TEM observation and grain boundary analysis of non-sensitized stainless steels

(First report)

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Scope

To study if the material with higher N content contains a large amount of nitrides containing Cr which would deplete the matrix and/or the grain boundaries.

TEM samples

Chemical compositions

Materials	C	Si	Mn	P	S	Cr	Ni	Mo	N
316NG-L	0.19	0.54	0.82	0.03	0.006	17.6	11.2	2.06	0.05
316NG-H	0.18	0.4	1.1	0.17	0.001	17.2	12.4	2.58	0.17

Austenite stability (=Ni-eq/Cr-eq)

Materials	Austenite stability
316NG-L	0.667
315NG-H	0.912

Priority

Materials	Cold work	
	0%	33%
316NG-L	2	1
315NG-H	2	1

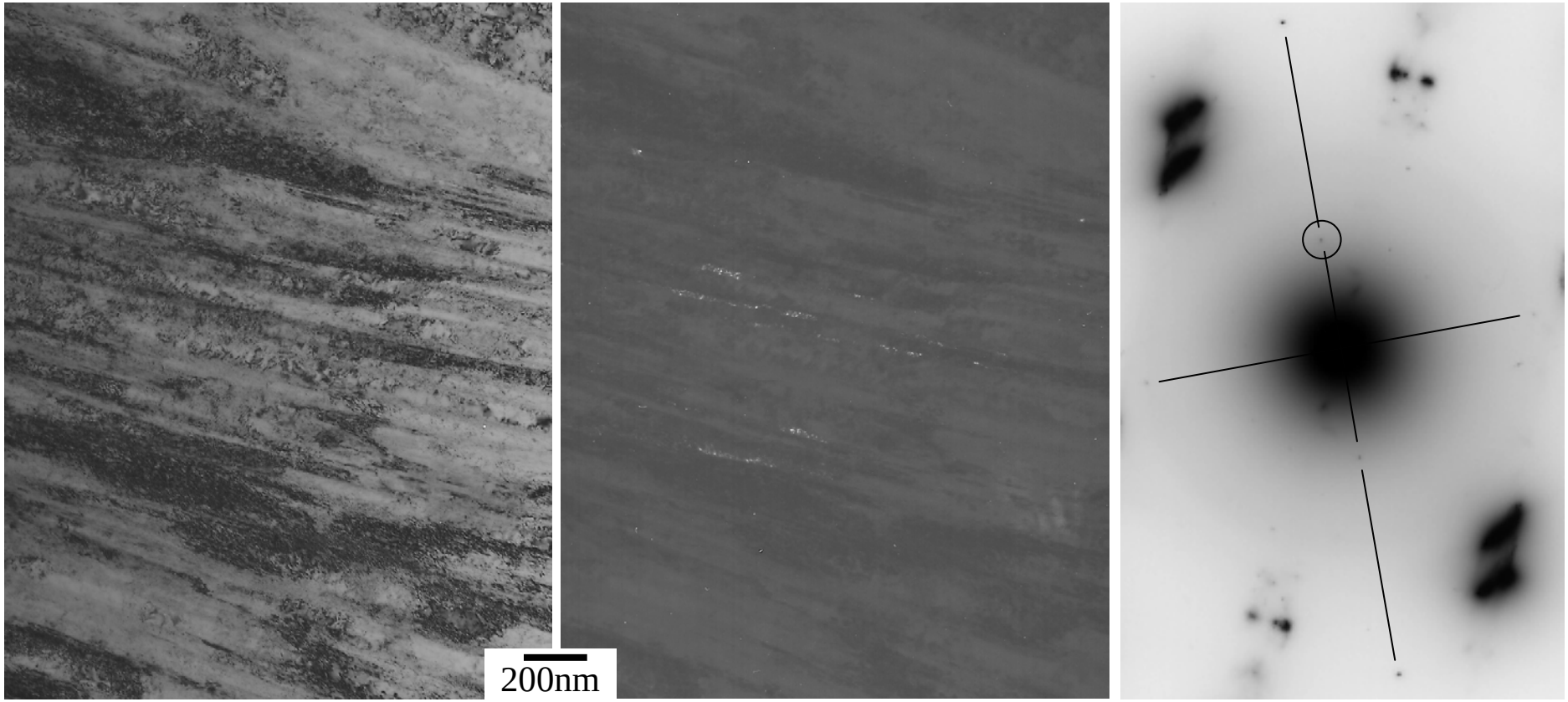
SCC susceptibility (CBB tests)

