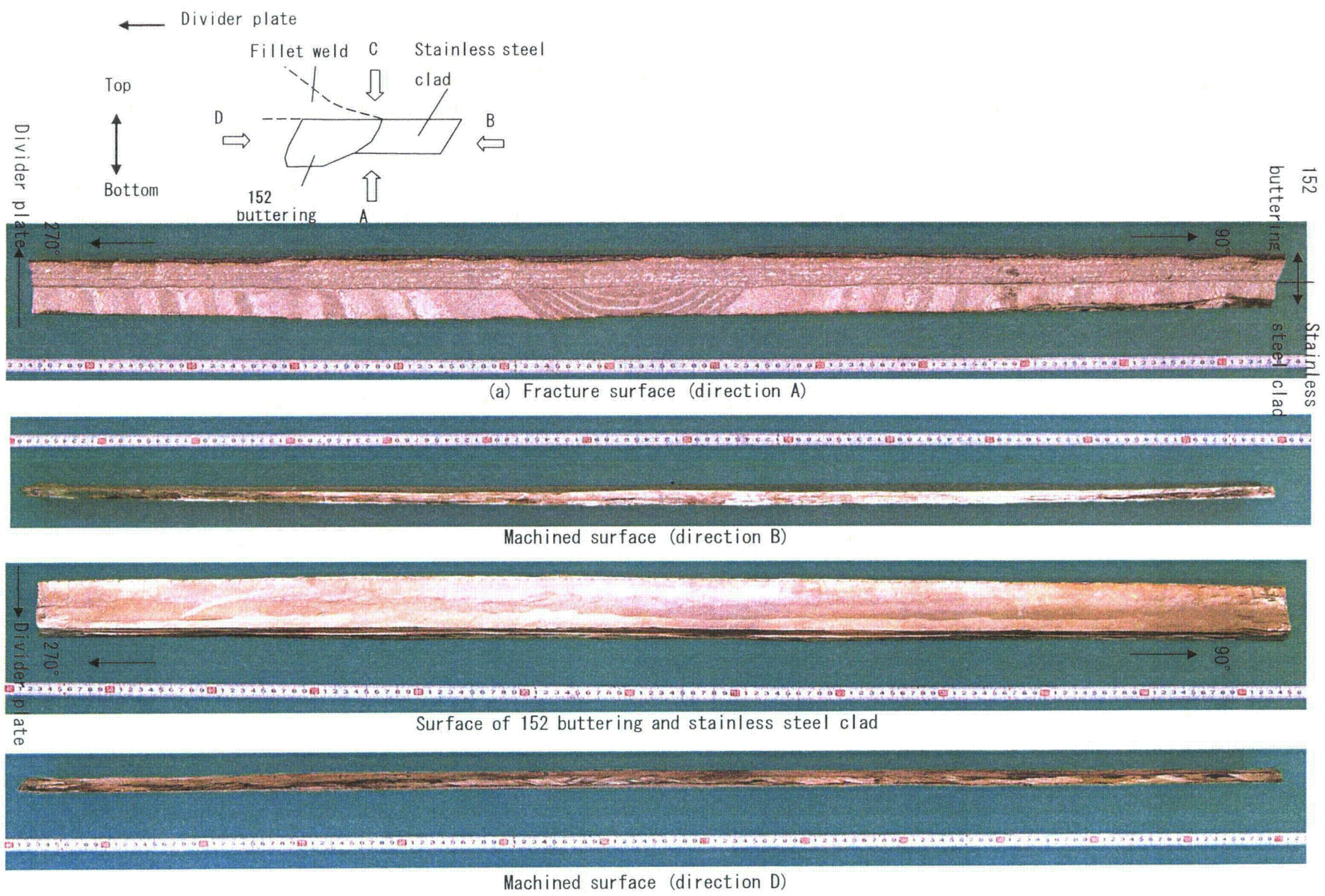
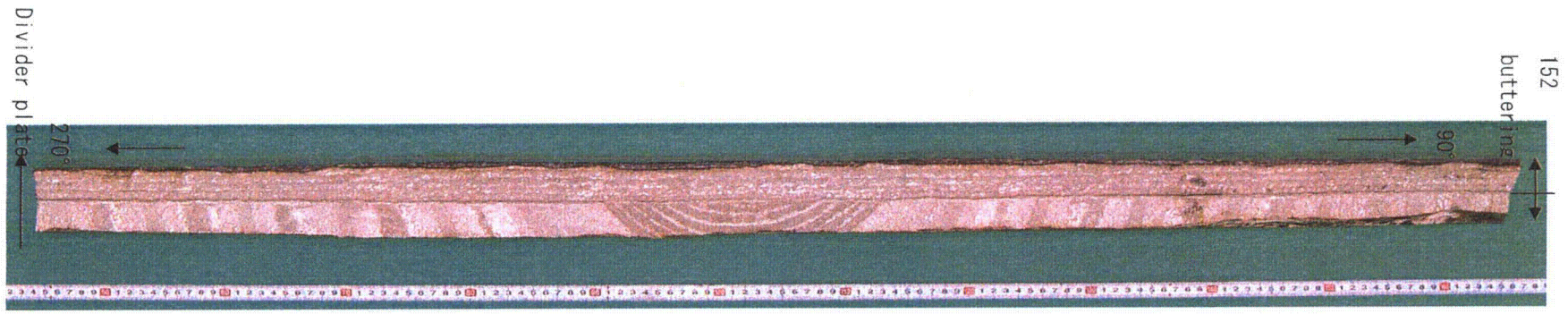
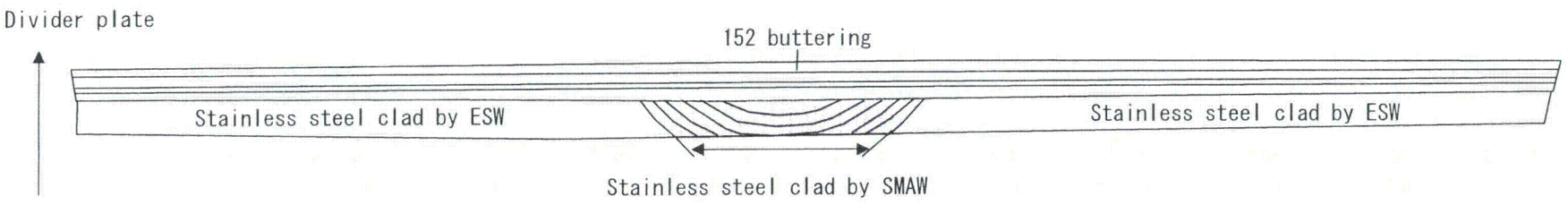


