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Nb alloyed press hardening steel with improved properties for crash performance

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Reporter: Bian Jian

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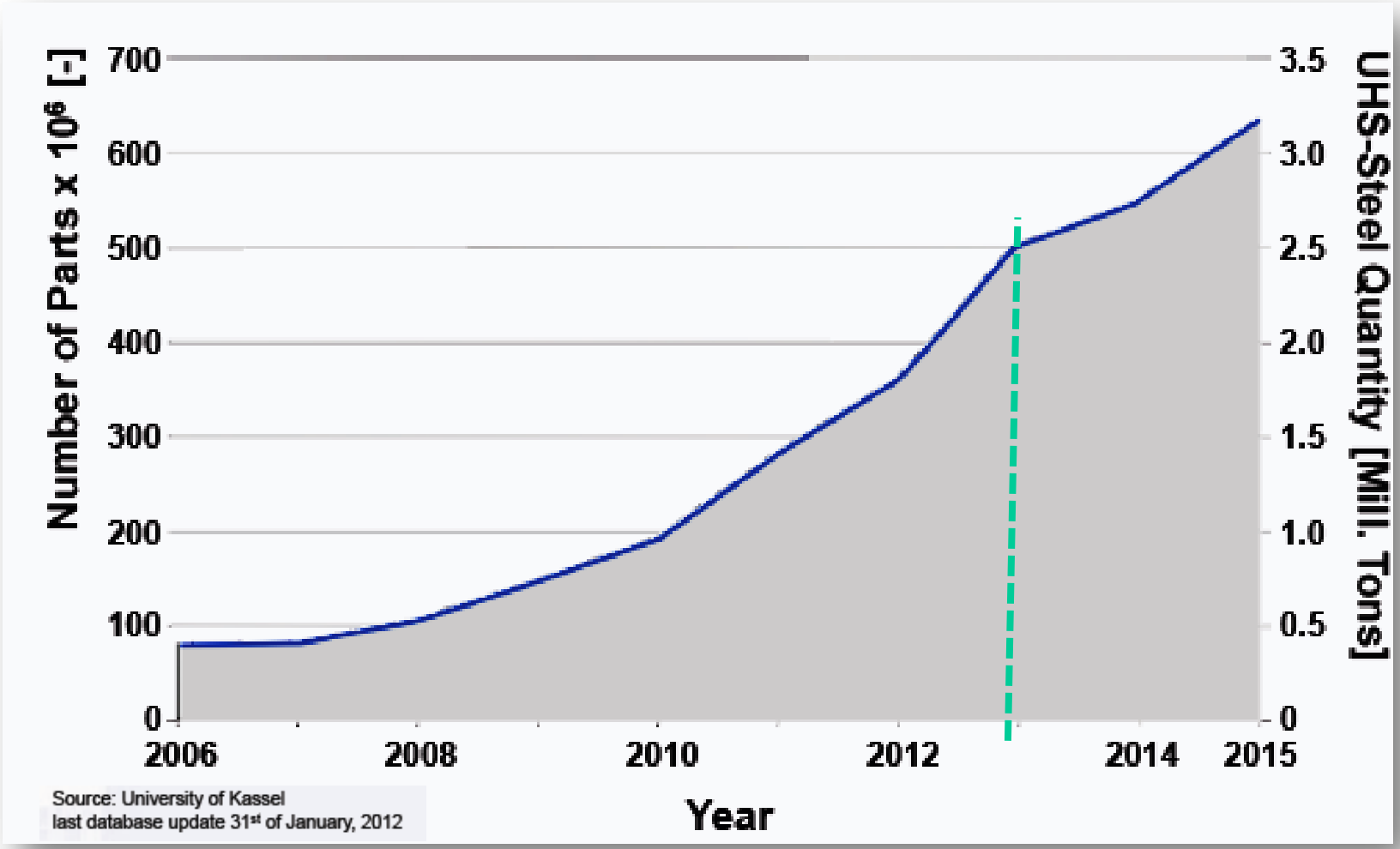
- State of art in press hardening
- Why to develop new press hardening steels?
- Metallurgical concepts
- Major results
- Application examples

PHS has increased steadily in production capacity



With gram improves ton (Nb alloyed steel)