316NG-H(33%) > 316NG-L(33%)

Test conditions

Instrument : FEG-TEM (Hitachi HF-2000)
with EDS (ultra-thin window X-ray detector)
Acc. Voltage : 200kV
Probe diameter: about 1nm
Acquire time : 100 sec (detector live time)
Analysis point : 3 points on G.B.
1 point on 1, 2, 3, 4, 5, 10, 20, 50 nm from G.B.
Quantification : Cliff-Lorimer method

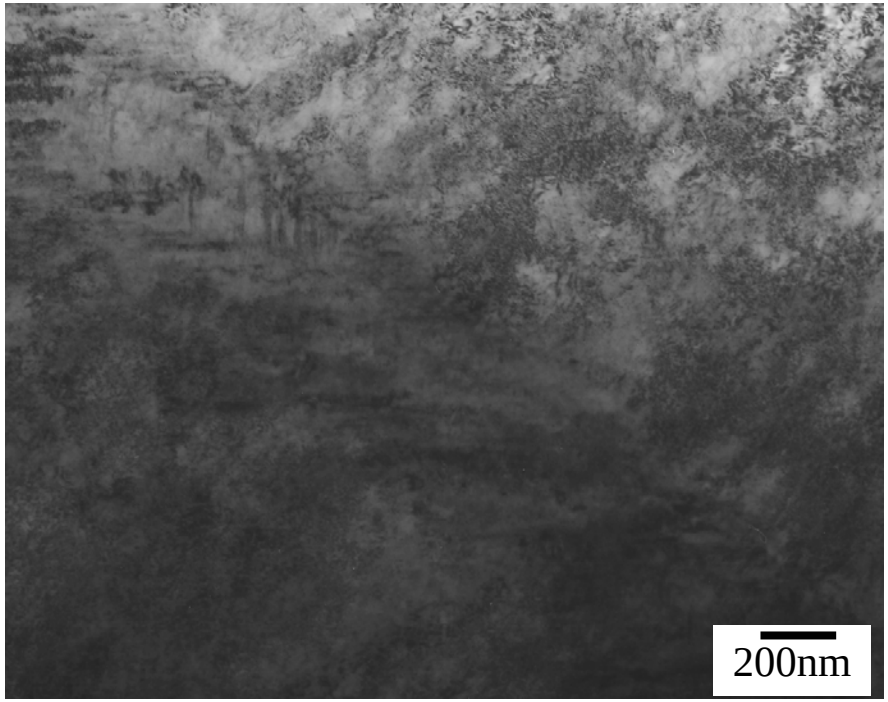
TEM result (316NG-H/33% cold work)



Bright field image　　Dark field image　　Diffraction pattern

Very small precipitate is observed in 316NG-H.

