High-strength Al-Mg-Sc alloy with 0.1wt.%Sc content

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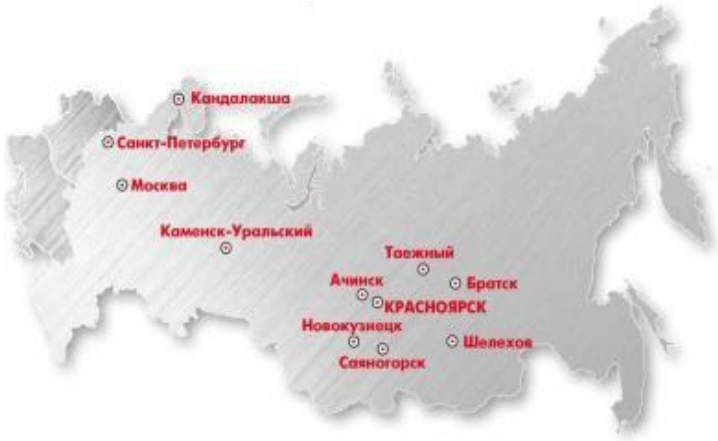
RUSAL R&D

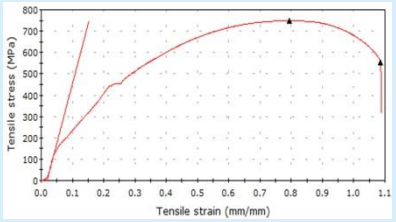
- In 2017, UC RUSAL set up the Light Materials and Technologies Institute (LMTI) in Moscow to develop new alloys and materials for customers requirements and to solve research and technology problems common to all the production facilities of the Company
- LMTI staff - 32 employees, 6 of them have PhD degree, and 2 - Doctor of Sciences
- LMTI has its own testing centres to carry out general and specific tests (mechanical, corrosion, physical etc.) according to Russian and International methods
- Research directions LMTI:
  - alloys for die casting
  - alloys for high pressure die casting
  - wrought alloys
  - mathematical modeling in the development of new materials and processes
  - technologies for the production of pastes, pigments, gasifiers
  - metal matrix composite materials
  - additive technologies



Representative RUSAL R&D offices

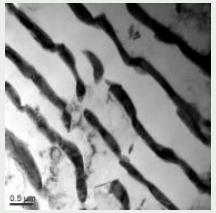
LMTI Testing center

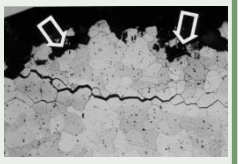
Mechanical properties



Tensile, compression and fatigue properties according to GOST, ASTM (E8, E9, E606), ISO (6892), DIN (50106) etc.

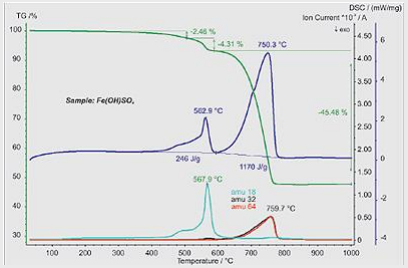
Corrosion and microstructure





SEM studies, microstructure analysis.
Corrosion tests (general, IGC, EXFO) according to GOST and ASTM (G66, G67, G34) etc.

Physical properties



Determination of electrical and thermophysical properties of metallic materials

ILMIT R&D center can perform various tests according to the specific methods, which are necessary for the customer. Some methods can be developed if necessary