PHS has increased steadily in BIW application

FIAT Alfa Romeo
MiTo 2008
14% PHS

Porsche
Panamera 2009
16% PHS

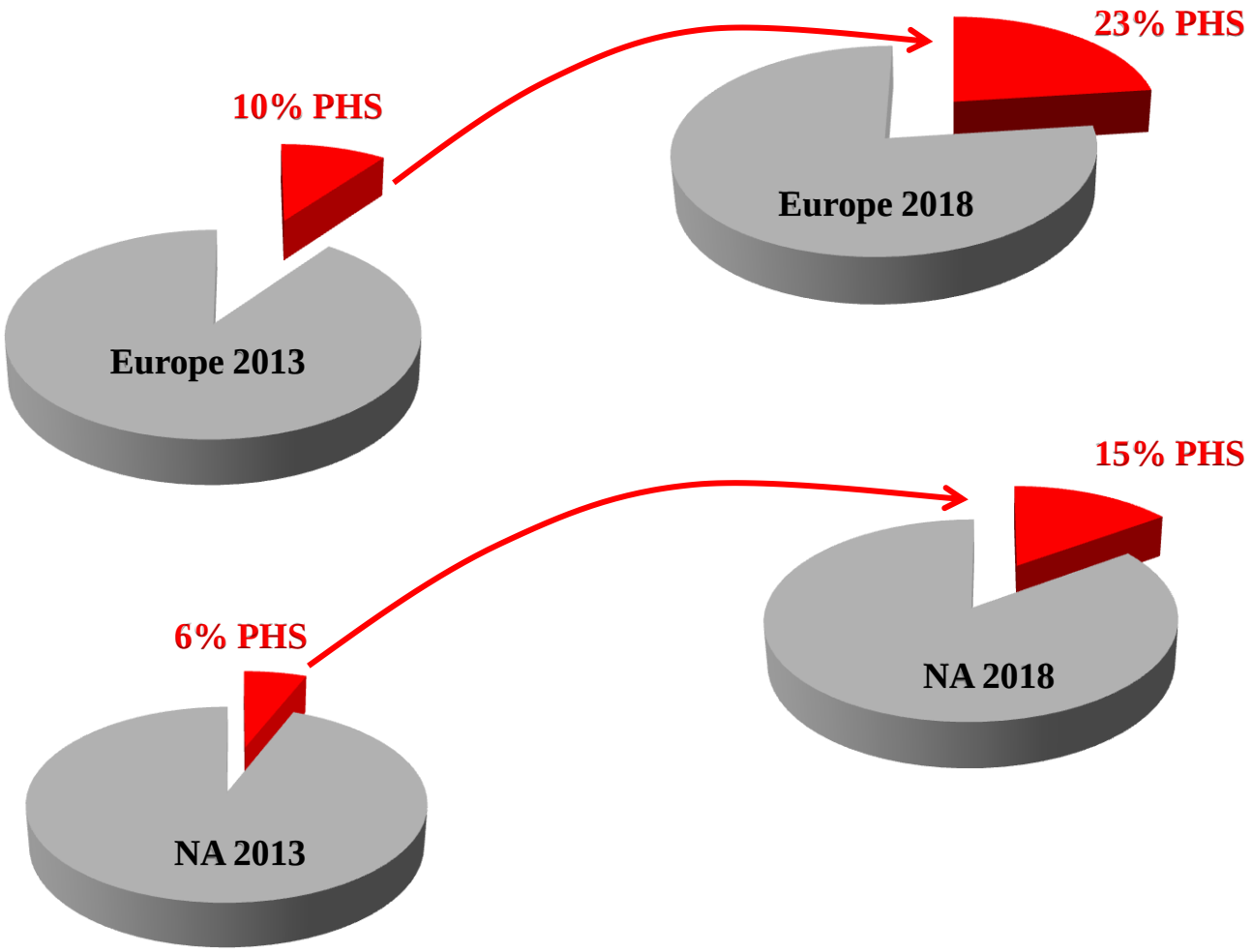
VOLVO
V60 2010
18% PHS

Golf-VII-2012
28% PHS

VOLVO
XC90-2015
40% PHS

With gram improves ton (Nb alloyed steel)

PHS has high potential for future application



We must get ready for the challenge!

Why to develop new PHS?

Source: VW

- ✓ Control the intrusion
- ✓ Protect passengers

Source: Volvo

PHS is mainly used to strengthen passenger compartment

Why to develop new PHS?

- ✓ Control the intrusion
- ✓ Protect passengers

	Constant sheet with patch	TRB	CFK + TRB
			
weight [kg]	7.3 kg	6.3 kg	5.4 kg
Δ weight/ vehicle[kg]	-	2.0 kg	3.8 kg (1.8 kg)*
Δ weight [%]	-	14 %	26 % (14 %)*

Due to limited formability PHS will fracture if the impact load is beyond the fracture resistance

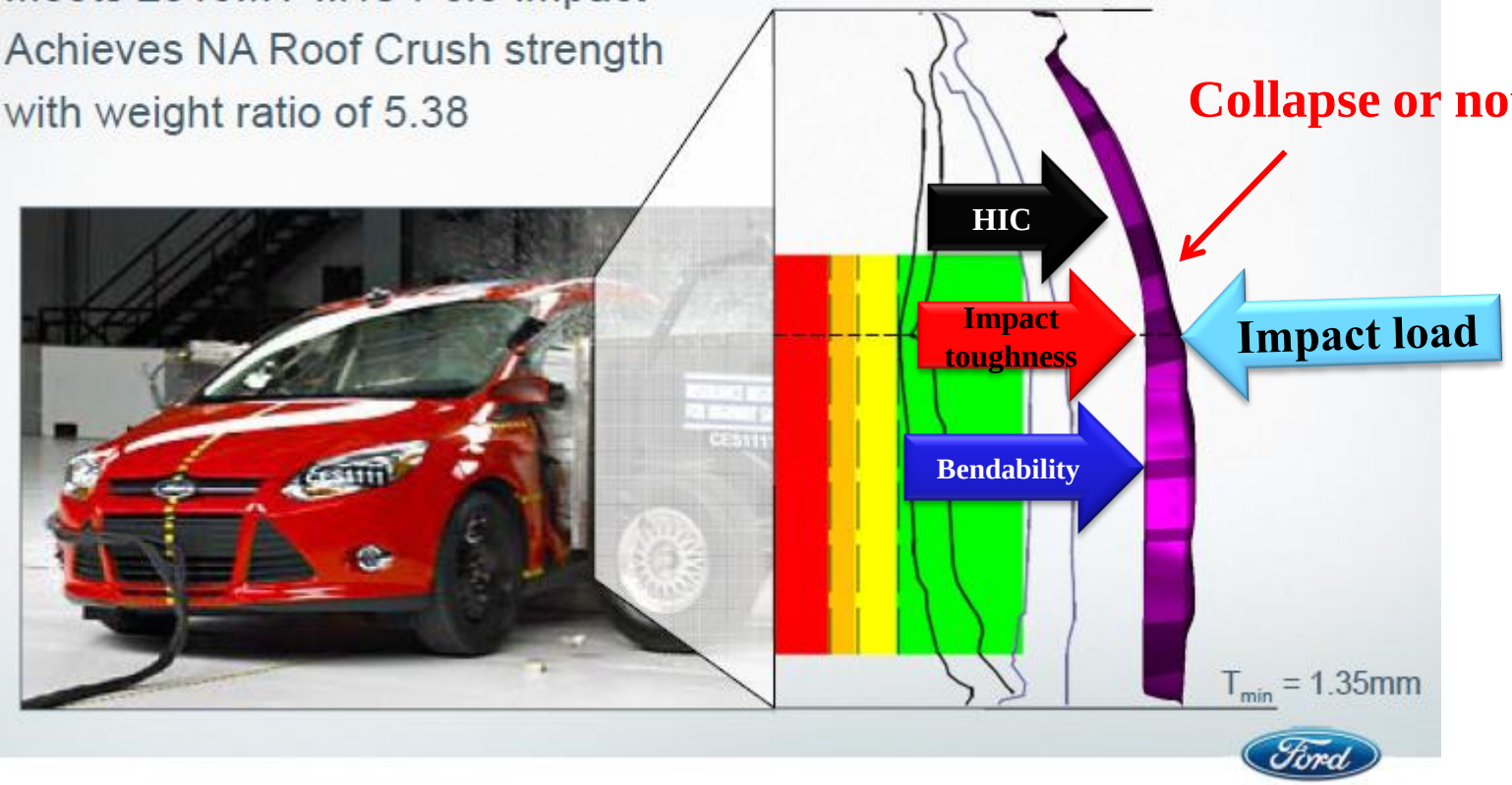
Source: Mubea

Why to develop new PHS?