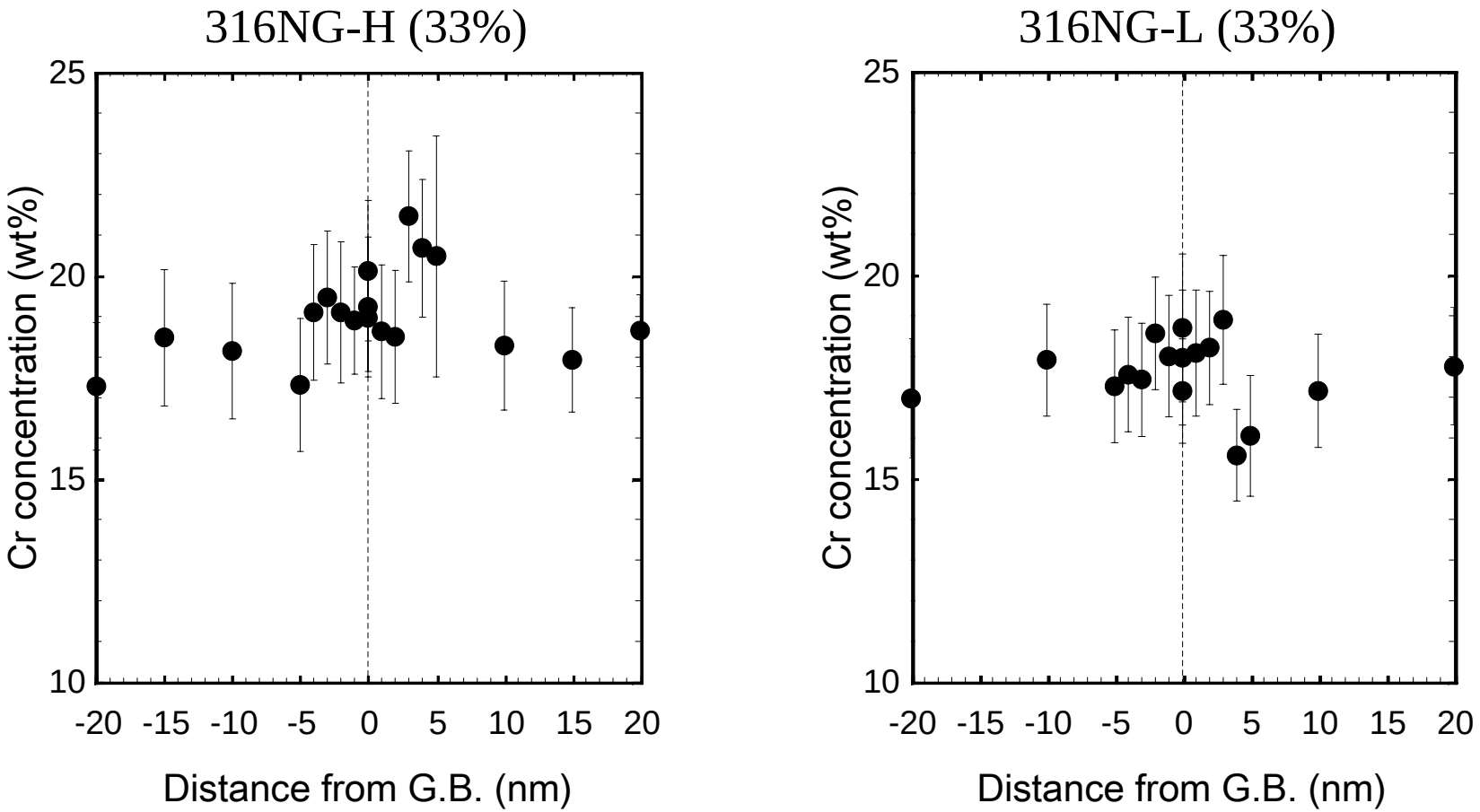
TEM result (316NG-L/33% cold work)