Fig.A.41 Appearance of sample E



(a) Appearance of fracture surface



(b) Schematic illustration of fracture surface

Fig.A.42(1) Appearance of fracture surface (Schematic illustration)

Divider plate

152 buttering

Stainless steel clad by ESW

Stainless steel clad by ESW

Stainless steel clad by SMAW

270°

Welding bead by ESW

Welding bead by ESW

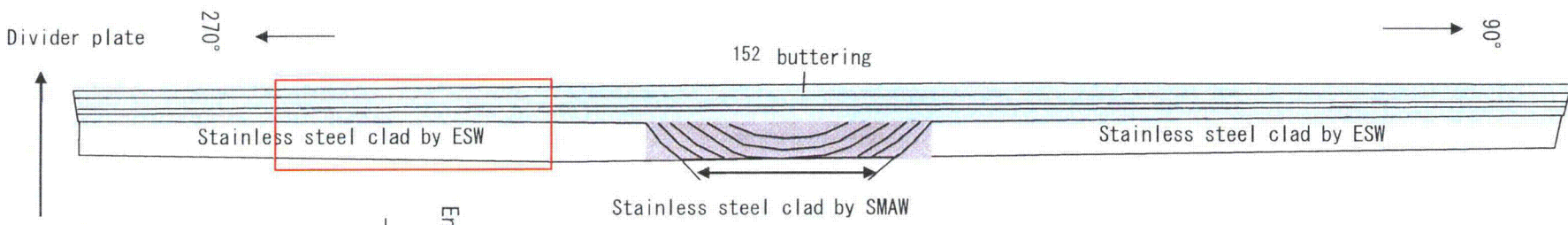
