Aluminum Coating of ACC Tubes

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Current ACC tubes:

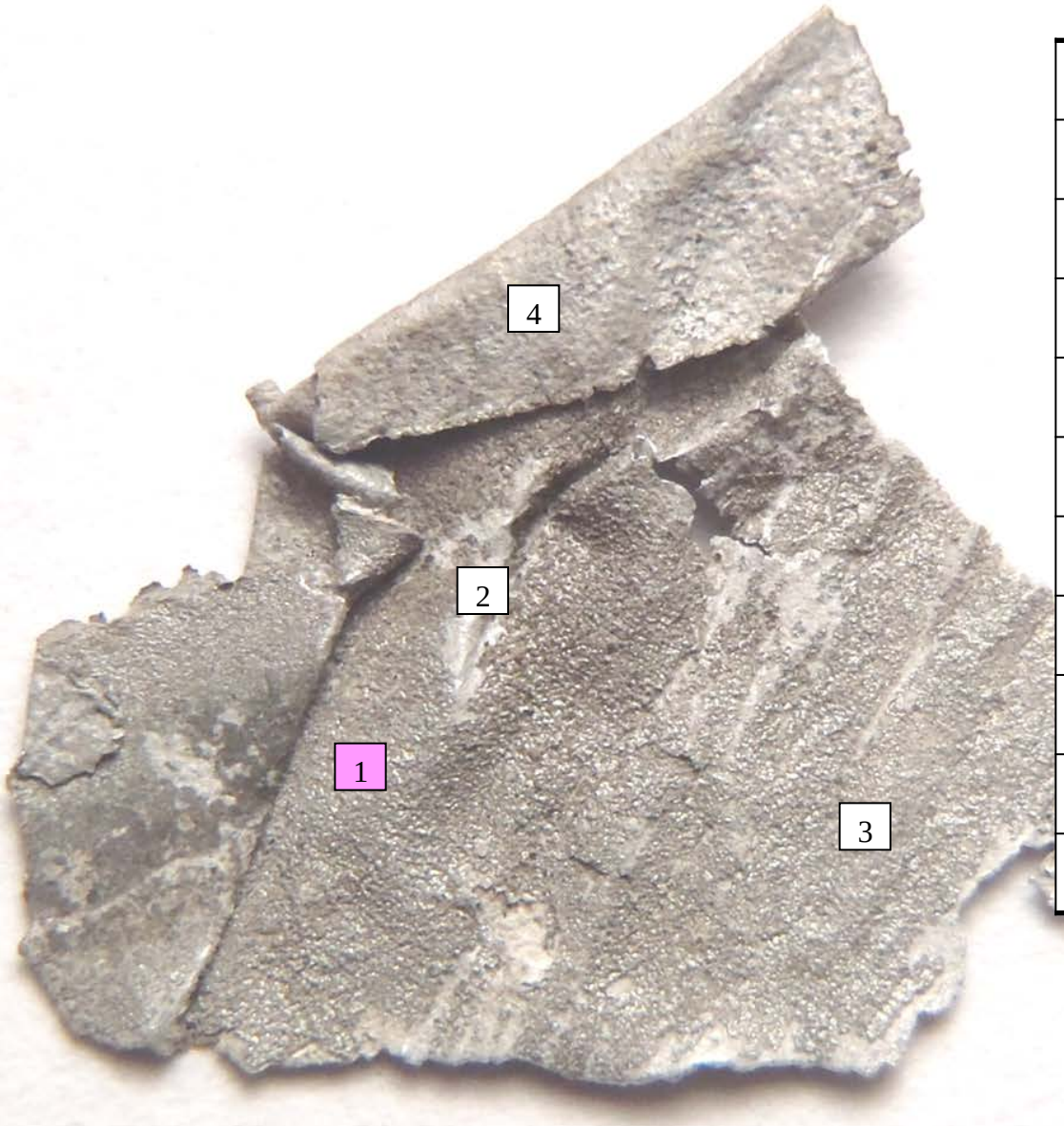
Normally Al-coated carbon steel, followed by attachment of Al fins by brazing.

- Al surface is required for brazing from Al to Al.