Safety - IIHS Side Impact

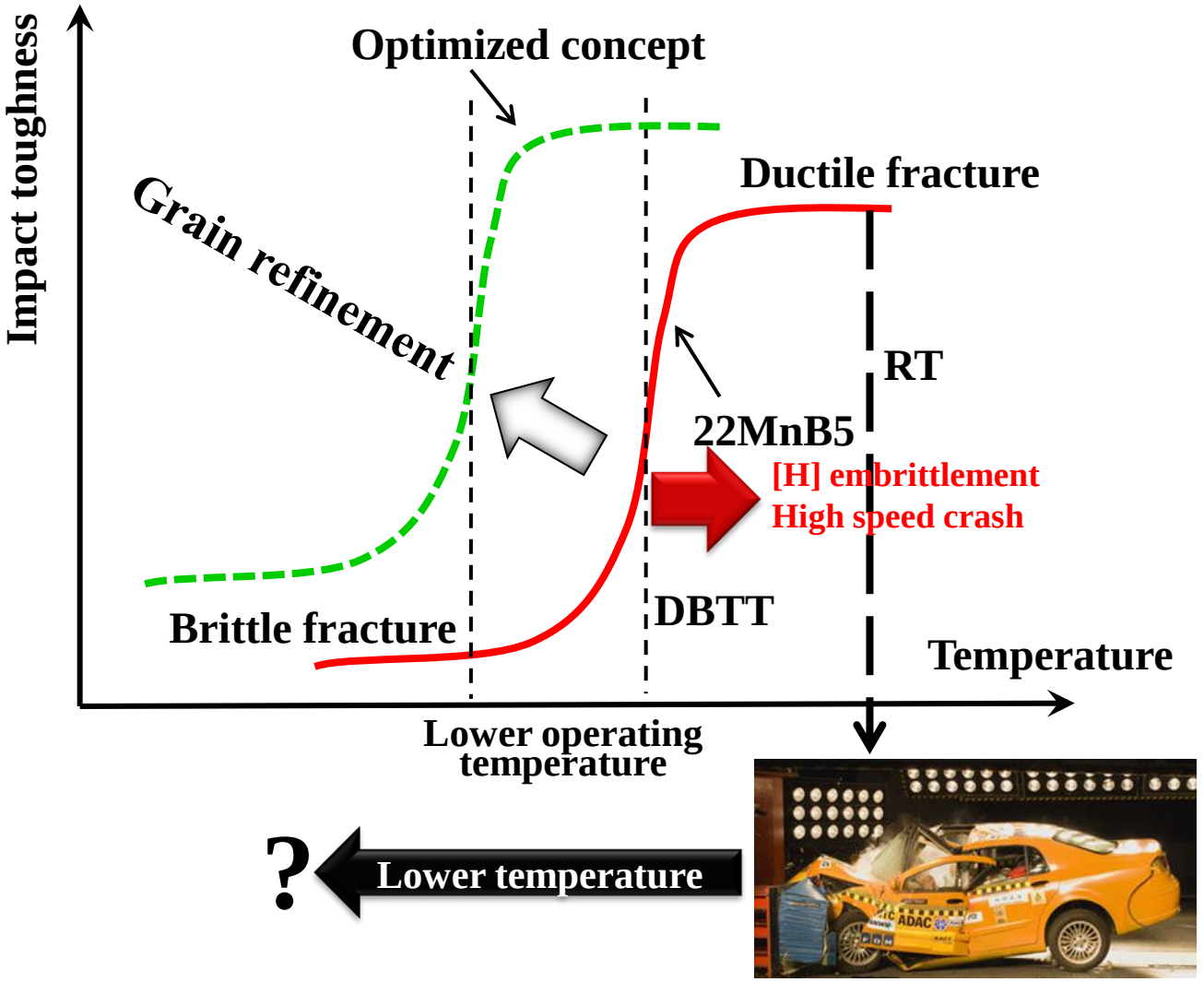
22MnB5

- IIHS 'Top Safety Pick' rating
- Meets 2013MY IIHS Pole Impact
- Achieves NA Roof Crush strength with weight ratio of 5.38



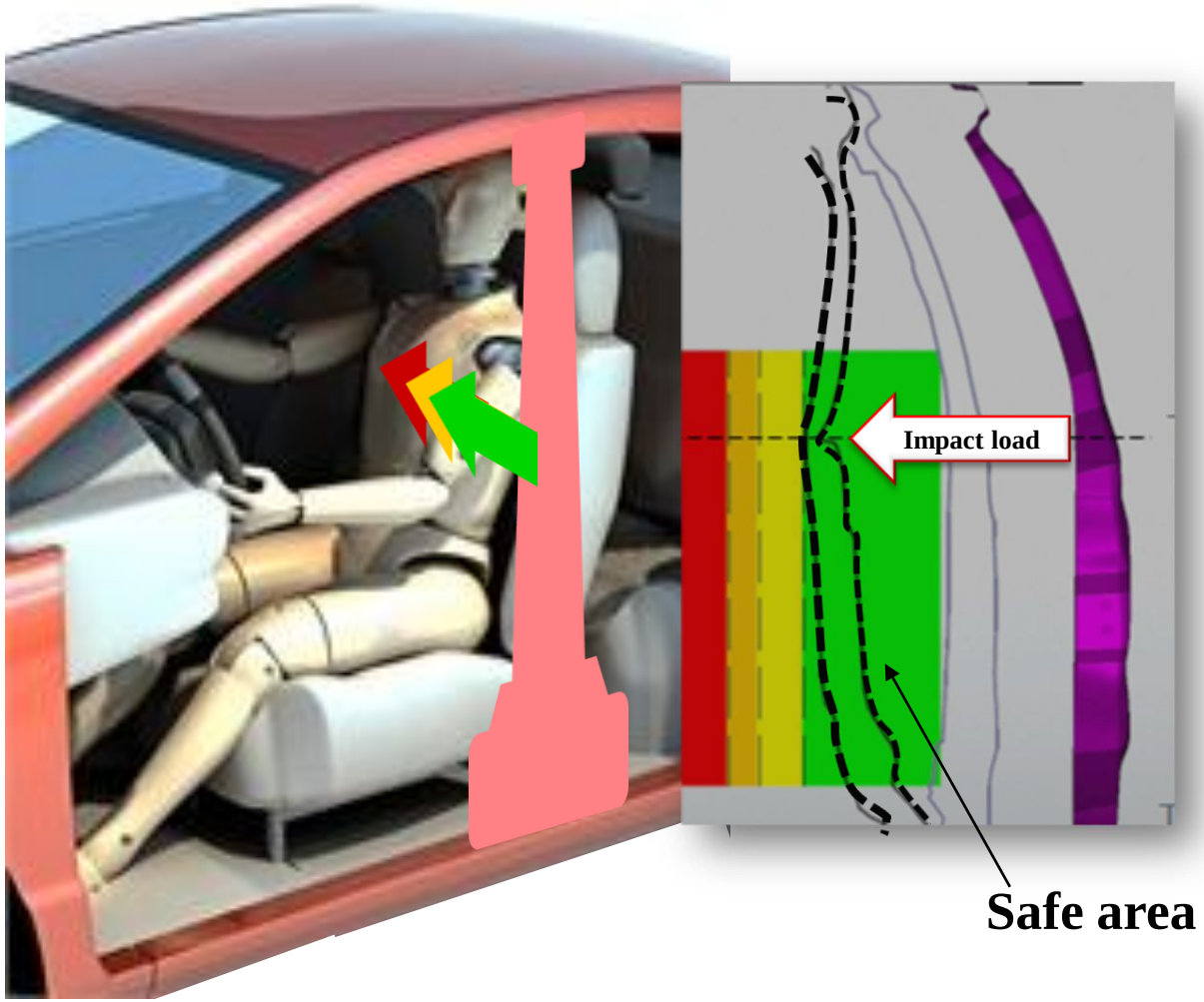
It is important to improve these material properties to make sure that B-pillar will not collapse in the crash situation under severe conditions (high speed, low temperature and [H] embrittlement)