Bright field image

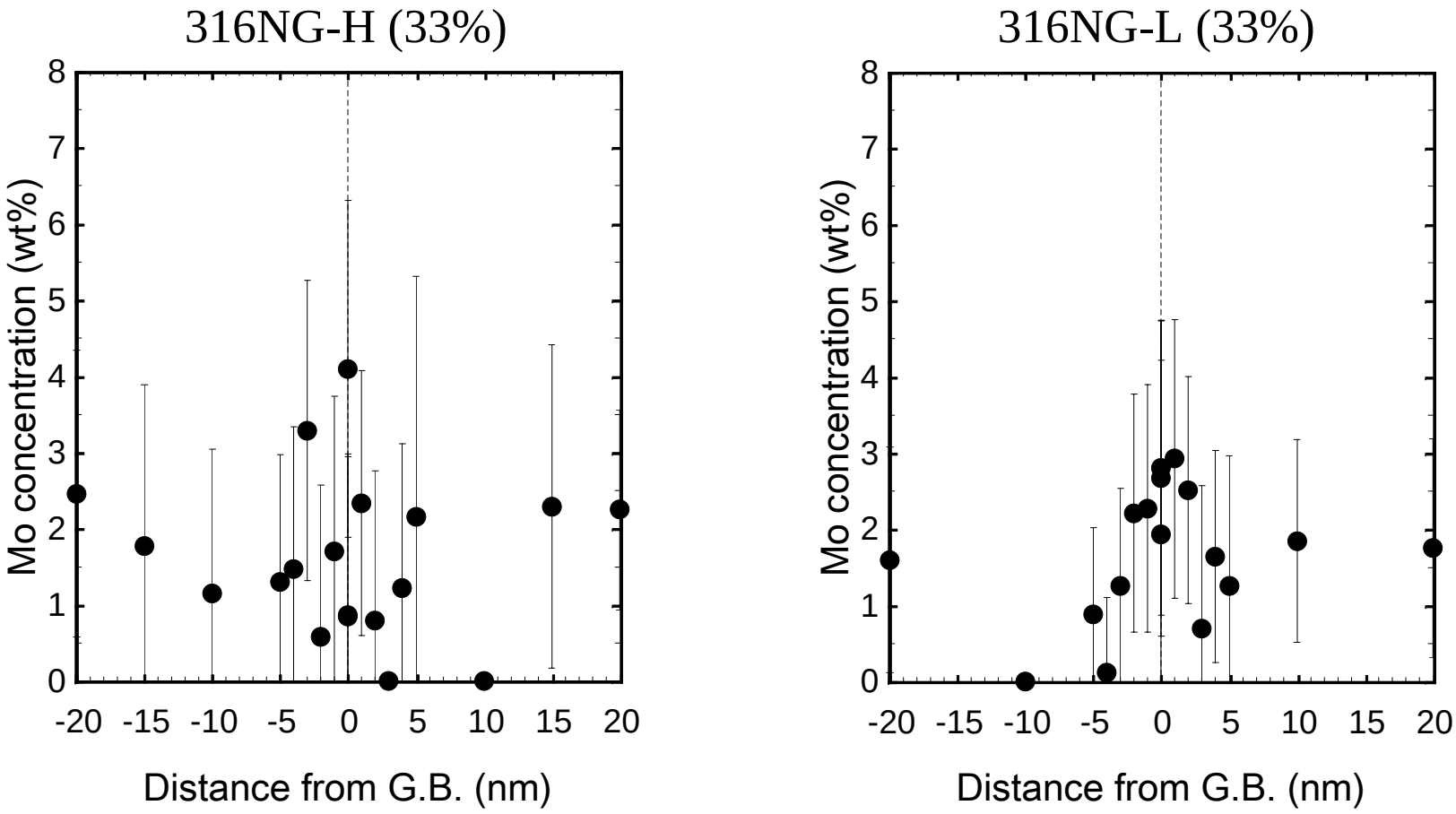
No precipitate is observed in 316NG-L.