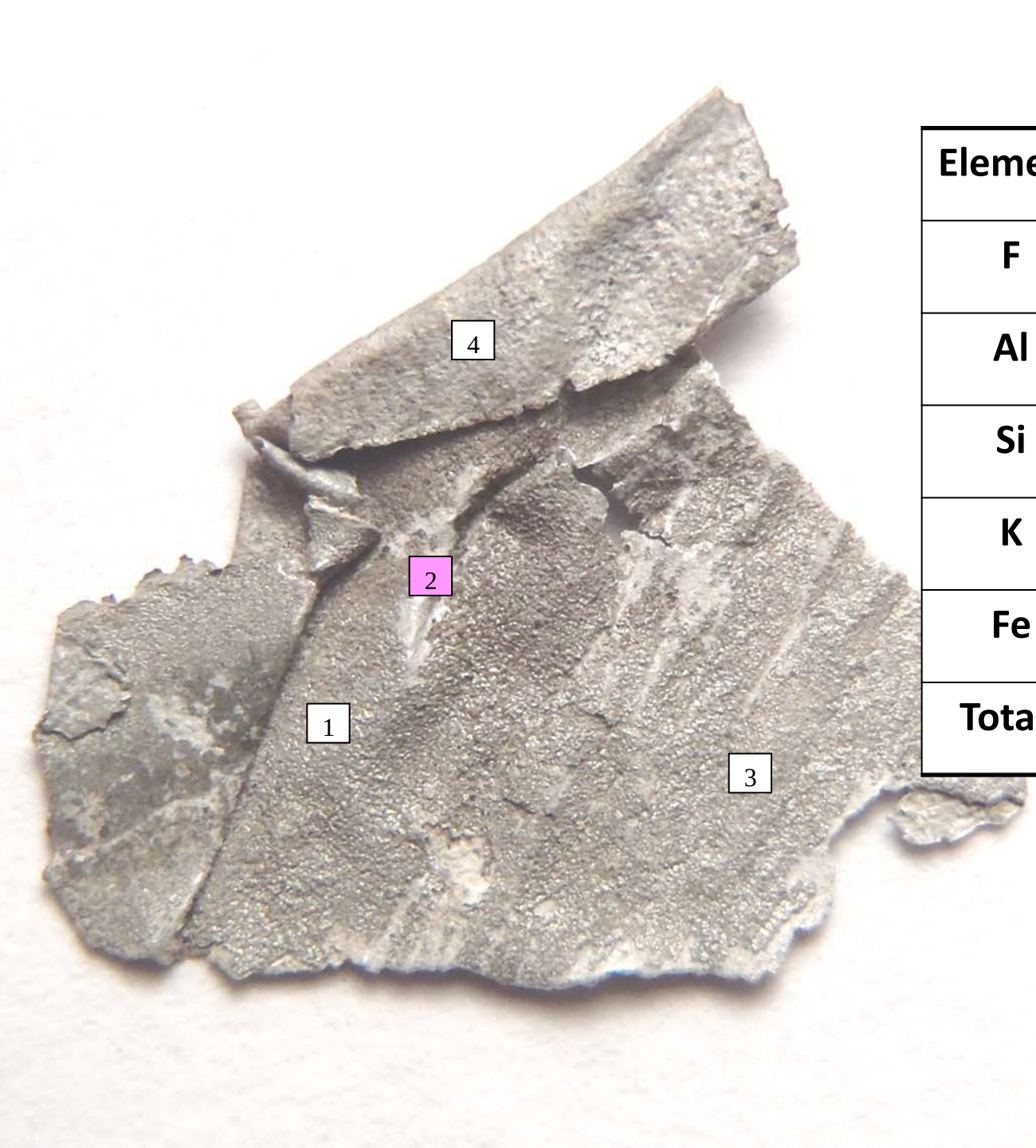
Concerns regarding Al coating

- **Detachment of Al from base steel**
  - **severe heat transfer penalty if widespread air gaps**
  - **increased corrosion susceptibility for ~0.06” thick carbon steel tubes**
    - **water trapped within gap results in differential aeration corrosion cell**
    - **carbon steel exposed to atmosphere if coating detaches**

