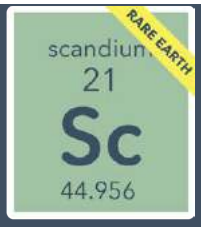
SCANDIUM

Scandium is a chemical element with symbol Sc and atomic number 21. A silvery-white metallic d-block element, it was discovered in 1879 by spectral analysis of the minerals euxenite and



gadolinite from Scandinavia.

- Sc is the 36th most abundant element in the crust
- Earth's crust abundance of 22 mg/kg, the occurrence of scandium is comparable with that of lead (14 mg/kg) and cobalt (25 mg/kg)
- However, scandium is rarely concentrated in nature and remains widely dispersed in the lithosphere as it lacks affinity to combine with the common ore-forming anions

Sc is 'more rare' than all other REEs

WHERE IS SC FOUND?

VIABLE SOURCES OF SC TODAY

TiO2 PIGMENT PRODUCT ACID WASTES STREAMS

URANIUM PROCESSING WASTES (SOVIET STOCKPILES)

NICKEL-COBALT LATERITES (AUSTRALIA/TURKEY/USA)

BAUXITE RESIDUES (RUSAL, AOG)

> Bauxides and nickel laterite ores are proposed as the most promising Sc resources for future large scale production; Parnassos/Greece could well be a worldwide resource for Sc!

GLOBAL PRODUCERS

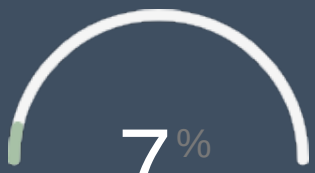
SC IS PRODUCED IN A HANDFUL OF PLACES GLOBALLY

- A major source for scandium deposits was the now flooded Ashurst mine in Zhovti Vody outside Kiev, Ukraine, that was once a major harvesting ground for iron ore and uranium for the Soviet military.
- Today there is an active mine for Sc is in Kazahkstan
- Other Sc sources include REE byproducts

in Kola Peninsula in Russia and Bayan Obo in China and there are several Acid Waste facilities (TiO2 production) in China, USA, Philippines and Japan

China

Russia



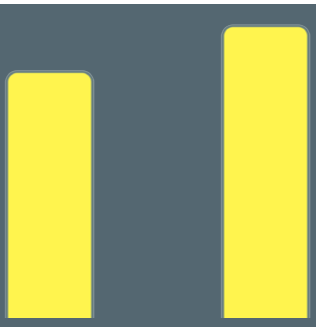
Ukraine

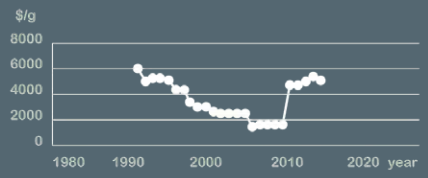
The current Sc world production is estimated at 10 – 12 tpy of scandium oxide

THE ECONOMY OF SC

SUPPLY	DEMAND
10-12 tpy	12-14 tpy

Al – Sc 2%: 100-150 $/kg





Sc2O3 99.99% price per kg

Sc metal 99.9% price per kg

SC VALUE CHAIN:

*data from 2013

0.9 $/g
Sc2O3 99%

5 $/g
Sc2O3 99.99%

253 $/g
ScF3
99,99%

206 $/g
Sc
Metal

SC HAS SUPERPOWERS

SC ACHIEVES SUPERIOR RESULTS THAN Y IN MATERIAL APPLICATIONS

SOLID OXIDE FUEL CELLS

Sc-stabilised Zirconia has lowered operational temperatures facilitating the commercialisation of the technology

+ SEE EXAMPLE

LASERS WITH Sc GARNETS

have 3 times higher efficiency than

Y garnets

+ SEE EXAMPLE

NATURAL LIGHT

Sc compound is used as phosphors for high intensity “natural” light – close to solar optical spectrum

Sc+Al

SC GOES WELL WITH AL

SCANDIUM-ALUMINIUM ALLOYS

AL20LI20MG10SC20TI30

- as strong as titanium
- as light as aluminium
- as hard as ceramic

Sc drastically improves Al alloys, increasing strength, corrosion resistance & allowing welding…

Sc Al alloys origin

Scandium – Aluminium alloys were first used in the 1980s for structural purposes in Soviet aircrafts and missiles.

Weldable alloys

The strength that Scandium alloys brought to weldable alloys, allowed Soviet to built aircrafts (MIG-29) and utilize welded structures. This gave these planes tremendous weight, maneuverability and range advantages.