Cr compositional profiles across grain boundary



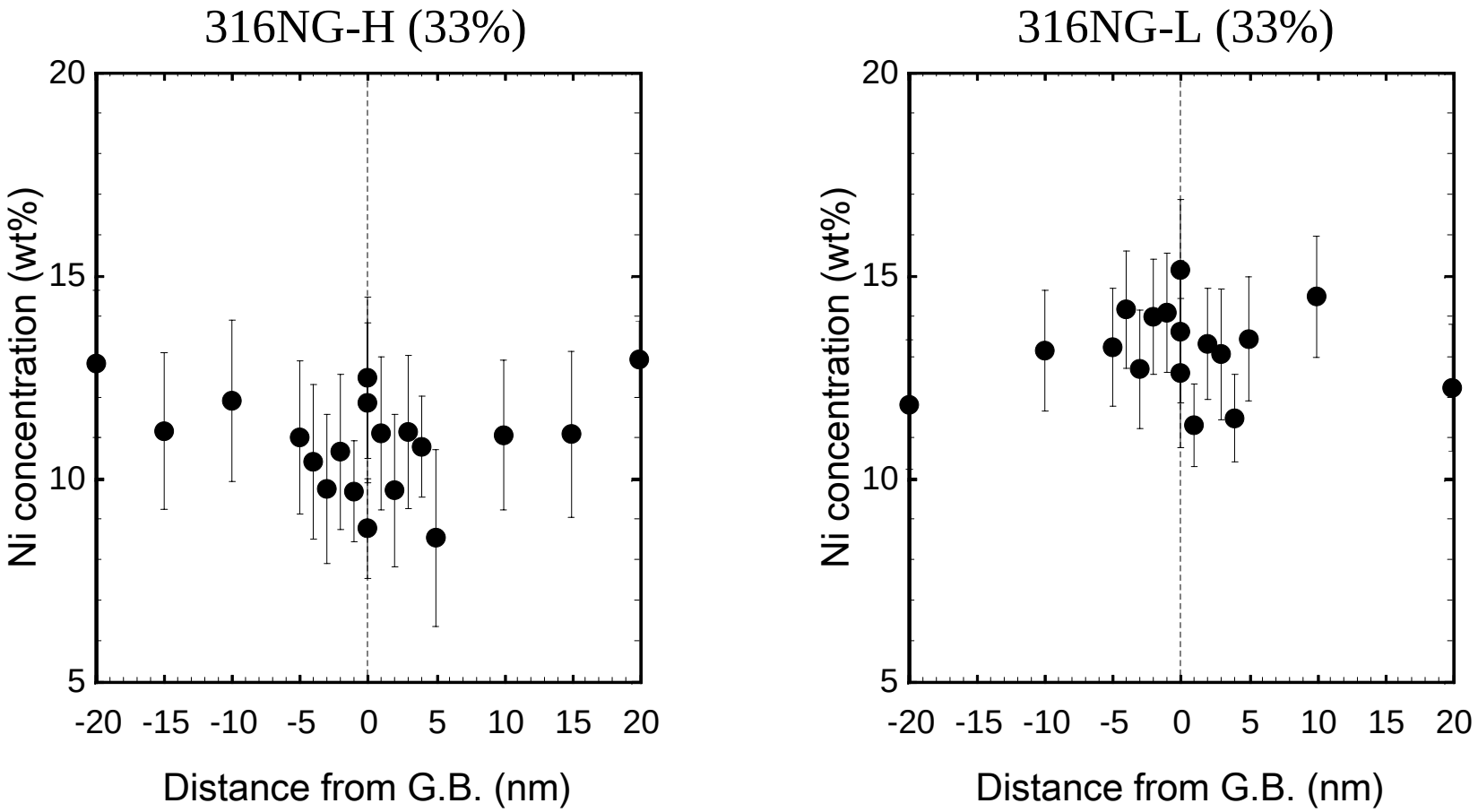
Chromium is not segregated at grain boundary.