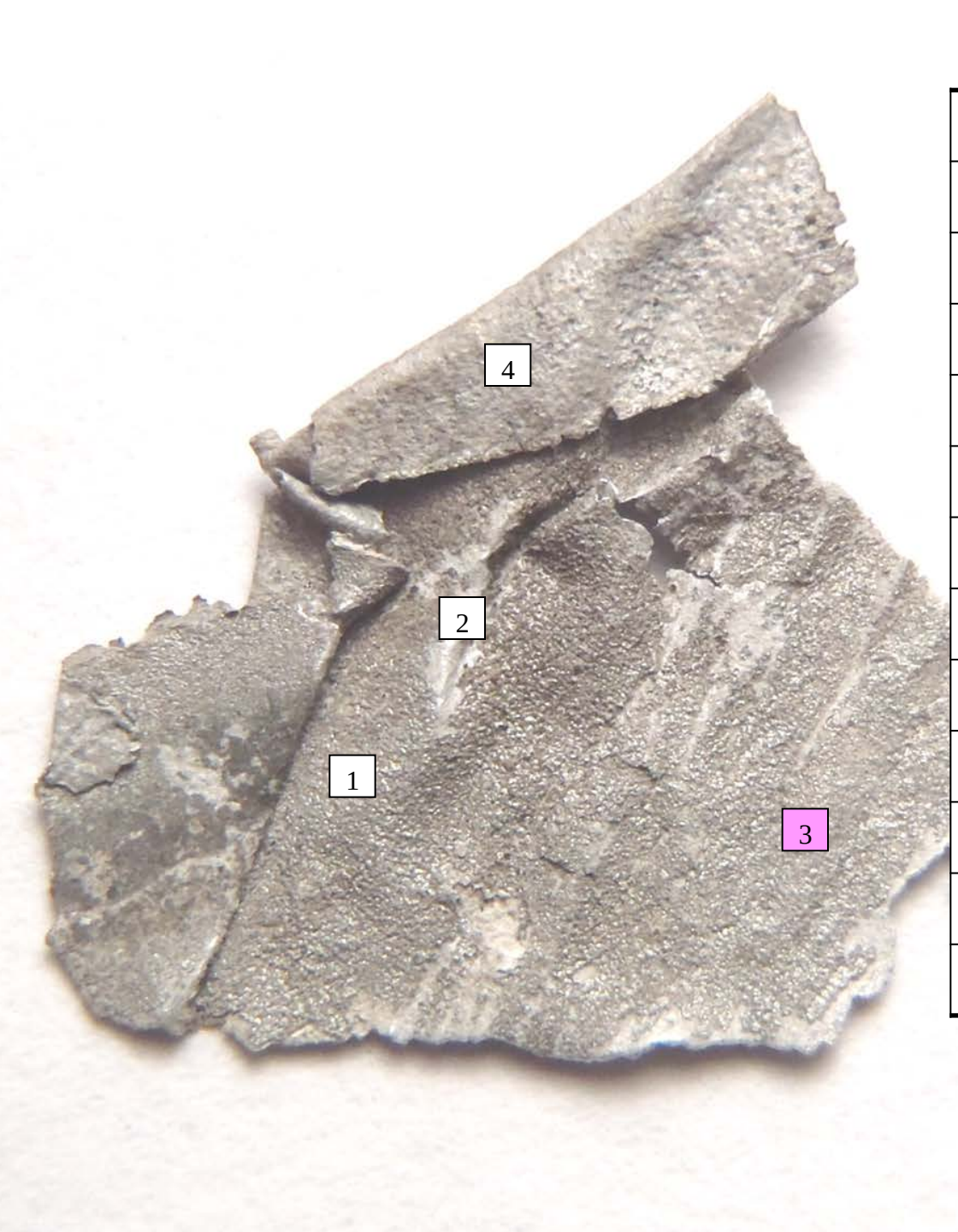


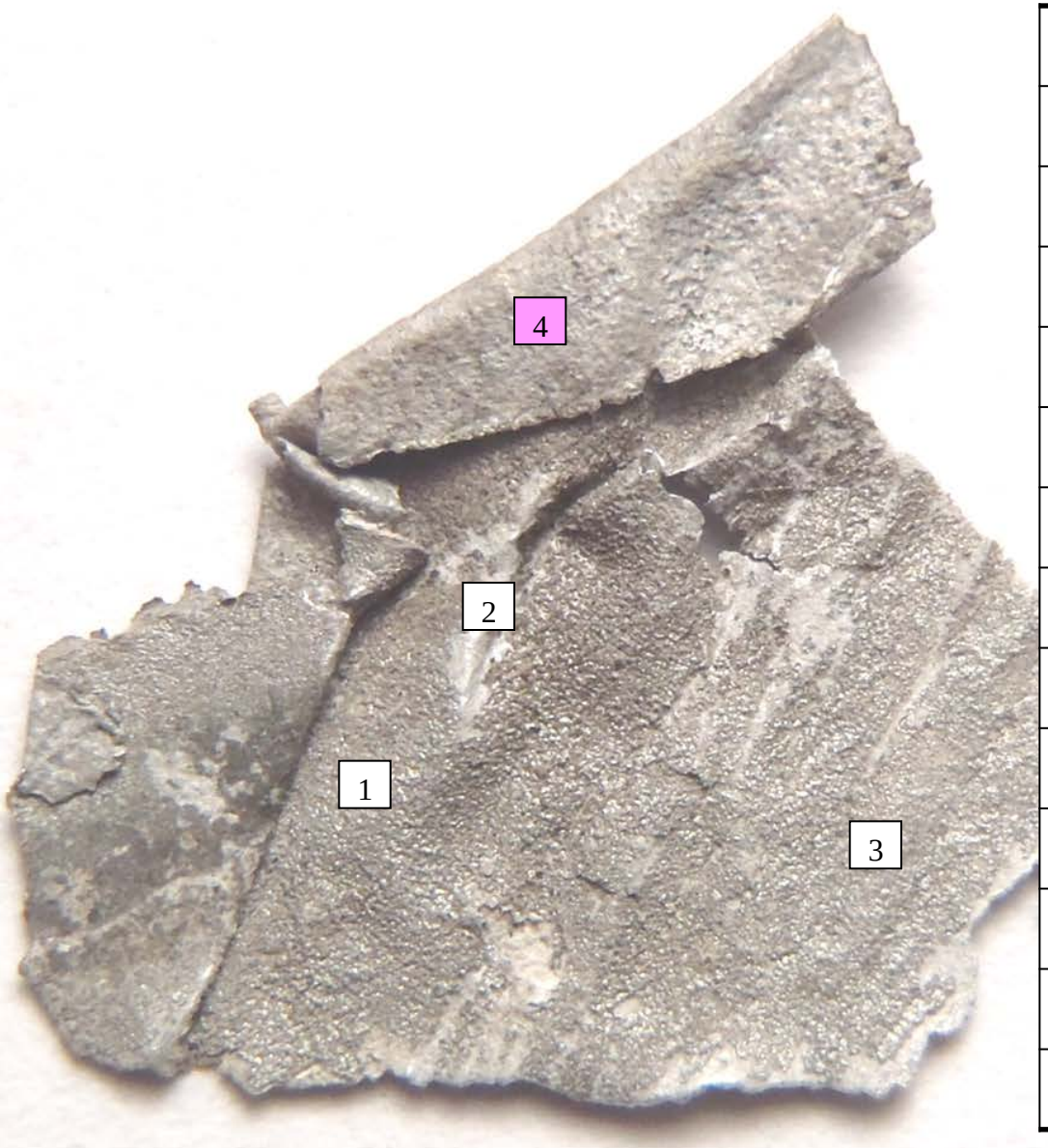
Element	Weight%	Atomic%
F	19	26
Al	56	56
Si	9	8
P	<1	<1
S	<1	<1
K	10	7
Ca	1	<1
Fe	3	2
Zn	1	<1
Totals	100	