Welding bead by SMAW

Welding bead by ESW

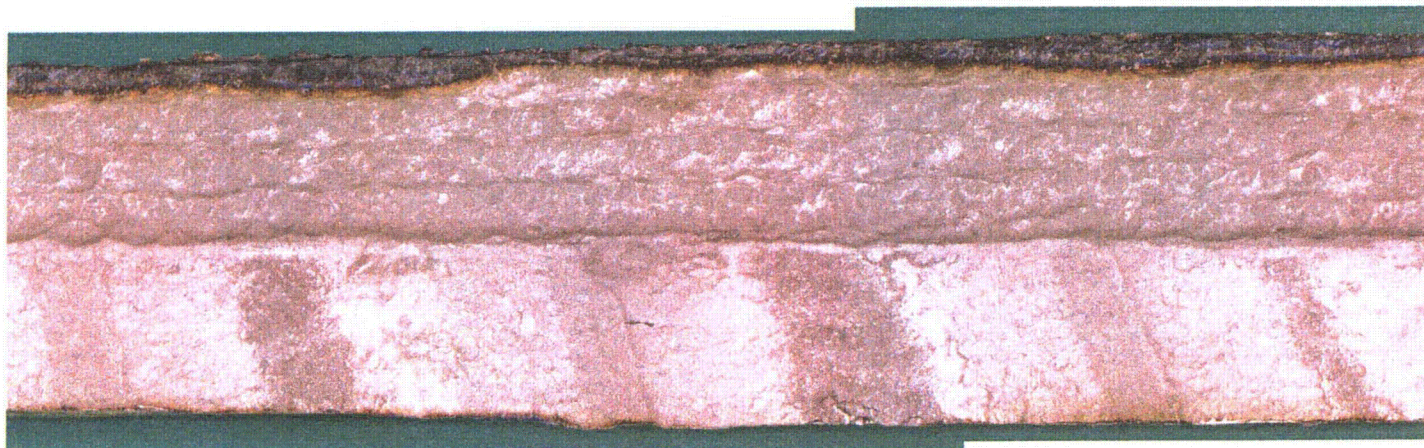
Welding bead by ESW

90°

Fig.A.42(2) Appearance of fracture surface



Enlarged
↓



10mm

Fig.A.42(3) Appearance of fracture surface

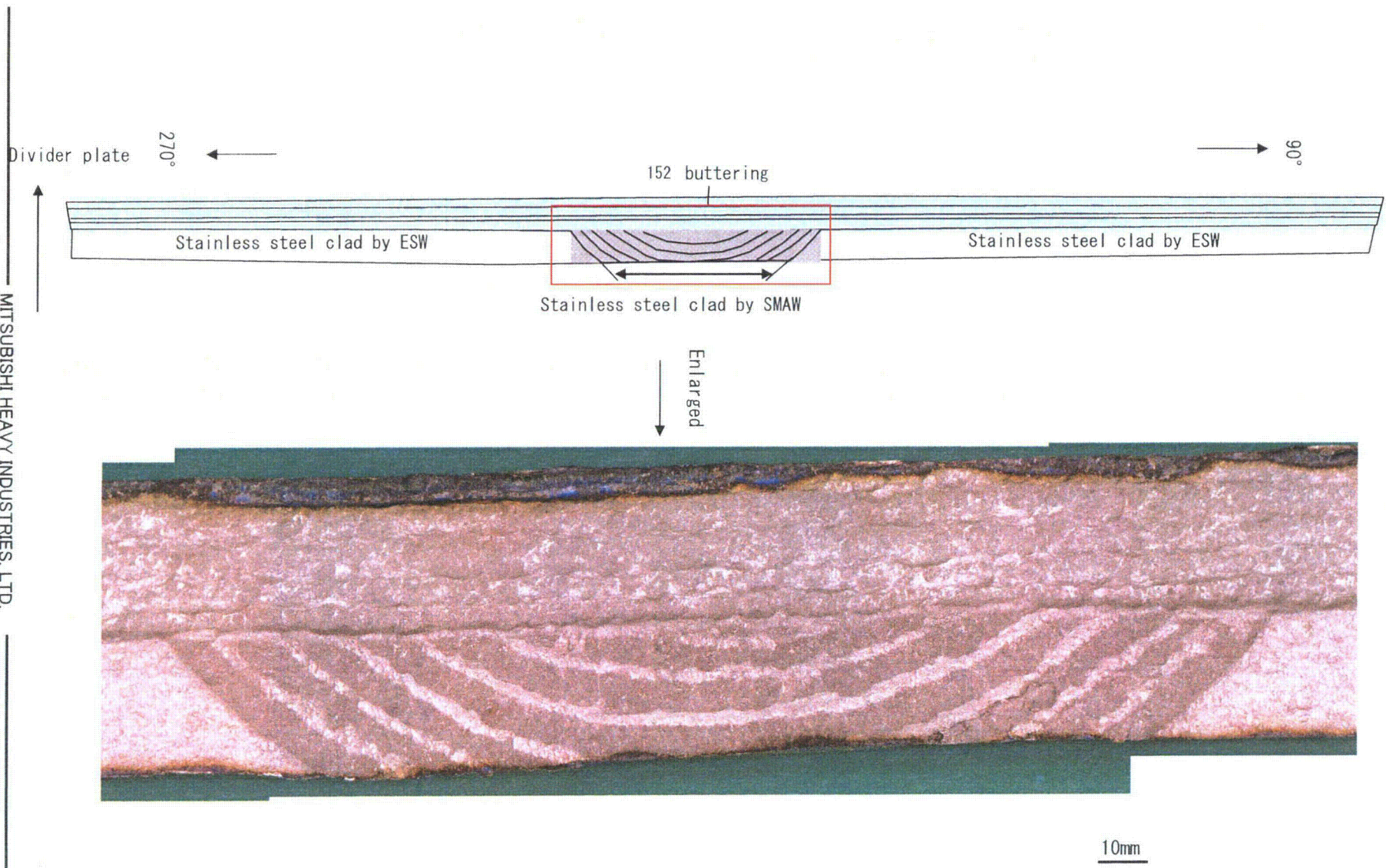


Fig.A.42(4) Appearance of fracture surface

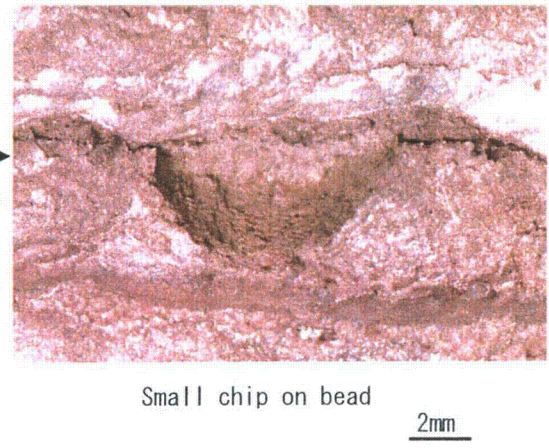
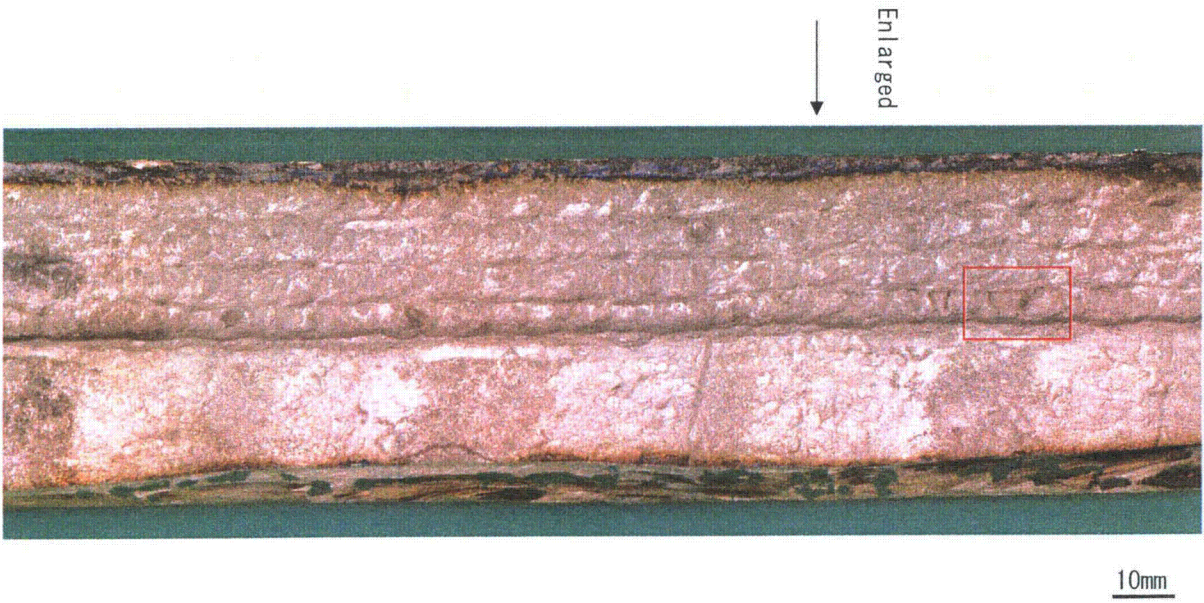
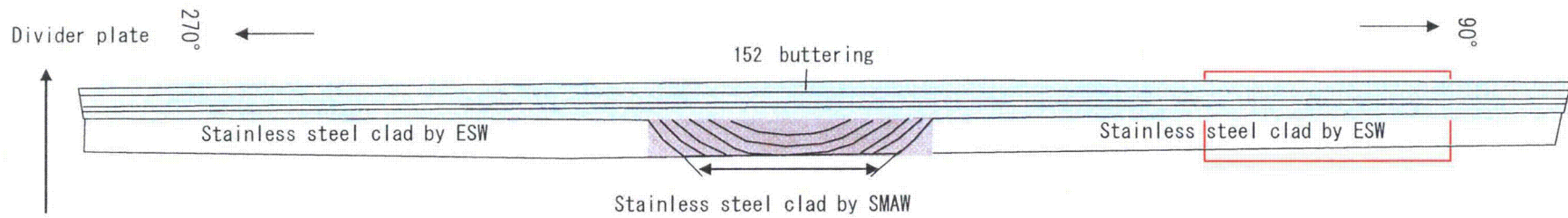