Toughness property is important for the crash performance of press hardening steel

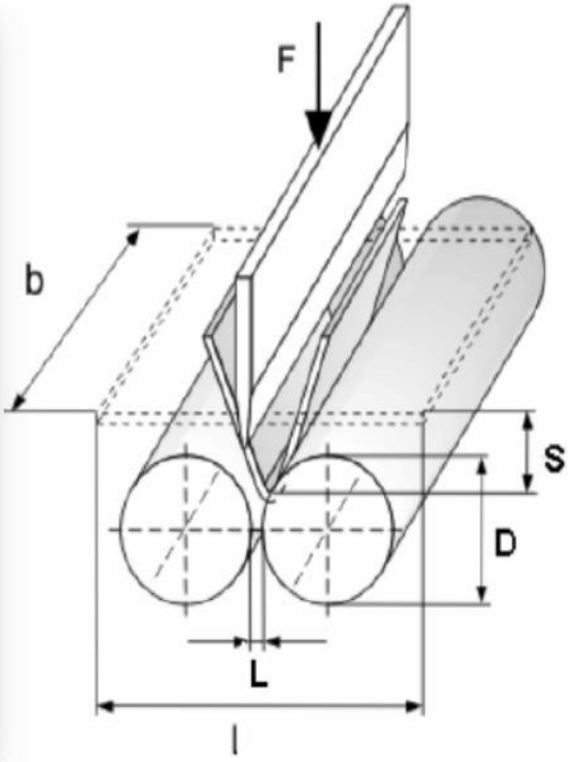


With gram improves ton (Nb alloyed steel)