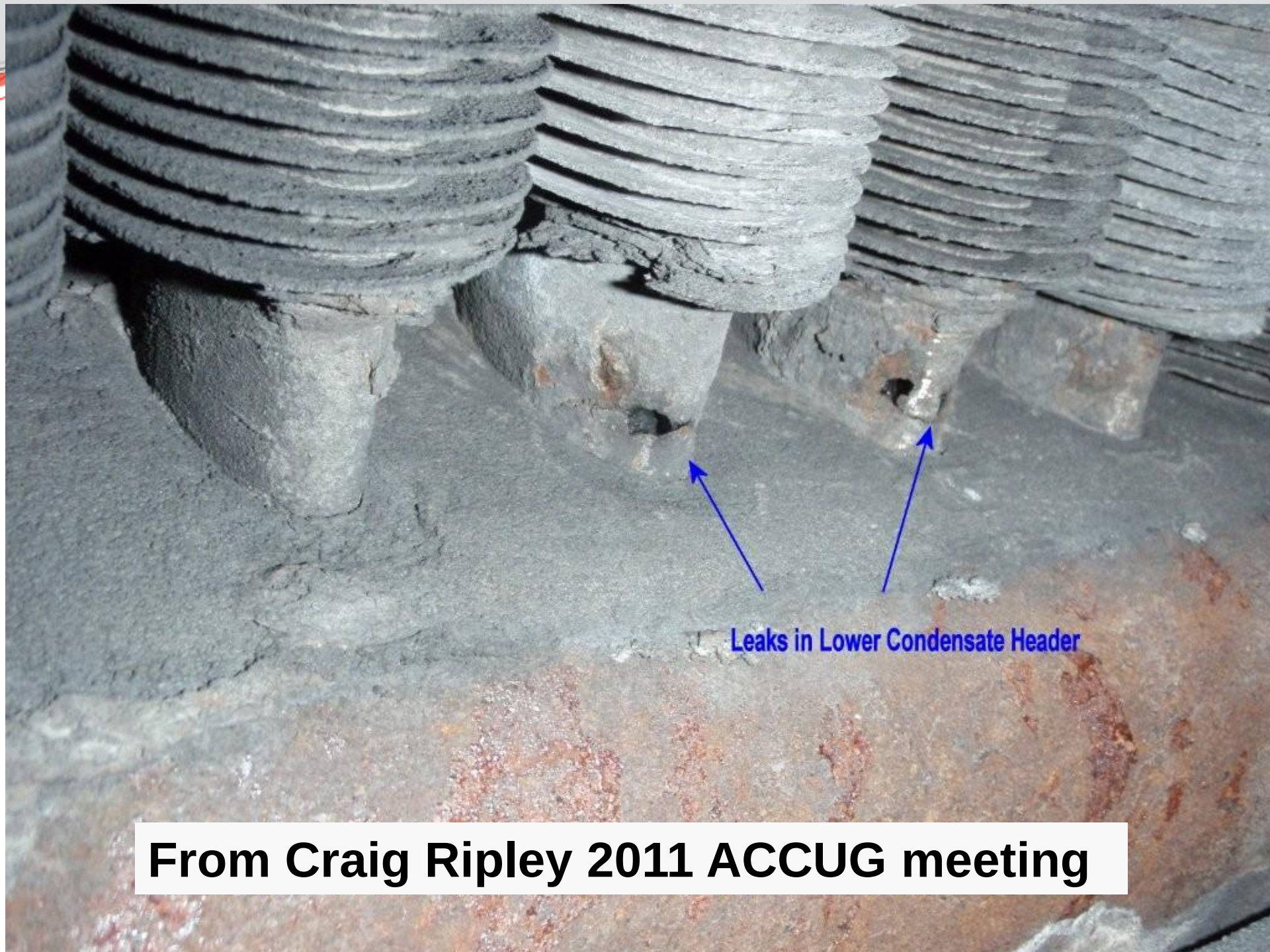
Element	Weight%	Atomic%
F	13	18
Al	81	78
Si	1	1
K	4	3
Fe	<1	<1
Totals	100	



Element	Weight%	Atomic%
F	24	32
Na	<1	<1
Mg	<1	<1
Al	51	48
Si	9	8
P	<1	<1
S	<1	<1
K	11	7
Ca	2	1
Fe	2	1
Zn	<1	<1
Totals	100	