Mo compositional profiles across grain boundary



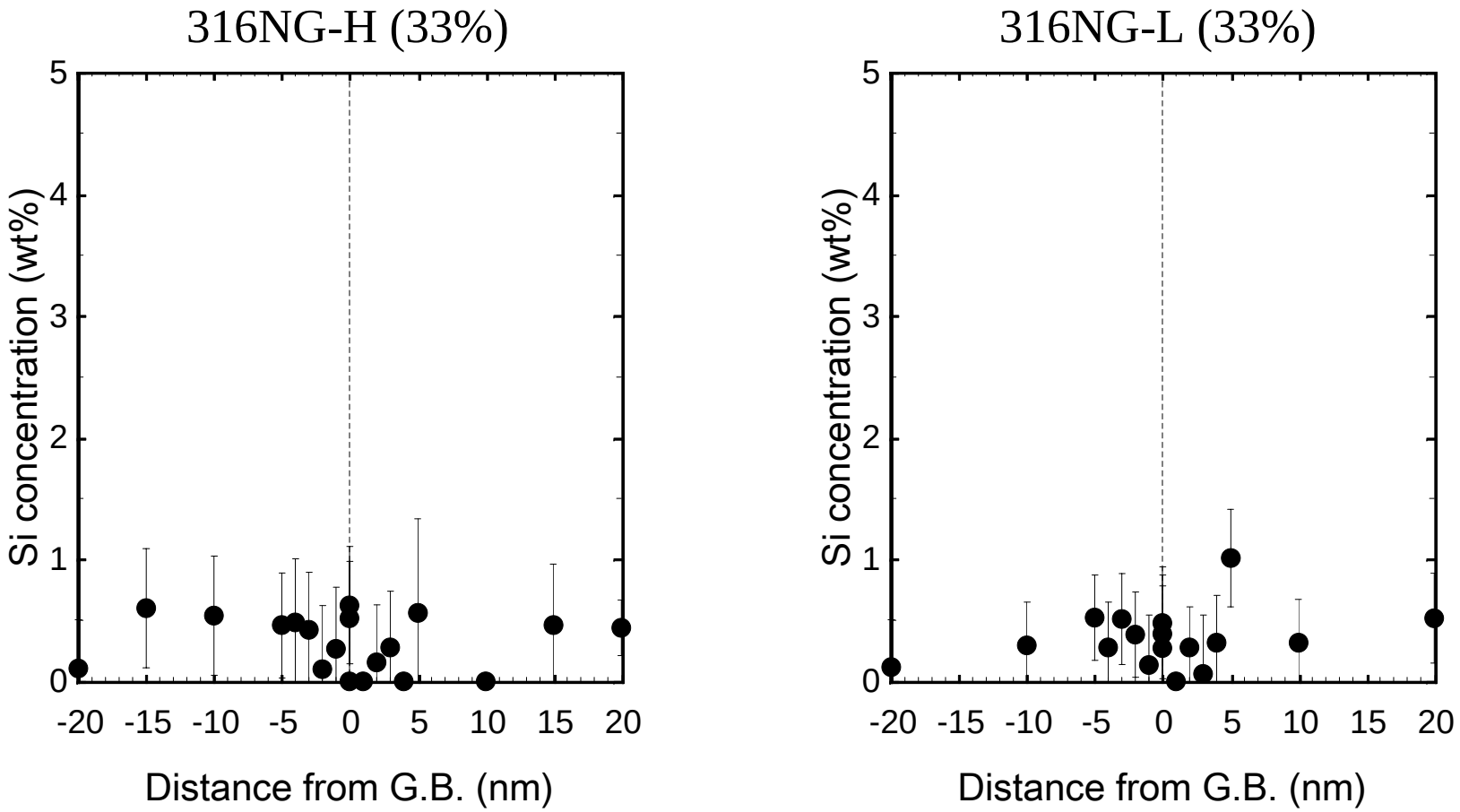
Molybdenum is enriched near grain boundary of 316NG-L.