Sparingly alloyed high-strength Al-Mg-0.1%Sc alloy

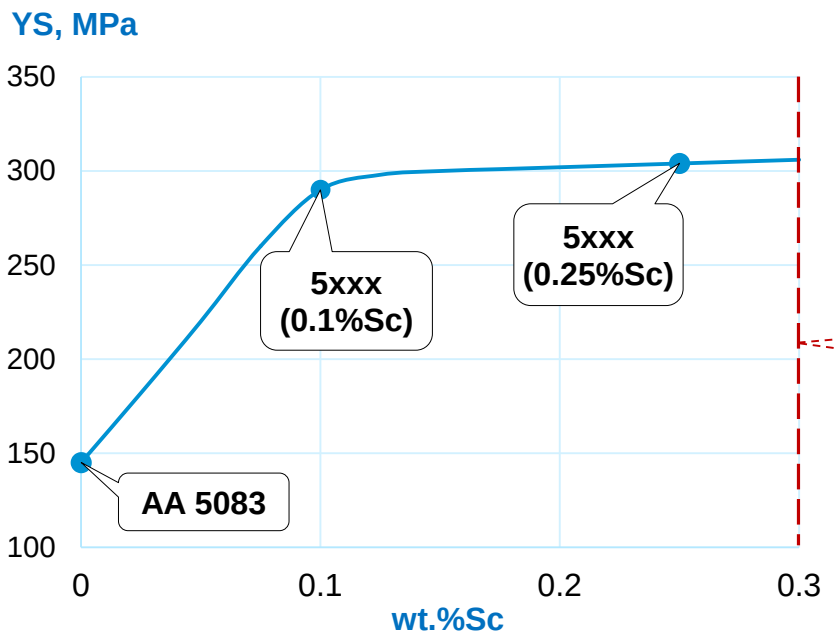
MOTIVATION

- Resources for increasing of mechanical properties of the Al-Mg alloys are exhausted
- It is known, that Sc is the most effective hardener of the Al-Mg alloys
- At the same time, addition of Sc in concentrations, which correspond to commercial Al-Mg-Sc alloys, increase significantly the price of material

Sc-containing materials can be applied in case of their cost efficiency

Sparingly alloyed high-strength Al-Mg-0.1%Sc alloy

Influence of Sc on strength properties

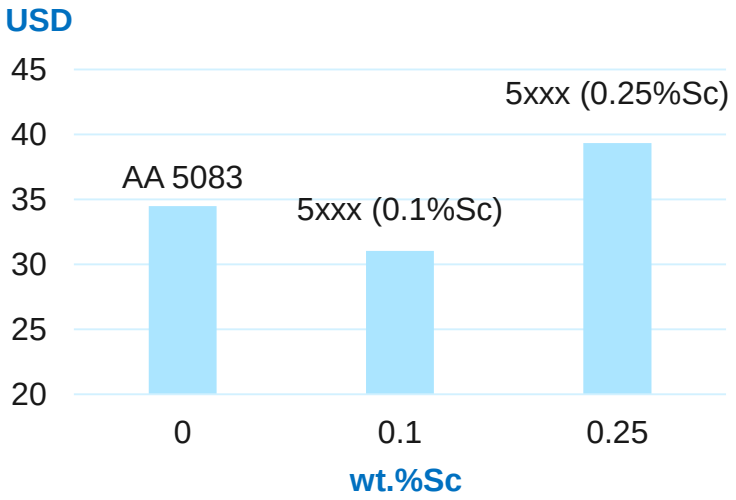


The greatest strength properties growth of Al-Mg system alloys is observed at Sc concentrations up to 0.1%. With a further increase of Sc concentration strength growth rate decreases.

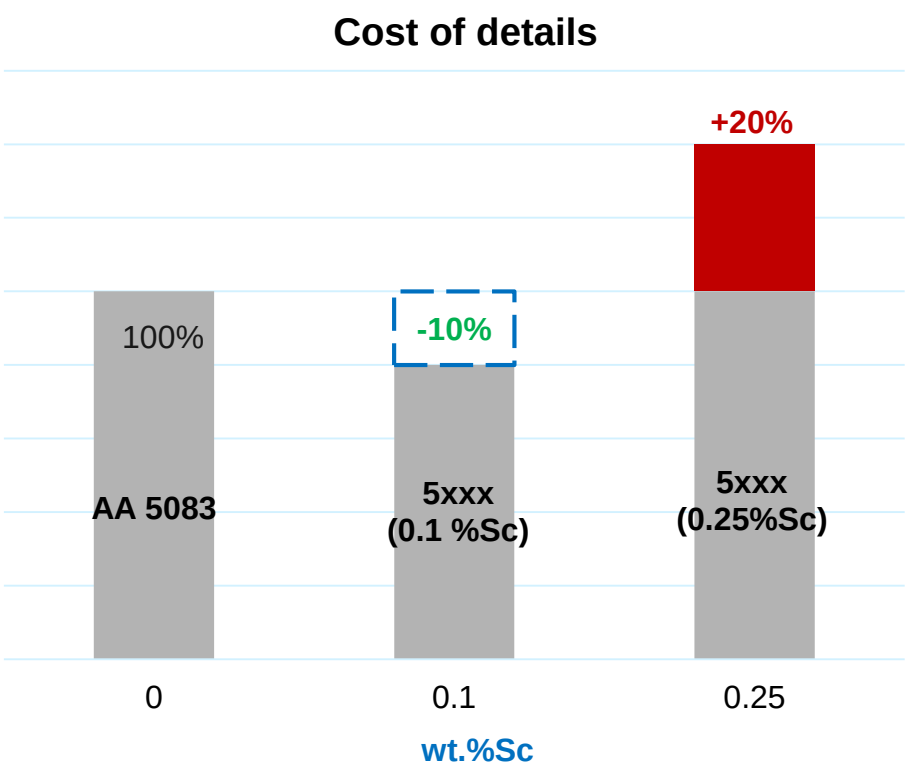
Concentrations >0.3wt.%Sc are not commonly used for traditional casting and rolling technology