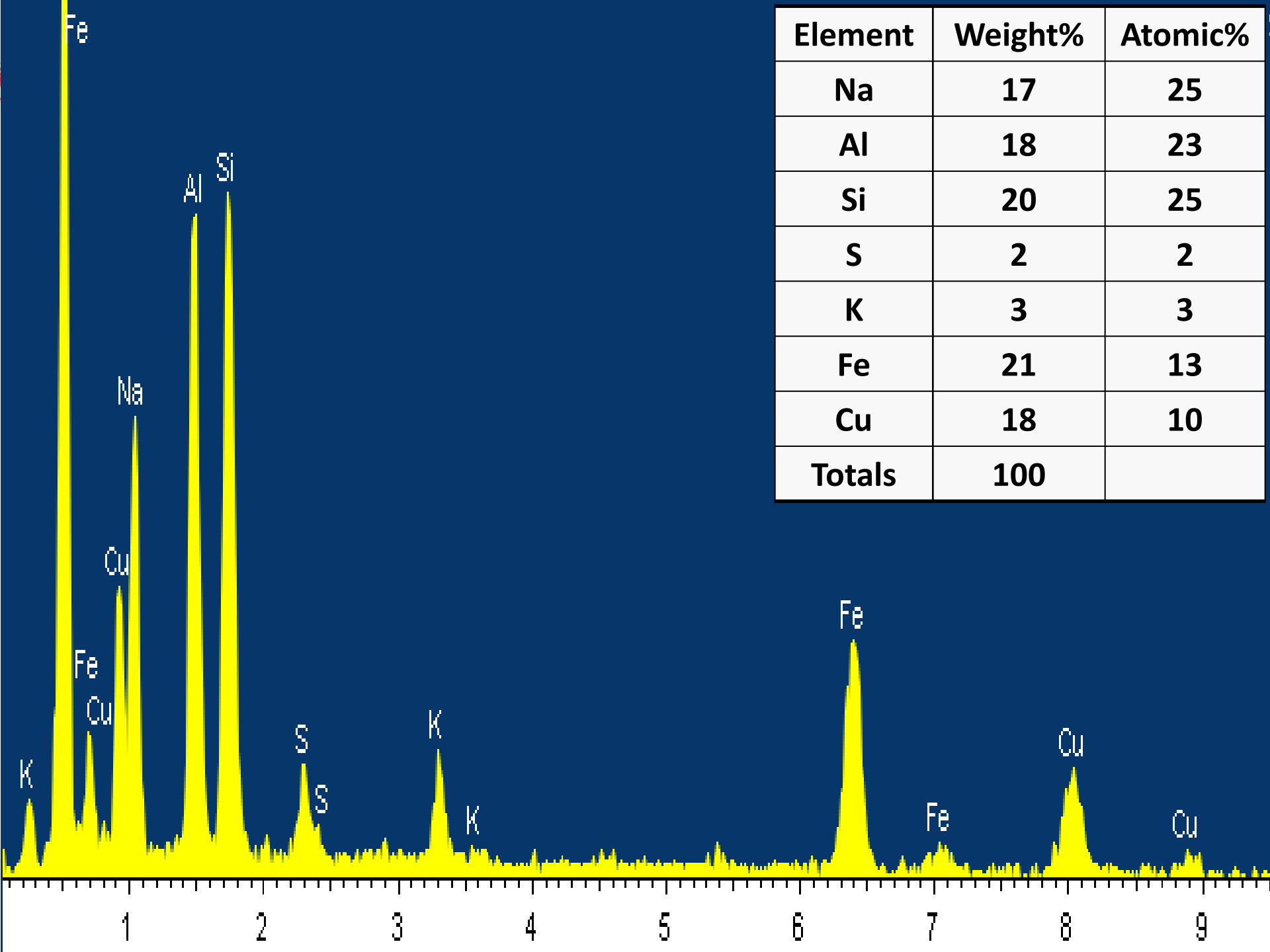
Element	Weight%	Atomic%
F	17	24
Na	<1	<1
Al	72	68
Si	4	4
P	<1	<1
S	<1	<1
Cl	<1	<1
K	1	<1
Ca	2	1
Ti	<1	<1
Mn	<1	<1
Fe	2	1
Totals	100	



From Craig Ripley 2011 ACCUG meeting

Concerns regarding Al coating

- **Possible ingress of Al to tube interior during manufacture**
  - **deposition on HP section of steam turbine and loss of turbine performance**
  - **limited options for removal of Al deposits from HP turbine other than turbine outage (7 to 10-year cycle)**