Fig.A.42(5) Appearance of fracture surface

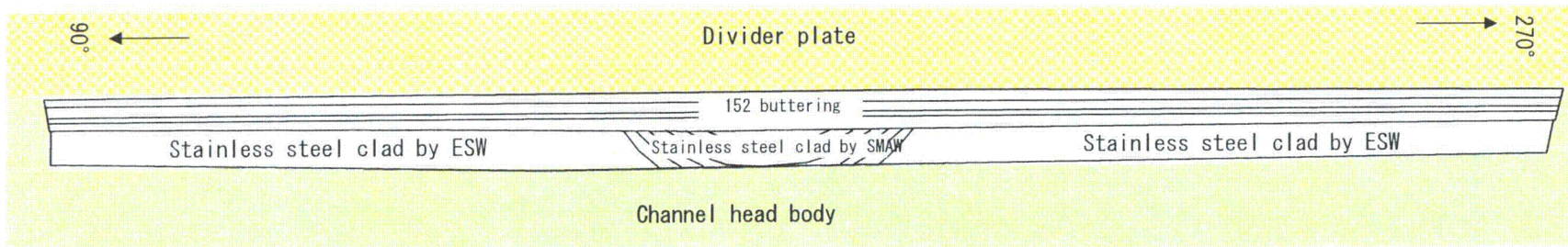


(a) Appearance of fracture surface of sample



(b) Appearance of fracture surface of channel head body after removal of sample

50mm



(c) Schematic illustration channel head body after removal of sample

Fig.A.43(1) Appearance of fracture surface of channel head body after removal of sample