As a simple criterion for economical efficiency of Sc adding, the price of 1 MPa of the rolled products is taken.

"Price" of 1 MPa (rolled products)



Sparingly alloyed high-strength Al-Mg-0.1%Sc alloy



Existing commercial 5xxx series alloys containing Sc have lower cost efficiency (about 20%) in comparison with 5083 alloy, making it difficult to use them widely as an alternative to the latter.

From this perspective Al-Mg-0.1%Sc alloy can be used as an alternative to 5083 in marine constructions.

The advantages of 5xxx(0.1%Sc):

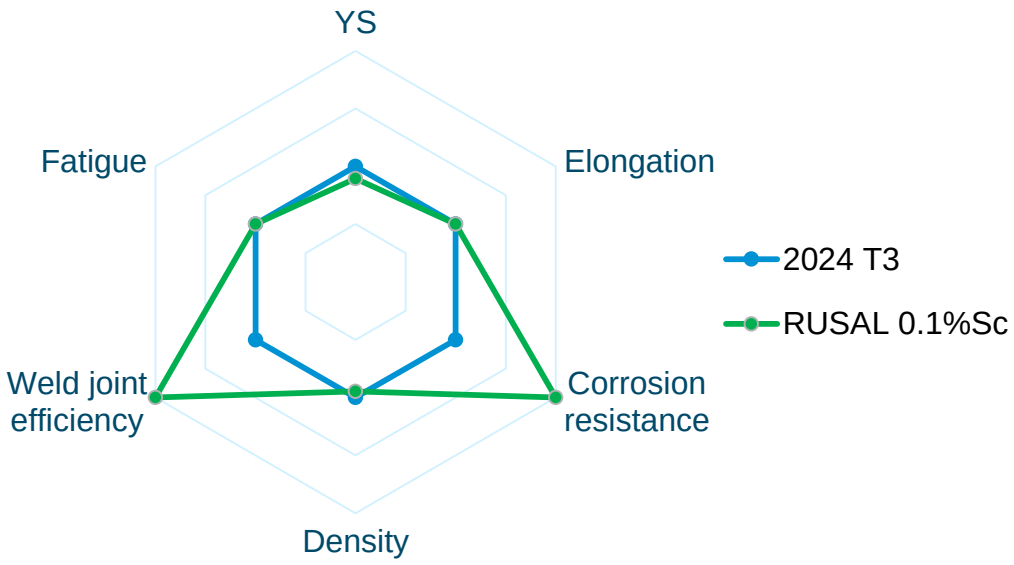
- material costs
- weight of constructions
- fuel consumption
- CO2 footprint

Sparingly alloyed high-strength Al-Mg-0.1%Sc alloy

Al-Mg-0.1%Sc alloy can be considered as an possible alternative to AA2024 for aerospace application through:

- High YS value, close to 2024
- 5% lower density
- High fatigue characteristics
- Excellent weldability
- Good corrosion resistance
- No need for heat treatment

Comparison with 2024 alloy



Problems with 2024 alloy:

- Additional costs for heat treatment operation
- Prone to warping
- Low corrosion resistance
- Low weldability

RUSAL Al-Mg-0.1%Sc alloy

RUSAL has developed a new Al-Mg-Sc alloy with 0.1wt% Sc content, combining:

- High strength properties comparable to commercial alloys with higher Sc content
- Lower price
- Good workability (as good as traditional 5xxx series alloys)