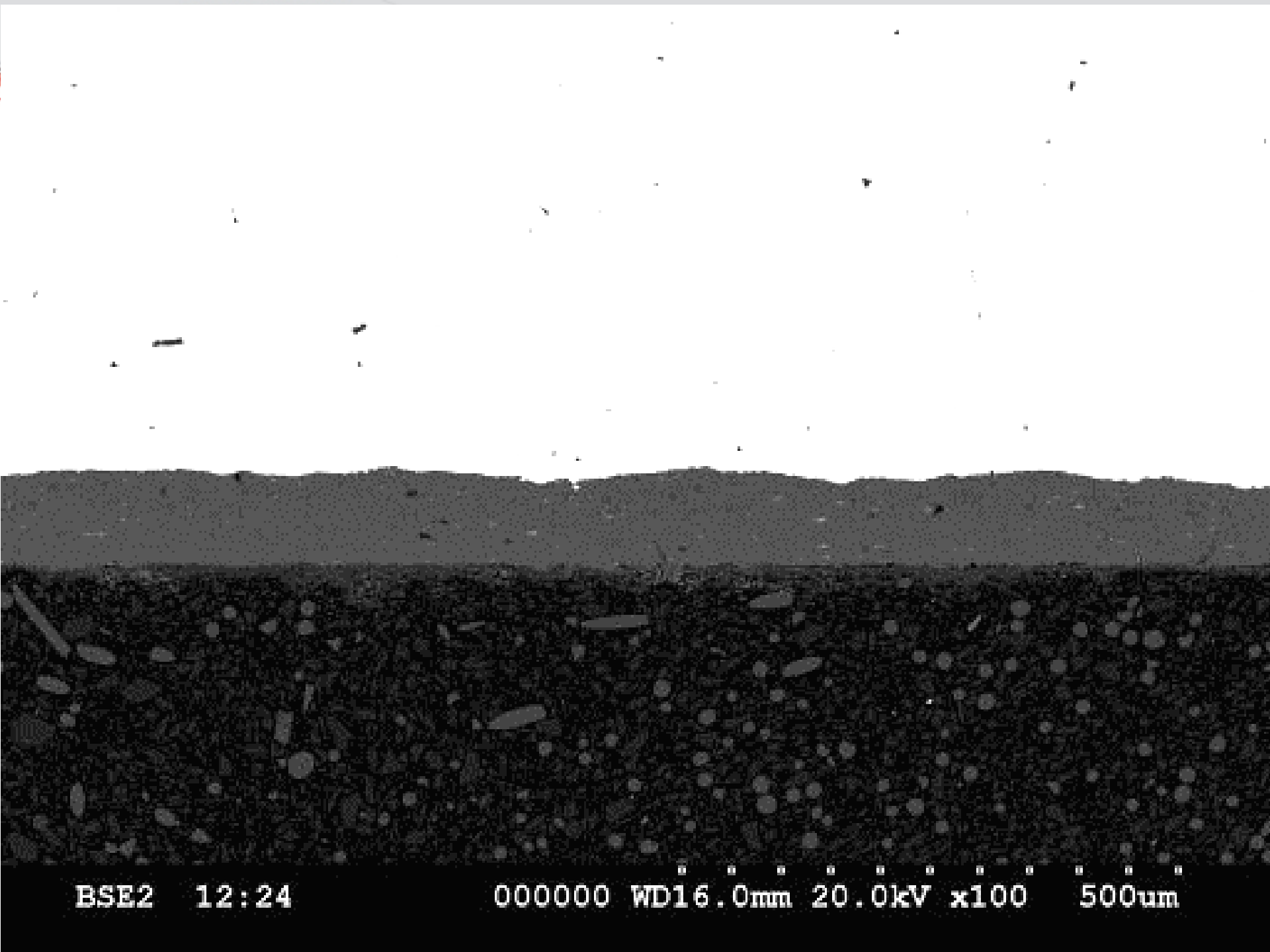


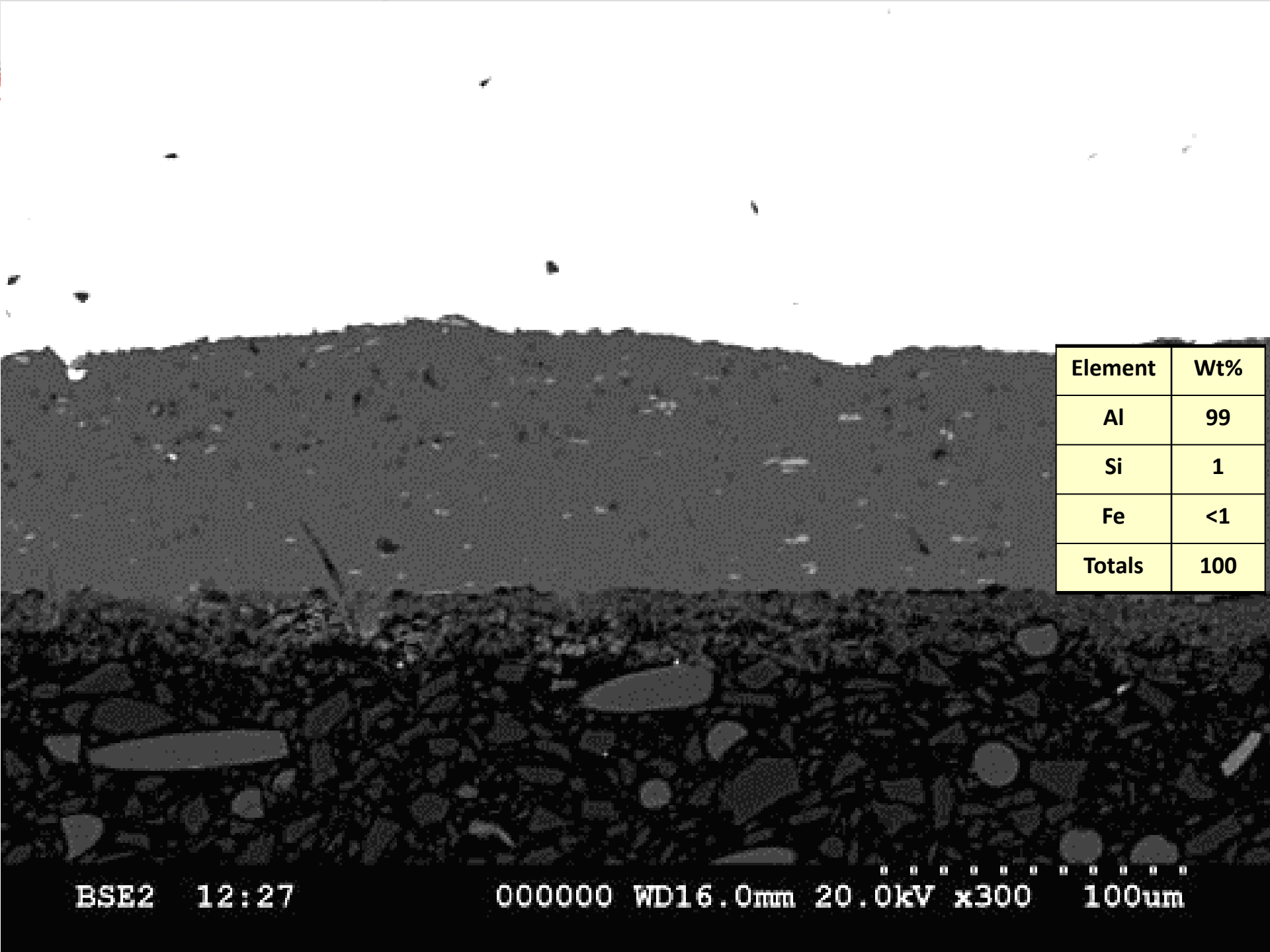
Element	Weight%	Atomic%
Na	17	25
Al	18	23
Si	20	25
S	2	2
K	3	3
Fe	21	13
Cu	18	10
Totals	100	

Coating process options

Note: only high-pressure cladding and molten aluminum dipping are believed to have been used for Al coating of ACC tubes at this point.

- **High pressure cladding**
  - **costly process although costs have lowered**
  - **strong steel-to-aluminum bond**


BSE2 12:24
000000 WD16.0mm 20.0kV x100 500um



Element	Wt%
Al	99
Si	1
Fe	<1
Totals	100

Coating process options

- Dipping tubes in molten aluminum
  - lower cost
  - lower thickness
  - uniformity and durability of coating uncertain

Coating processes

- **Influence of manufacturing process on internal tube Al contamination is uncertain**
  - **dipped tubes risk internal Al if not enclosed adequately (parallel with known problem for Zn-coated tubes)**
  - **brazing temperature is too low for Al volatilization**

Guidelines document on Al coating processes

- Insure transparency to end-user regarding what is being specified / supplied
- Allow end-user to understand and select coating process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