INSTITUT FÜR SELTENE ERDEN UND METALLE AG

ISE-Specification Al-01-2026

For the comparison and evaluation of high-purity aluminium intended for electronics, semiconductor and thin-film applications, ISE recommends the determination of the following impurity elements:

Li, Na, K, Mg, Ca, Si, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Pb, Bi

In addition, the following non-metallic elements should be analysed separately:

O, C, N

This analytical package broadly reflects industry practice for 5N and 6N aluminium used in electronics, semiconductor manufacturing and sputtering target production.

Basis of Element Selection

The recommended core list is based on three key criteria:

1. Typical impurities introduced during production and refining
2. Influence on electrical, mechanical and chemical properties
3. Common specification requirements of electronics, semiconductor and target manufacturers

Critical Element Groups

Alkalimetalle

Li, Na, K

These elements are among the most critical contaminants in electronic applications.

Potential effects:

- High ionic mobility
- Migration within oxide layers
- Increased leakage currents
- Long-term device instability

Sodium and potassium are subject to particularly stringent limits in semiconductor applications. Their removal requires advanced refining processes and has a significant impact on the commercial value of the material.

For example, aluminium containing:

- Na = 5 ppm

is considerably less valuable for semiconductor applications than aluminium with:

- Na < 0,05 ppm

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Alkaline Earth Metals

Mg, Ca
Typical sources include:
- Electrolytic production processes
- Melt treatment operations
- Refractory materials

Potential effects:
- Oxide formation
- Non-metallic inclusions
- Reduced thin-film quality

Low magnesium and calcium concentrations are generally regarded as indicators of advanced refining quality.

Silicon

Si
Silicon is the most common impurity found in aluminium.

Even at low concentrations it may influence:
- Electrical conductivity
- Microstructure
- Recrystallisation behaviour

Silicon is therefore one of the primary parameters evaluated when assessing high-purity aluminium grades.

Transition Metals

Ti, V, Cr, Mn
These elements are typical transition-metal impurities.

These elements may contribute to:
- Precipitation formation
- Intermetallic phases
- Reduced electrical conductivity

They are particularly important in:
- Sputtering targets
- Thin-film applications
- Semiconductor metallisation processes

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Iron

Fe
Iron is the most significant metallic impurity in aluminium.

Even a few ppm may:
- Reduce electrical conductivity
- Alter the microstructure
- Affect material performance

Consequently, iron is one of the principal evaluation criteria for 4N, 5N and 6N aluminium.

Electrically Active Transition Metals

Co, Ni
These elements are particularly critical for:
- Semiconductor applications
- Electronic thin films
- Target materials

Low concentrations are generally associated with high-quality refining processes.

Typical Cross-Contamination Elements

Cu, Zn
Common sources include:
- Recycling streams
- Alloy production facilities
- Manufacturing equipment

Potential effects:
- Changes in electrical conductivity
- Altered corrosion behaviour
- Modified thin-film performance

Gallium

Ga
Gallium exhibits unique behaviour in aluminium.
Potential effects:

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- Influence on grain boundaries
- Changes in material stability

As a result, gallium is often specified for electronic-grade materials.

Tramp Elements

Pb, Bi
These elements may:
- Segregate to grain boundaries
- Influence mechanical properties
- Promote embrittlement

Accordingly, they are typically controlled at very low levels in high-purity aluminium.

Non-Metallic Impurities

Why are O, C and N assessed separately?
These elements are often not determined or evaluated reliably as part of the standard metallic impurity analysis.

Oxygen (O)
May influence:
- Oxide layer formation
- Sputtering behaviour
- Melt quality

Carbon (C)
May indicate:
- Organic contamination
- Manufacturing residues

Nitrogen (N)
May:
- Form nitrides
- Influence thin-film processes

Relevance for Commercial Evaluation

The recommended analytical package covers the majority of price-relevant impurities in high-purity aluminium.

Category	Elements
Process-related contaminants	Li, Na, K, Mg, Ca
Major metallic impurities	Si, Fe, Cu, Zn
Electronics and semiconductor critical elements	Ti, V, Cr, Mn, Co, Ni, Ga, Pb, Bi

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These 18 elements, together with separate oxygen, carbon and nitrogen analysis, typically account for more than 90% of the impurities relevant to the commercial valuation of high-purity aluminium.

Note

For quotation comparison and commercial assessment, this core analytical package is generally sufficient.

For the full qualification of 6N and 7N aluminium materials, comprehensive GD-MS full-scan analyses covering approximately 40–70 elements are often required.

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