Ni compositional profiles across grain boundary



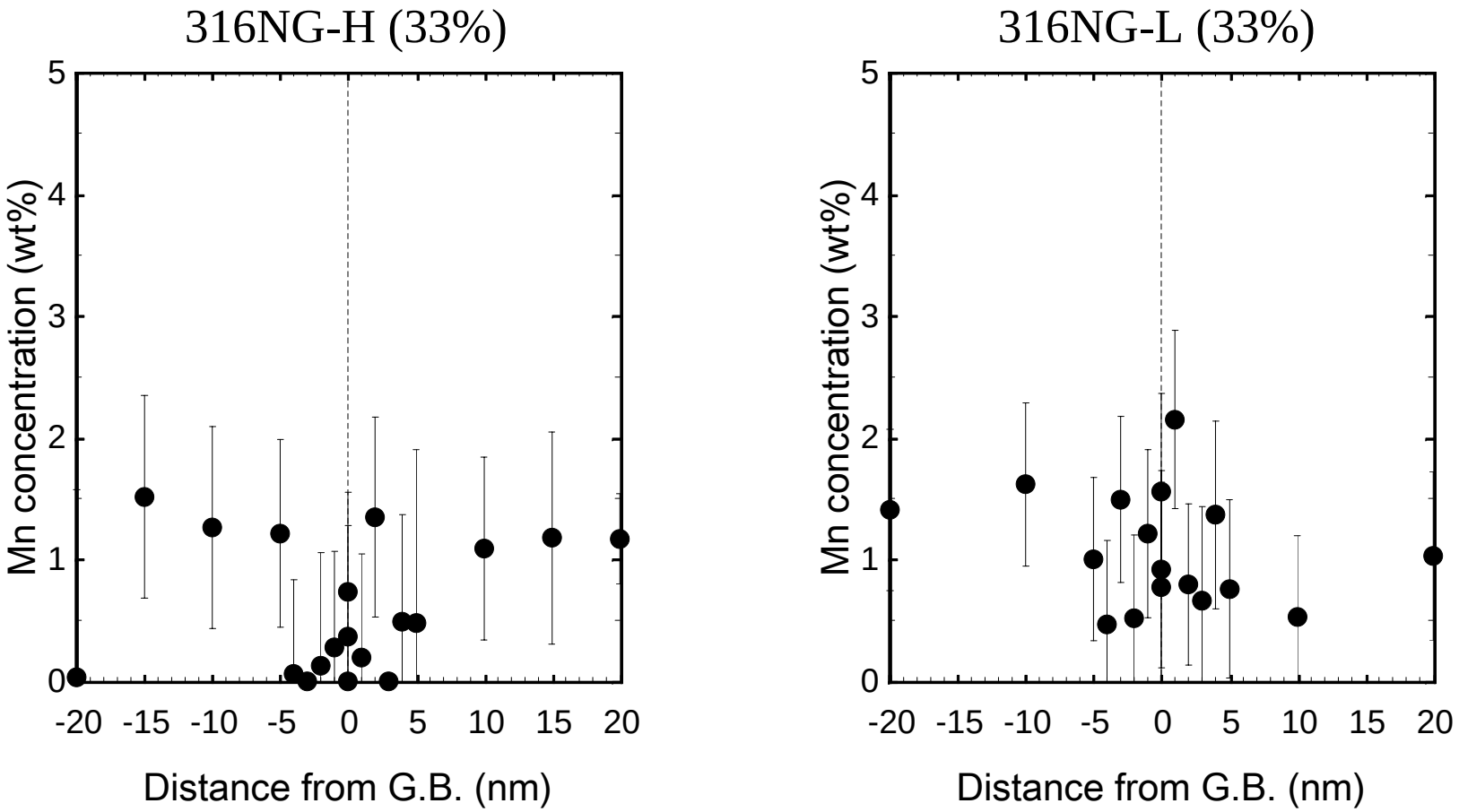
Nickel is not segregated at grain boundary.

Si compositional profiles across grain boundary



Silicon is not segregated at grain boundary.

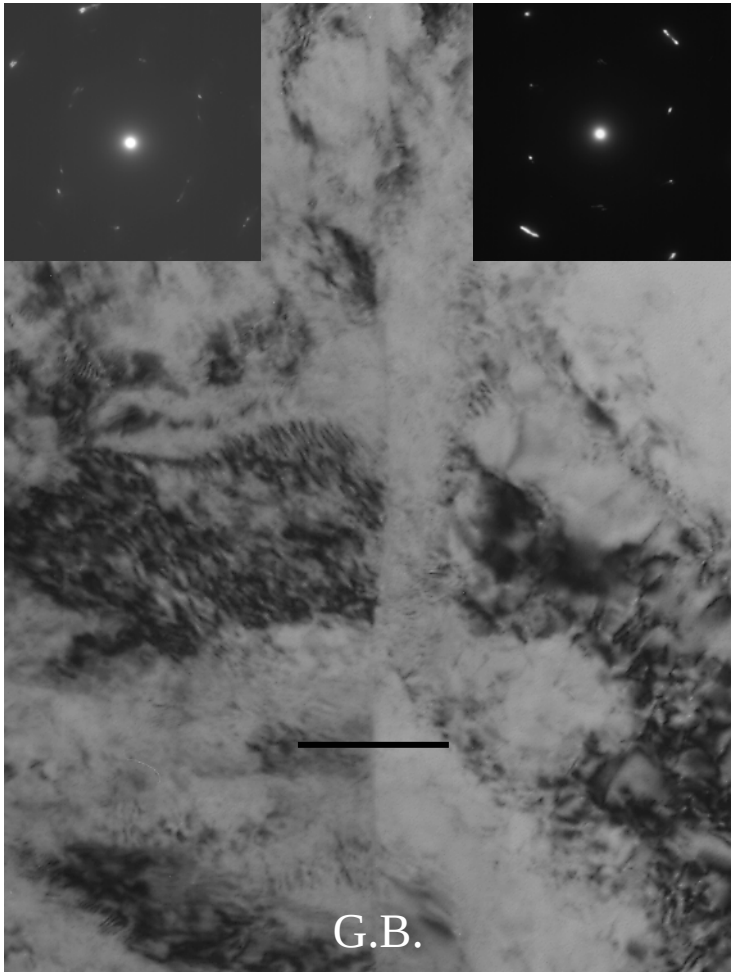
Mn compositional profiles across grain boundary