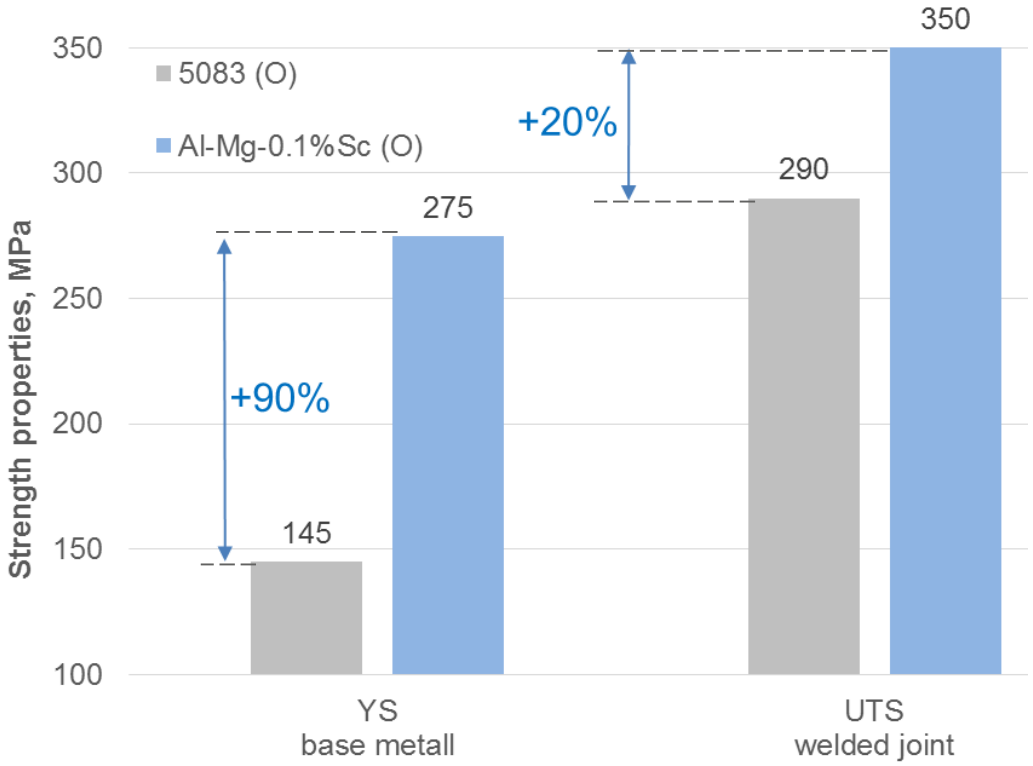
For serial production have been developed:

- Casting technology (slabs and billets)
- Rolling technology
- Forging technology

No special equipment is required.

Mechanical properties of Al-Mg-0.1%Sc (Rusal) and other commercial wrought alloys

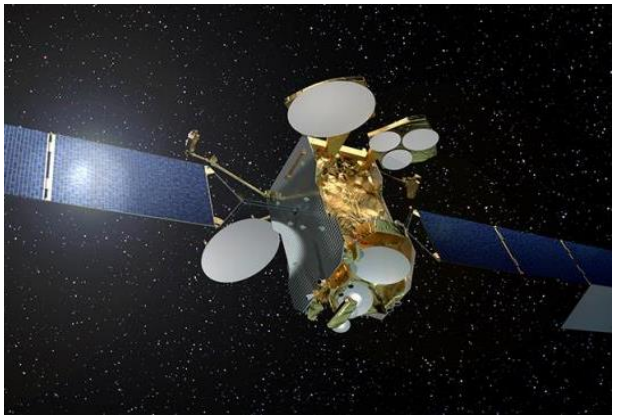
Alloy	State	UTS, MPa	YS, MPa	Elongation, %
5083	O	315	145	15
1570 (Russia) 0.25%Sc	O	400	310	15
2024	T3	465	325	10-16
Al-Mg-0.1%Sc (Rusal)	**O**	**380-410**	**280-320**	**14-19**



RUSAL Al-Mg-0.1%Sc alloy in comparison with 5083:
+90% increase of YS
+20% increase of UTS of the weld joints

Promising fields of wide application for Al-Mg-Sc alloys

Aerospace


Shipbuilding


Source:Moss

Industrial production of the semi-finished products



MECHANICAL PROPERTIES of semi-products

Semi-product	State	Yield stress Rp0.2, [MPa]	Ultimate tensile stress Rm, [MPa]	Elongation, %	Modulus of elasticity [GPa]	Density, g/cm³
sheets	annealed	280-320	380-410	14-19	70	2.66
extrusions	after extrusion	330	400	10		
forgings	annealed	255	380	15		

