WHY NEW STRUCTURAL MATERIALS FOR AUTOMOTIVE APPLICATIONS?
Global fuel efficiency regulations

Combustion Engine:
BIW Weight x Efficiency

In addition to the other advantages:

- Light Body to compensate for the additional battery weight
- Also Important:
- Cost and Packaging purposes / easy to engineer geometrically to accommodate battery volume.


RHETT ALLAIN SCIENCE, FUEL ECONOMY VERSUS MASS
(https://www.wired.com/2012/08/fuel-economy-vs-mass/)
Lightweighting: Strength with Lowest Mass

Safety: Toughness

NOTE: Low strength and low density may lead to good specific strength but large volume (thick sections)

CONCLUSION

- Including cost considerations steel is the best performer and Aluminum is second. They are most extensively used as structural materials.
- Other materials: used in spot applications.
- Multimaterials concept: challenge for assembly and corrosion, which has been solved in several cases.

Ashby plot, available at https://www.lehigh.edu/~intribos/Resources
2. 
NIOBIUM IN STEELS
**STRENGTH AND DUCTILITY: INVERSE RELATION**

**Option:**

Grain refinement increases strength without loss of ductility. Niobium: key effect in refining the grain of steels.
NIobiliUM IN STEELS FOR AUTOMOTIVE INDUSTRY

✓ Makes a lightweight design of vehicles a reality
✓ Increases steel strength and toughness
✓ Allows car body structures to be lighter
✓ Improves crash safety.

300 grams of niobium in the steel of a mid-size car

Reduces its weight by 200 kilograms

Results in fuel economy of one liter per 200 kilometers driven, and much lower emissions (increase efficiency in 0.6 to 1.5 km/l)
MANUFACTURING ABILITY

- Trip: complex manufacturing process
- DP: difficult local formability (forming defects)
- Martensitic (PHS): instability in process (furnace and limited ductility)
- Twip and Austenitic: high alloy content and cost challenges
- 3rd Generation: in development

SUMMARY:
Niobium increases strength and toughness simultaneously, enabling high strength steels with good formability or process reliability.
EXAMPLE 1:
HIGH STRENGTH LOW ALLOY STEELS (HSLA)

Typical composition:
0.05-0.09%C, 0.02-0.05%Nb, others: Mn, Si, Ti, V

Strength and ductility range (reference figures):
YS: 260 MPa-550 MPa
Elongation (ef): 16%-28%

Compared to mild steels, the alloy balance of HSLA steels is based on the reduction of carbon content to improve toughness and weldability.
EXAMPLE 2: DUAL PHASE STEELS

REDUCTION OF CRACKS

Bendability test demonstrating that the niobium modified DP steel can be submitted to tighter angles before fracture. The images show results after bending to more than 90 degrees, with cracks in the conventional steel but not in the niobium modified steel.

Source: H. Mohnbacher. Intl Symp. on New Developments in Advanced High-Strength Steel Sheets, AIST, 2013, p. 329-329

Typical composition: 0.07-0.20%C, 0.01-0.03%Nb, others: Mn, Si, Cr, Mo

Strength and ductility range (reference figures):
YS: 450 MPa-1,100 MPa  Elongation (ef): 5%-25%

BETTER BENDABILITY

GRAIN REFINING + LOWER C:
MUCH HIGHER HE
EXAMPLE 3: PRESS HARDENED STEELS

Typical composition:
- 0.15-0.25% C, 1.0-1.4% Mn, 0.02-0.04% Nb, others: B, Cr, Mo, Si

Strength and ductility range (after heat treating – final condition):
- YS: 1,000 MPa - 1,900 Mpa
- Elongation (εf): 5%-10%

Niobium controls grain growth during heating to press-hardening, leading to better bendability. In addition, Nb nano carbides decrease the mobility of H, reflecting in better resistance to hydrogen embrittlement.
EXAMPLE 4: GEAR STEELS

FINER GRAINS / POSSIBILITY HIGH T CARBURIZING

Niobium control in grain growth is more effective than Al, leading to:

i) smaller grain size and
ii) lower amount of Al inclusions.

Both factors lead to better fatigue life.

OTHER ADVANTAGES:

~30% less distortion
~10 to 20% better fatigue
+ cleanliness effect

+ Nb
+ Ti
3. NIOBIUM IN ALUMINIUM
NIOBIUM IN ALUMINIUM CAST PARTS

BACKGROUND


MAIN APPLICATIONS

Gearboxes
Cylinder Heads
Engine blocks
Wheels
EXAMPLE 5: IMPROVING CASTABILITY OF HIGH Si ALLOYS

NIOBIUM ADDITION CREATES FINE AND UNIFORM GRAIN STRUCTURE

- Improving strength
- Reducing casting defects and shrinkage porosity
- Consistent across thin and thick sections

ENABLES LIGHTWEIGHTING
EXAMPLE 6: IMPROVING MECHANICAL PROPERTIES AND RECYCLABILITY

HIGHER STRENGTH AND SAFETY

MORE TOLERANCE FOR IRON CONTAMINATION

New advanced materials enable car makers to meet constant need to increase efficiency and safety whilst cutting cost and increasing performance.

Niobium steels have increased strength in combination with adequate formability (cost) and toughness (safety). Important either for current high strength steels and for new steels under development.

In Aluminum cast alloys, Niobium can reduce casting defects and potentially increase mechanical properties and recyclability:
- Enabling use of cast Aluminum alloys in new applications
- Large scale production of Aluminum cast parts