Importance of bendability to crash behavior



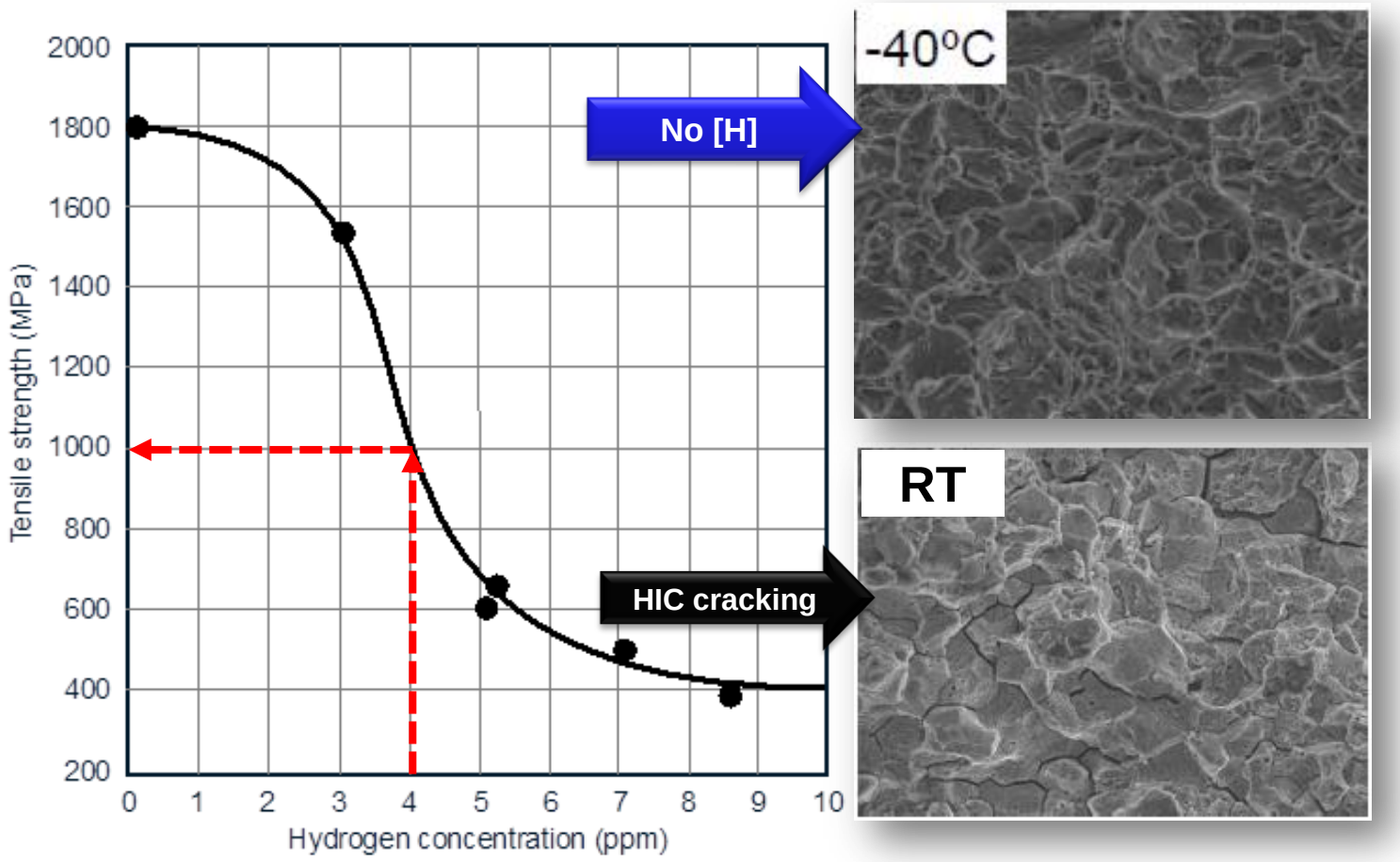
3-point-bending test



VDA-238-100

Sufficient bending angle to absorb crash energy without fracture

Hydrogen induced cracking can cause severe damages to PHS

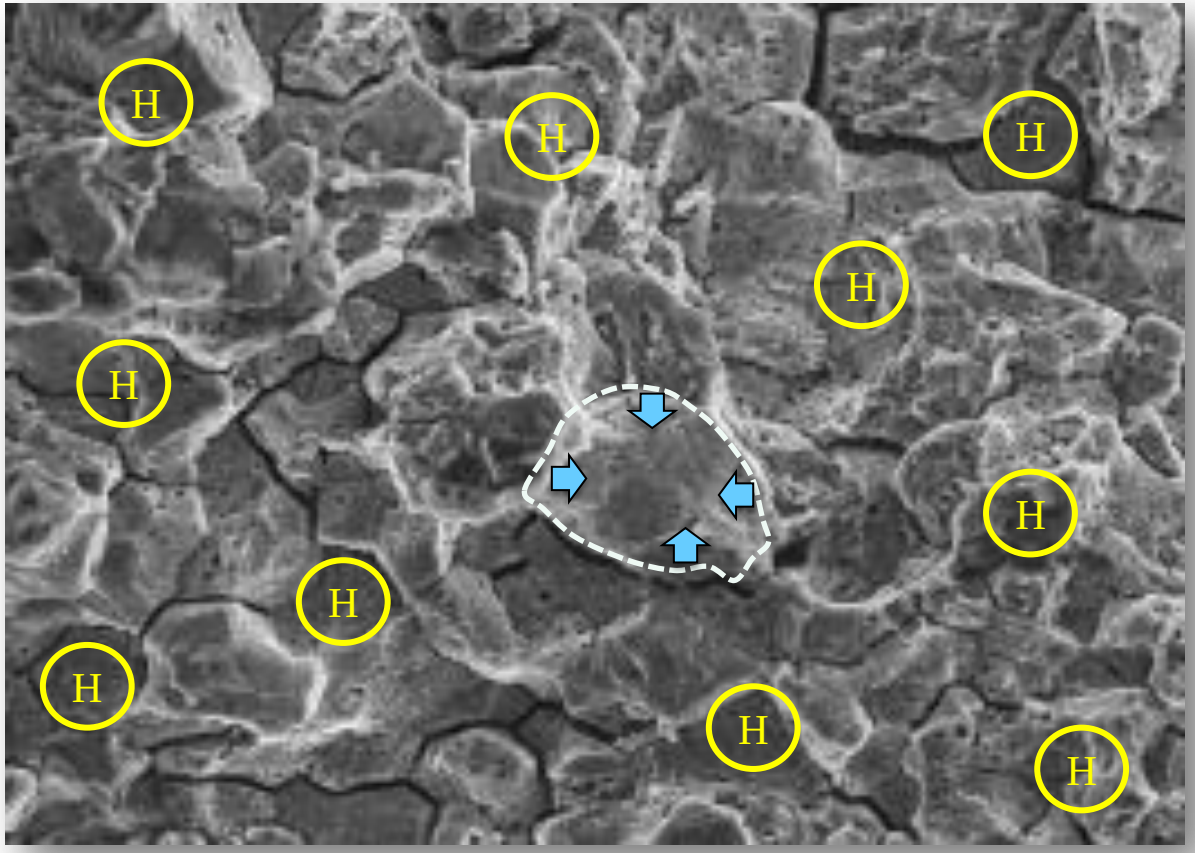


Source: G. Lovicu, el. at

Metallurgical solutions to improve crash performance of PHS

Nb metallurgy

- ✓ Grain refinement to improve the toughness
- ✓ [H] trapping to improve the cracking resistance



Metallurgical concepts for new press hardening steel

(max. wt.%)	C	Si	Mn	P	S	Cr + Mo	B	Ti	Nb
22MnB5	0.25	0.4	1.4	0.025	0.01	0.5	0.005	0.05	n.a.
Concept 1	Adjust to target strength			As low as possible					Add >0.05
Concept 2							No B	No Ti	Add >0.05
Concept 3						Add Mo ~0.15	No B	No Ti	Add >0.05