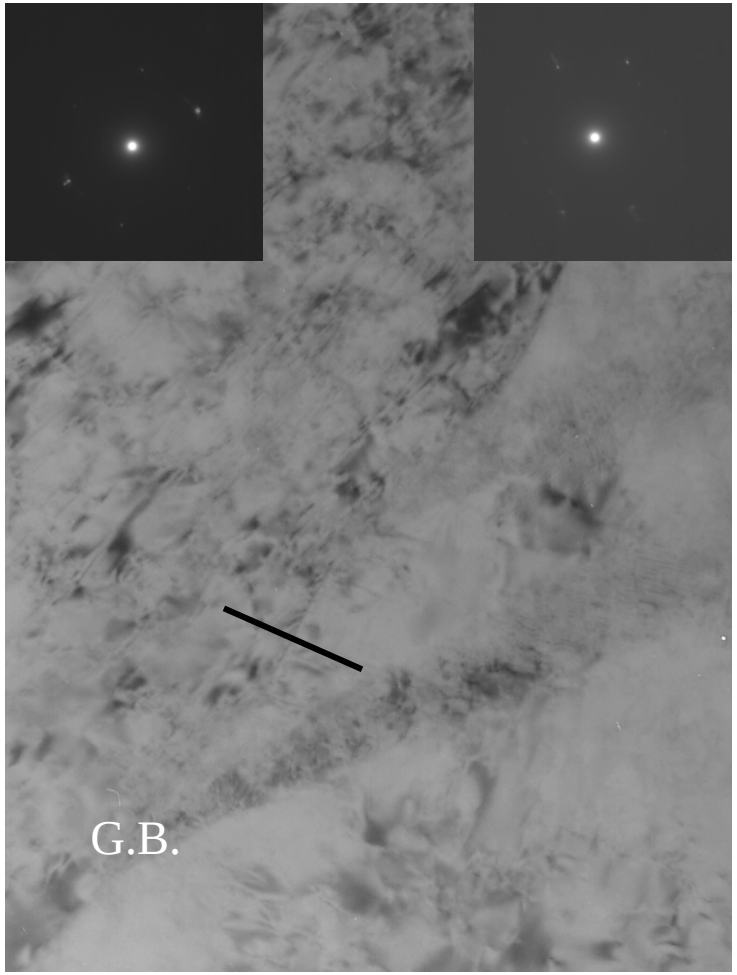
Manganese is depleted near grain boundary of 316NG-H.

TEM images of analysis grain boundary

316NG-H (33%)



316NG-L (33%)



50nm

There is no precipitate at grain boundary.

Summary (First report)

- Very small precipitate is observed in316NG-H.
  (The precipitate is not identified.)

- No precipitate is observed in 316NG-L.

- Remarkable grain boundary segregation is not observed.

- There is not obvious difference between 316NG-H and 316NG-L in grain boundary segregation.