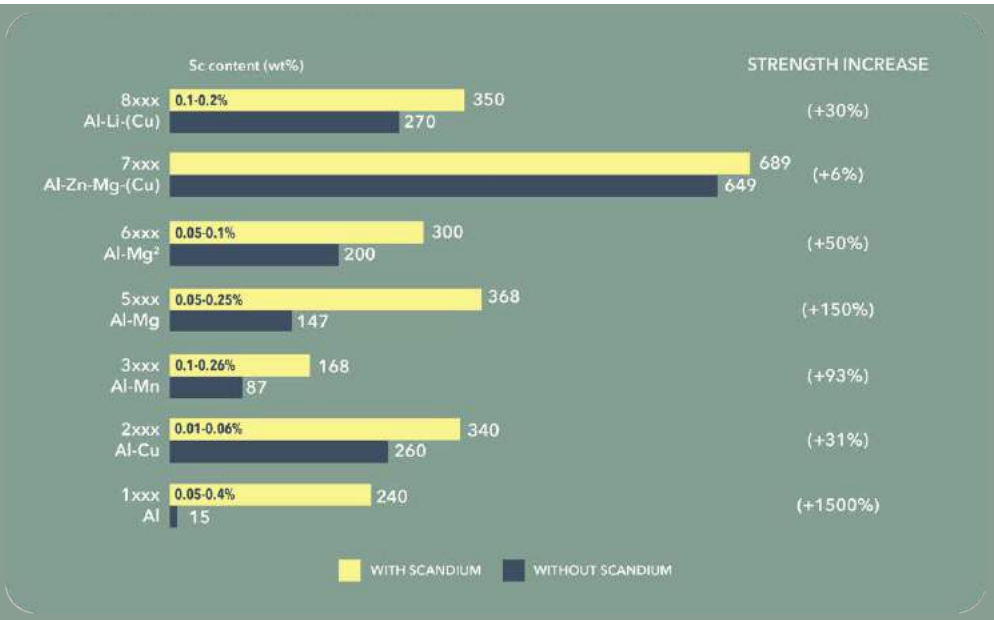
Strength

Sc offers the

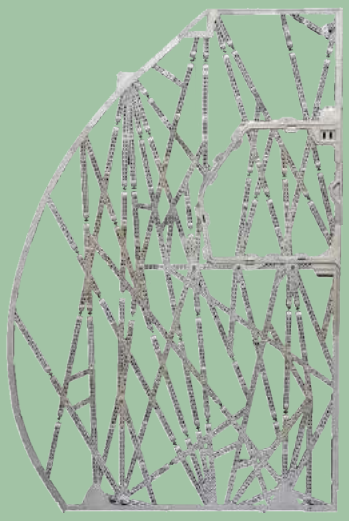
highest increment of strengthening per atomic percent of any alloying element when added to Al

Hot cracking

Sc reduces hot cracking during welding of Al-alloys



SC APPLICATIONS



THE AL-SC-MG ALLOY POWDER IS USED IN 3D PRINTING BY AIRBUS

We did produce

Compound	Application	Today	Future
Sc2O3	SOFC – SSZ solid electrolyte	in market by Bloomenergy	Household use
Sc2O3	Er: YSGG garnets (Er:Y 3 Sc 2 Ga 3 0 12) for optics in lazer application		Er: YSGG has 3 times higher efficiency than Nd,Er: YAG in solid-state lasers radiating in

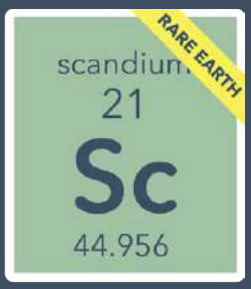
122 out of the 162 parts on our M400 out of SCALMALLOY®. The partition weights a massive 45% less than current Airbus A320 partition designs

APWorks, 2 December 2015

			the 3 µm
Sc-Al alloy	High resistance Al alloy used in welding or casting – best Al alloy available	High End sporting equipment	Aerospace, Automotive
Al-Mg-Sc (Scalmalloy®)	3D Printing – licensed by Airbus to Apworks		Aerospace, Automotive
ScF3	Material with negative thermal expansion coefficient		Advanced material composites
20% Sc - 80% Ti Carbide	doubling of the hardness TiC, to about 50 GPa, second only to diamonds in hardness.		Advanced materials
Phosporous / Lighting	Scandium has a broad emission spectrum that generates a ‘daylight’ effect. Sc2O3 and ScVO4	Stadium / studio lighting	Household lighting

are typical host materials for phosphorus in monitors

WHAT IS SCANDIUM?



Scandium is a chemical element with symbol Sc and atomic number 21. A silvery-white metallic d-block element, it was discovered in 1879 by spectral analysis of the minerals euxenite and gadolinite from Scandinavia.

Scandium is a rare-earth metal, used in small amounts but with drastic effects on properties of matter. It is a key component in producing high strength Aluminium alloys used in aerospace and 3D printing as well as in Solid Oxide Fuel Cell (SOFC) applications.

LEARN MORE

SCANDIUM SUPPLY

Scandium is present in most of the deposits of rare-earth and uranium compounds, but it is extracted from these ores in only a few mines worldwide. Scandium supply is limited due its scarcity and the high cost of its production, which currently takes place in Asia and Russia. Europe has no production of Scandium, but is home to many Scandium end-users and to industries having Scandium in their industrial residues. By converting waste into resources and thus developing a stable and secure EU scandium supply chain to serve the needs of EU aerospace and high tech industry, SCALE project will contribute to reduce dependency on imports of raw materials.

SCALE PROJECT

Scandium is an enabler in vital sectors like clean energy, transport, optics and advanced materials. Despite having a proven set of impressive applications, its volatile price and unreliable supply chain limit their deployment. SCALE develops innovative technologies that can extract economically and sustainably Sc from dilute mediums (<100 mg/L) and upgrade them to pure oxides, metals and alloys at lower energy or material cost. This will be achieved through the development of a number of innovative extraction, separation, refining and alloying technologies that will be validated in an appropriate laboratory and industrial environment to prove their technical and economic feasibility. SCALE builds on the success of previous and on-going European research projects like ENEXAL, EURARE,

REECover, REE4EU and REMAGHIC.

 SCALE has received funding from the European Community's Horizon 2020 Programme (H2020/2014-2020) under grant agreement n° 730105