Concept 1: to provide grain refinement

Concept 2: to avoid large inclusions

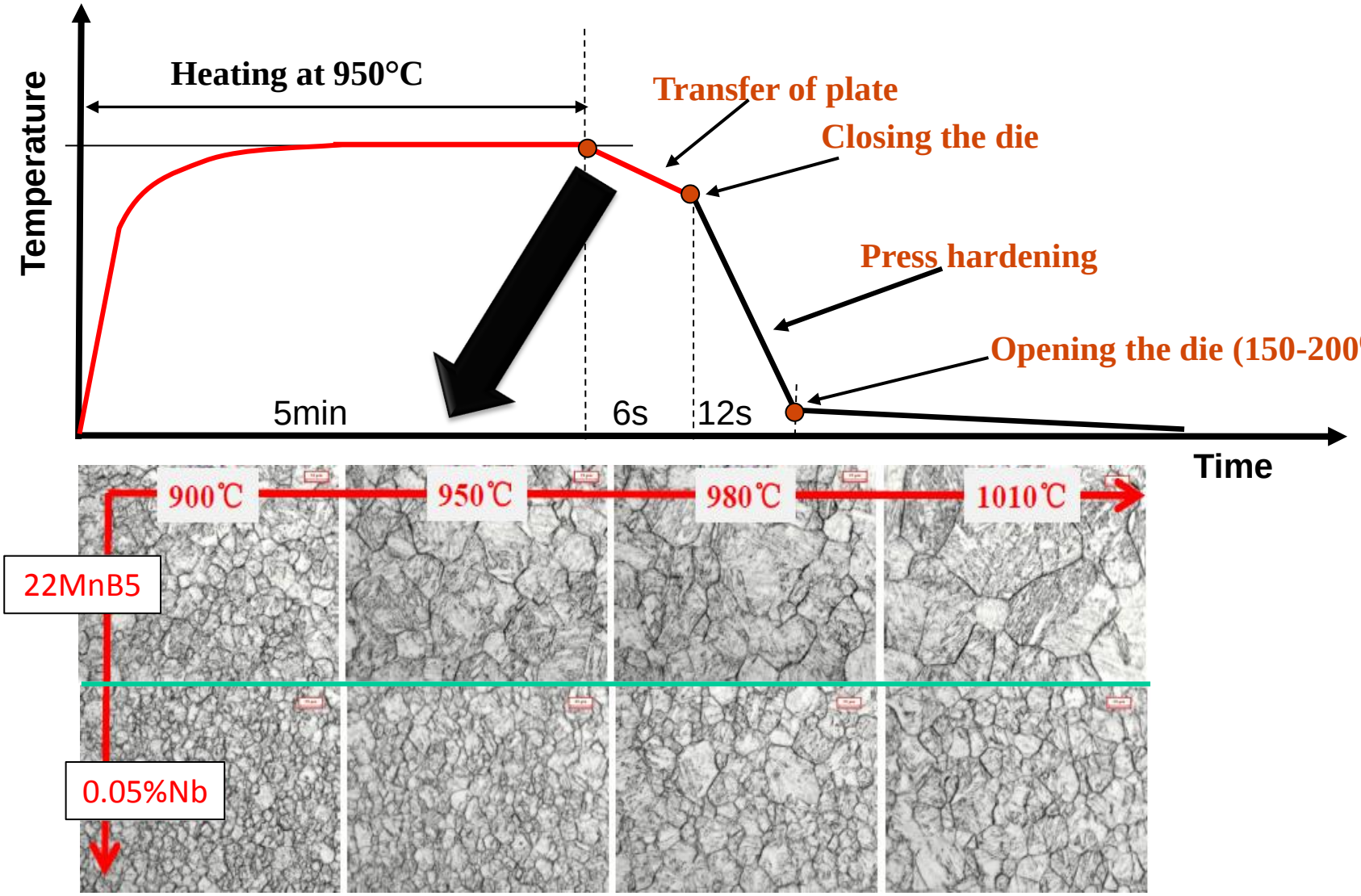
Concept 3: to strengthen grain boundaries of prior austenite

Target of development

- ✓ **Improve the toughness by grain refinement**
- ✓ **Improve the bendability**
- ✓ **Improve [HIC] cracking by hydrogen trapping**

With gram improves ton (Nb alloyed steel)

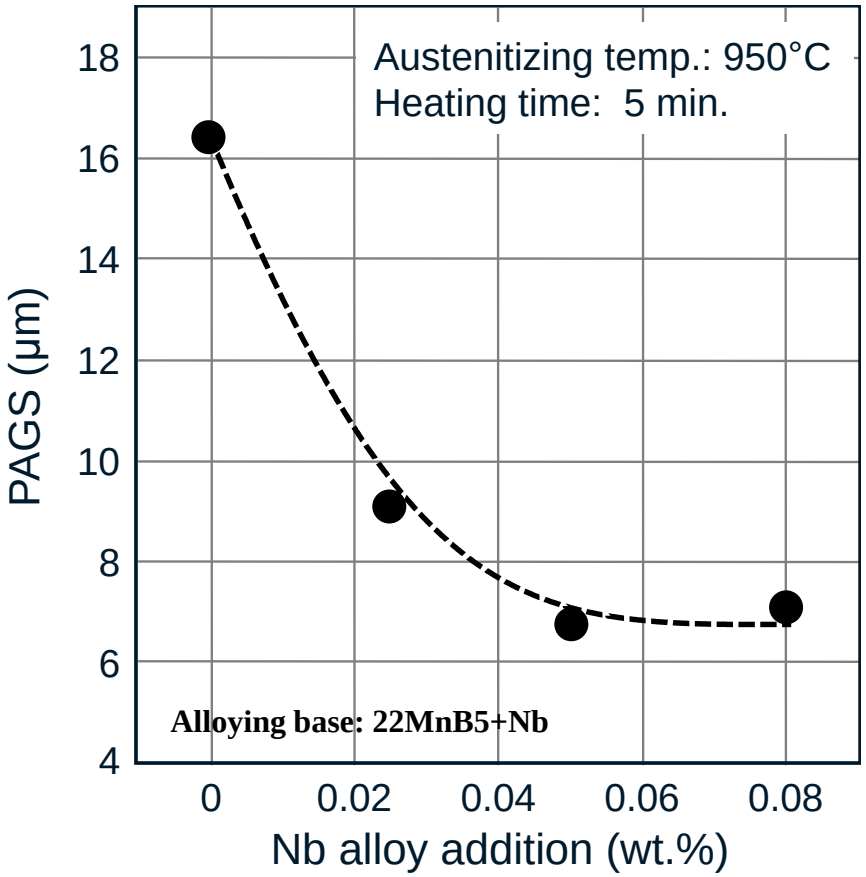
Grain refinement by Nb microalloying for PH process