CORROSION RESISTANCE

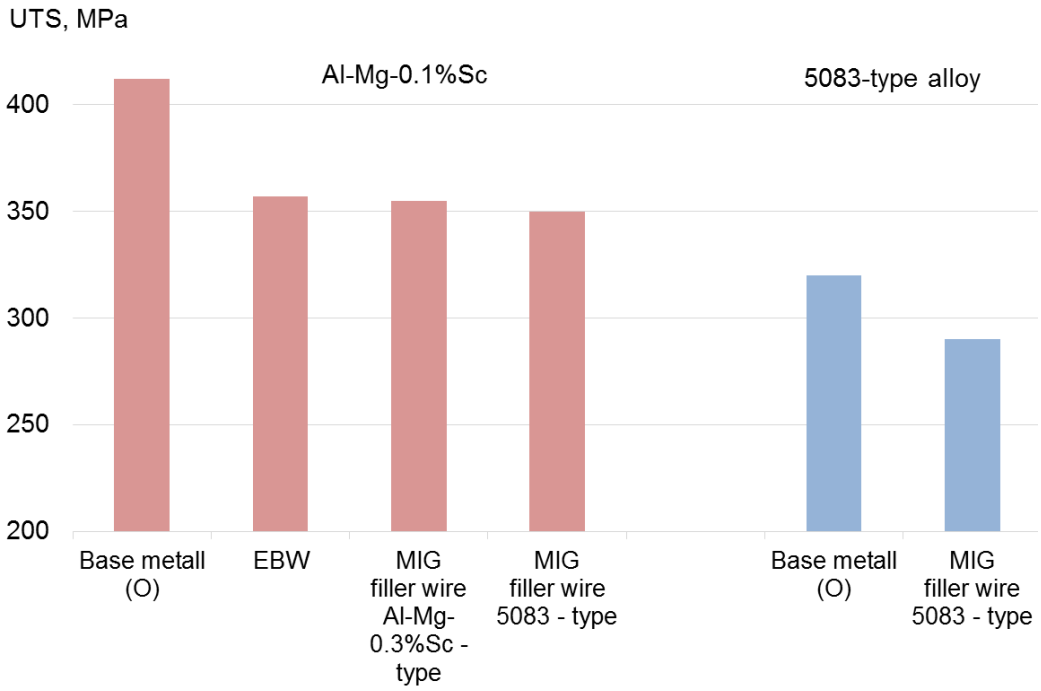
Test	Specification	Requirement	Typical values
NAMLT (Nitric Acid Mass Loss Test)	ASTM G67	<15 mg/cm²	2 mg/cm²
ASSET (Assessment of Exfoliation Corrosion Test)	ASTM G66	Within PB	PB

Industrial testing

It was proofed that alloy has good workability in standard technological operations along with its high mechanical properties and good weldability in comparison with 5083-type and 2024-type alloys, what makes it reasonable substitution for traditional alloys in aerospace construction.

Weldability

Alloy has shown good weldability by using MIG and EBW methods.
Welded joint efficiency (UTS_{base} / UTS_{weld}) of Al-Mg-0.1%Sc alloy is equal 0.9 and identical to 5083-type alloy.



Other properties

Fatigue

Test	Typical value
Fatigue Strength (200 000 000 cycles, stress ratio R = 0.1)	200 MPa

Tensile test at room temperature (after holding at 300 °C during 100 hours)

State	Sample	$б_{0.2}$, МПа
O	1.5mm sheet	320
after holding at 300 °C during 100 hours		305

Charpy impact test (4.5mm sheet):

State	Welding method	Impact strength, kJ/m²	Filler wire
O	-	371	
Welded joints	EBW	606	
	MIG	580 649	5083-type 1570 (0.25%Sc)

Available dimensions of slabs, billets and rolled products for delivery

Slabs:

Thickness, mm	Width, mm	Length, mm
300 … 560	1310 … 2150*	up to 6000

* on request

Billets:

Diameter, mm	Length, mm
∅ 125 … 410	up to 6000

Sheets:

Thickness*, mm	1250x2500	1500x3000	2000x4000	2000x6000	2500x6000 ** 2000x8000 **
1-3	✓	✓	✓		
4-12	✓	✓	✓	✓	
>12 ** (plates)					

* thickness tolerances according to EN 485-3 (for hot rolling) and EN 483-4 (for cold rolling);
** on request

Thank you for your attention!

РУСАЛ

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