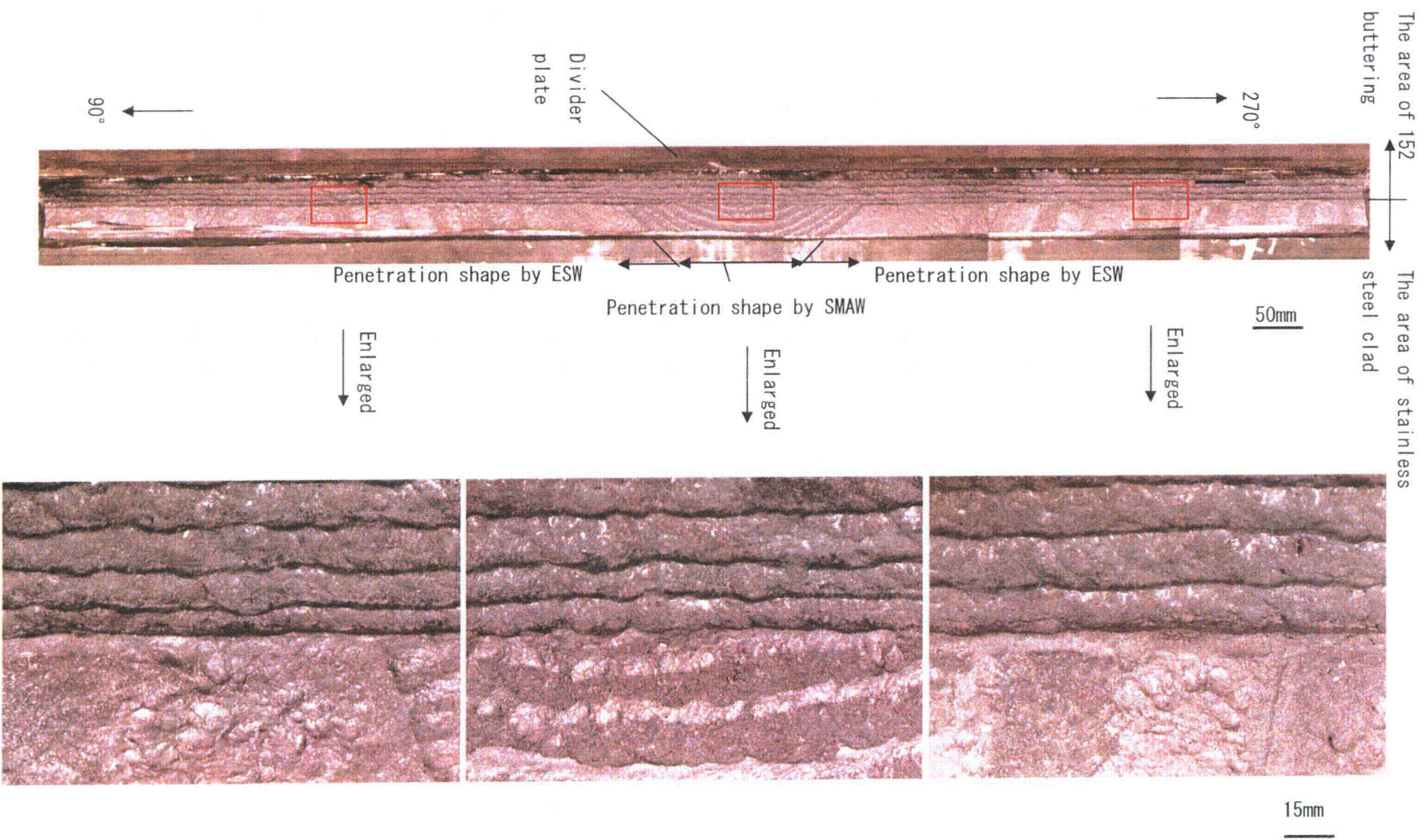


Fig.A.43(2) Appearance of fracture surface of channel head body after removal of sample