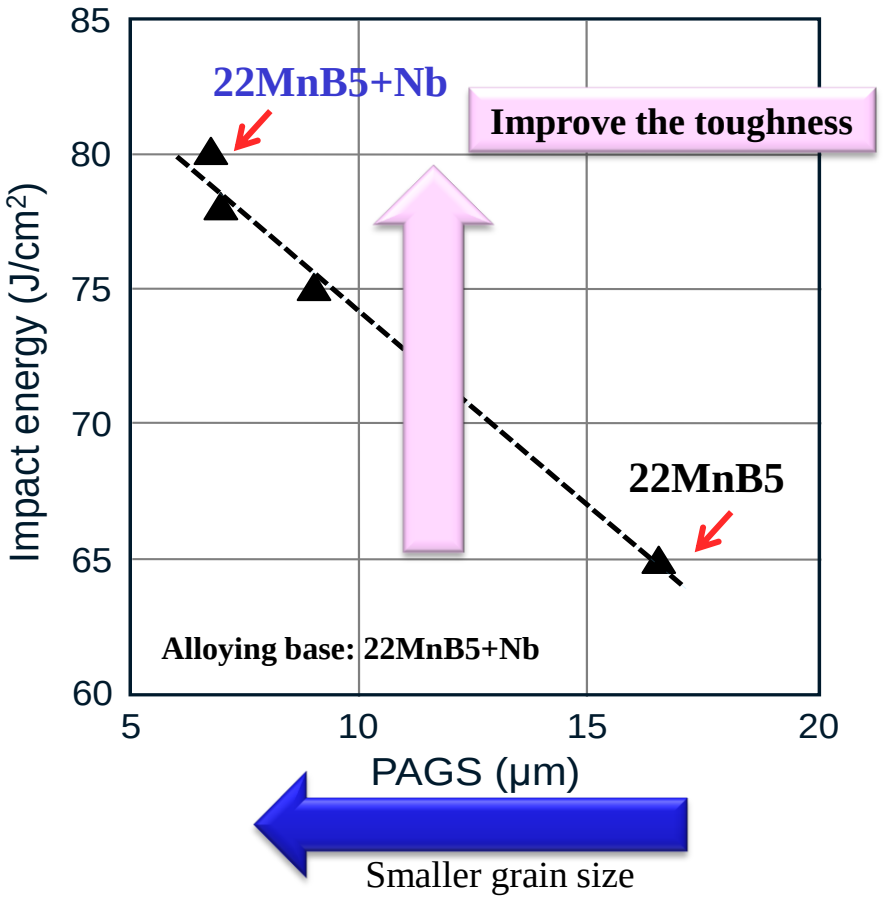


Evolution of prior austenite grain size with reheating temperature

Impact of Nb alloying on PAGS and impact toughness of PHS

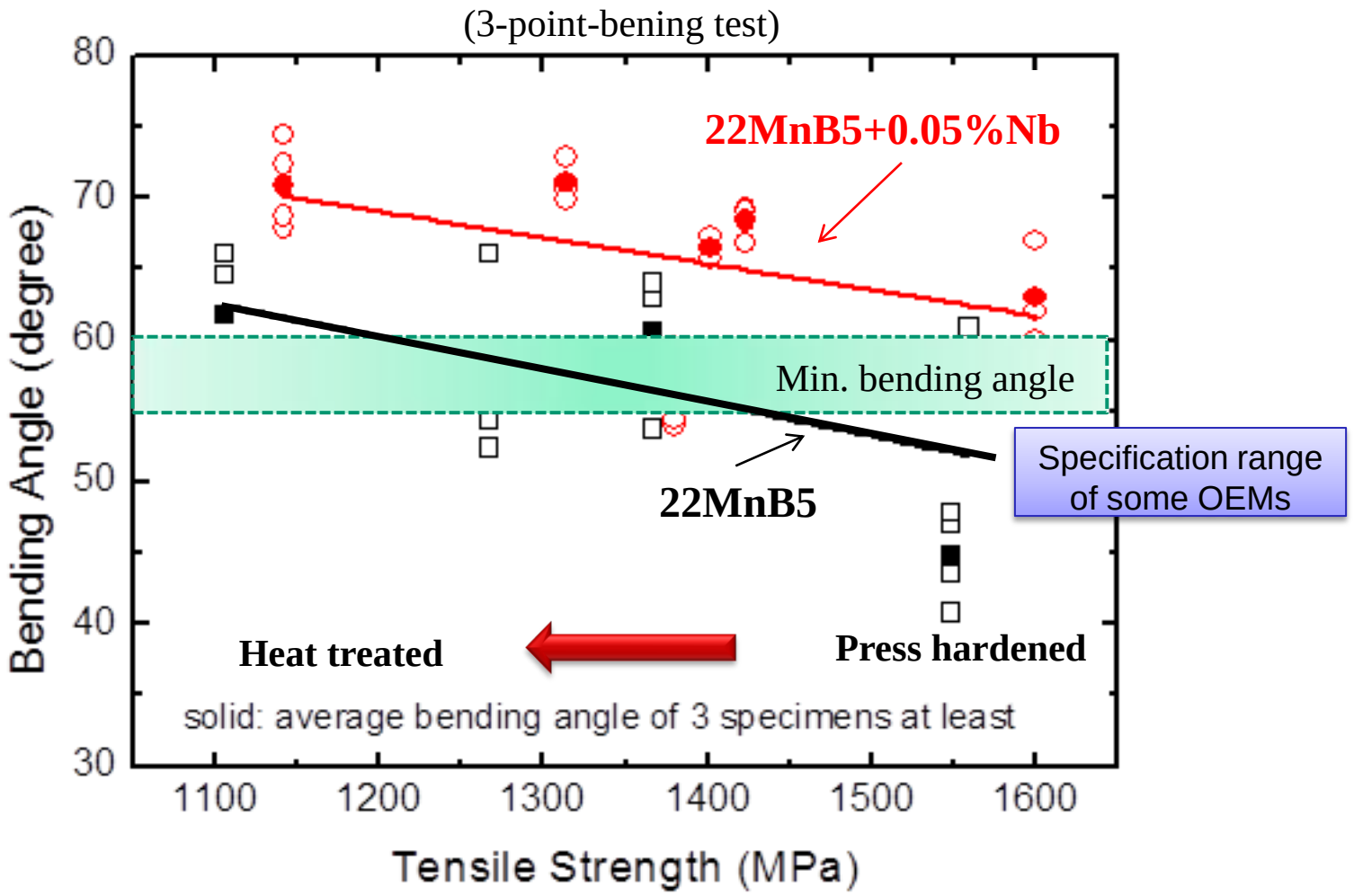
Grain refinement





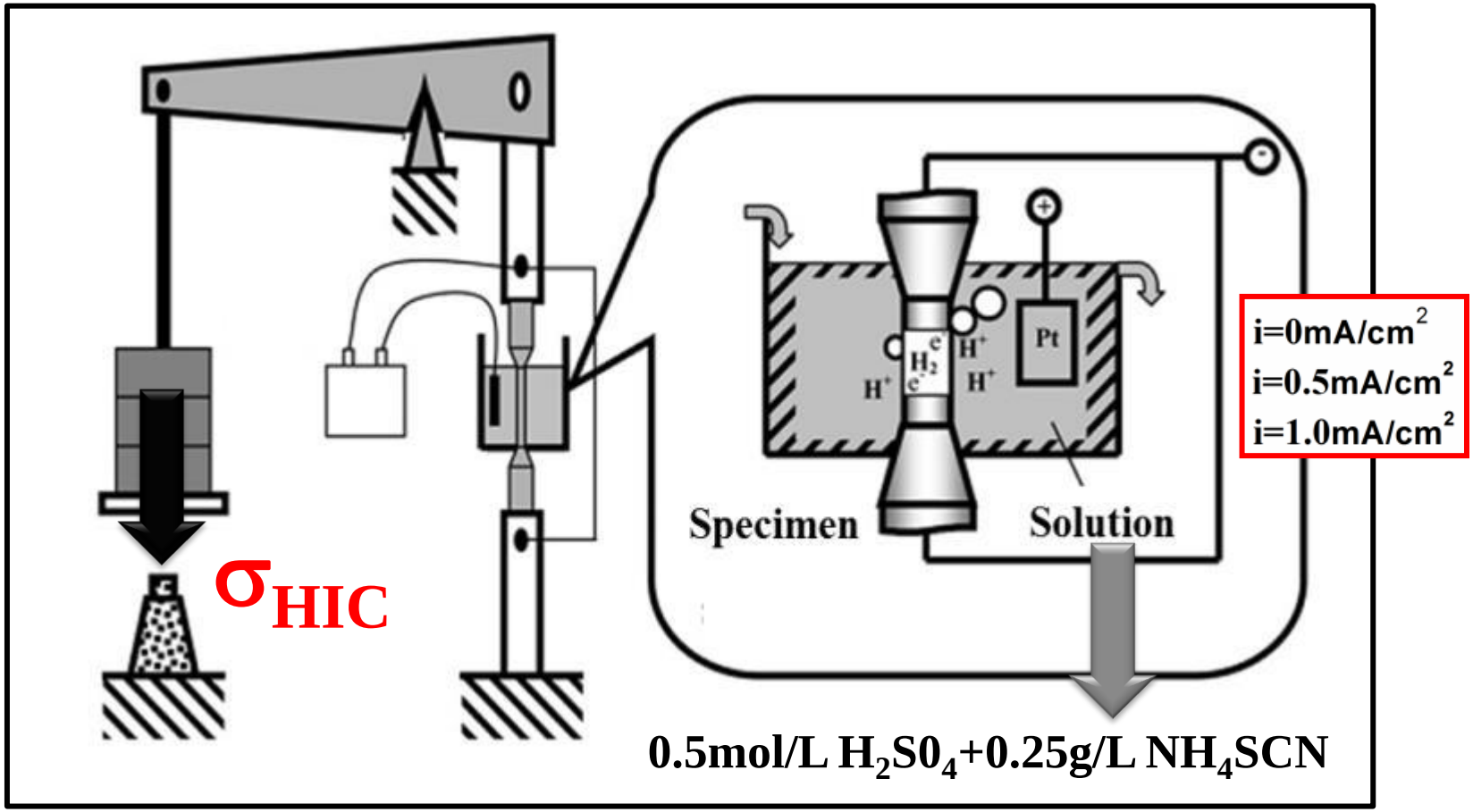
With gram improves ton (Nb alloyed steel)

Improvement of bendability of PHS by Nb microalloying



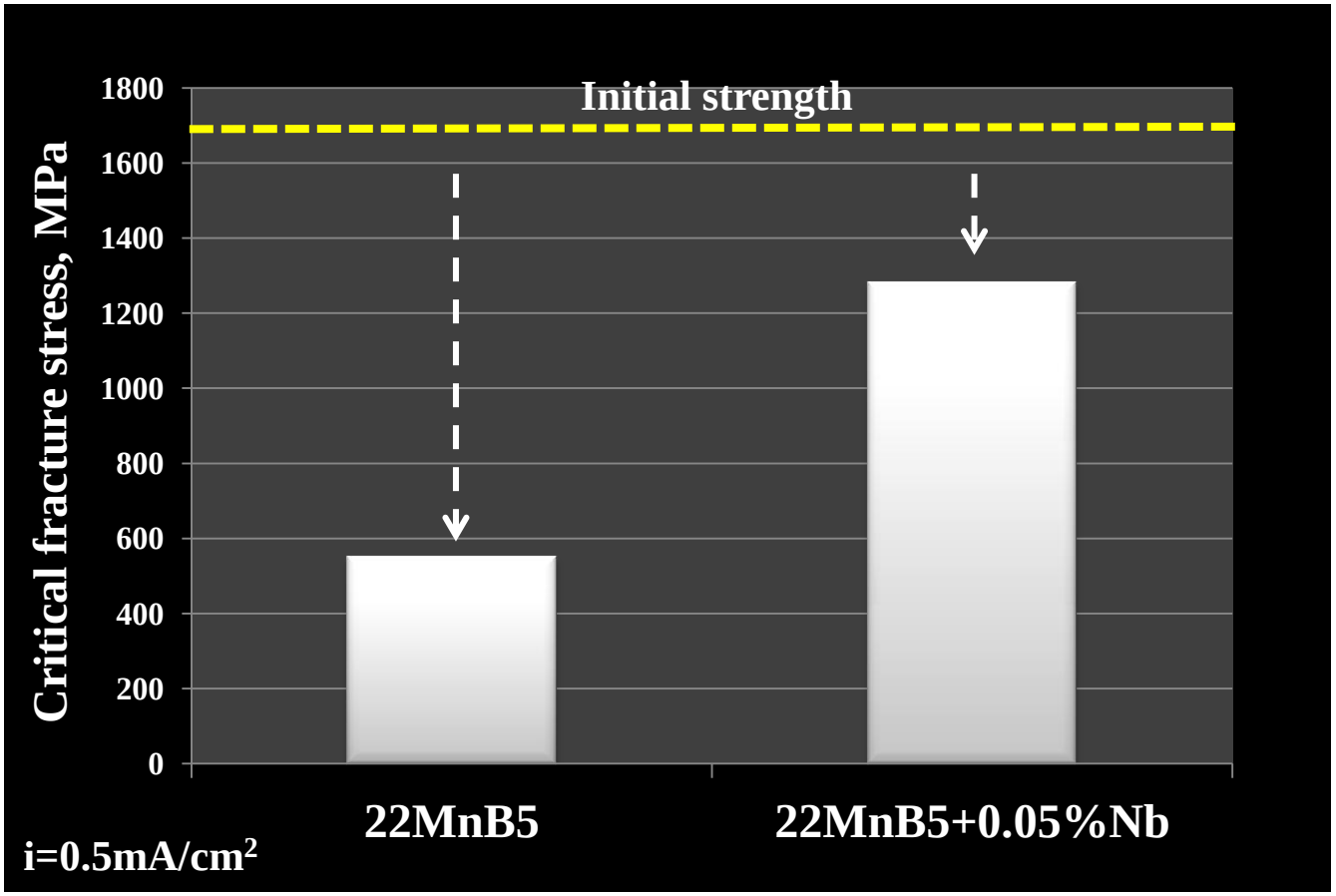
Hydrogen charging test under the constant load

Test target
Investigation of critical fracture stress against HIC induced cracking over 100h [H] charging



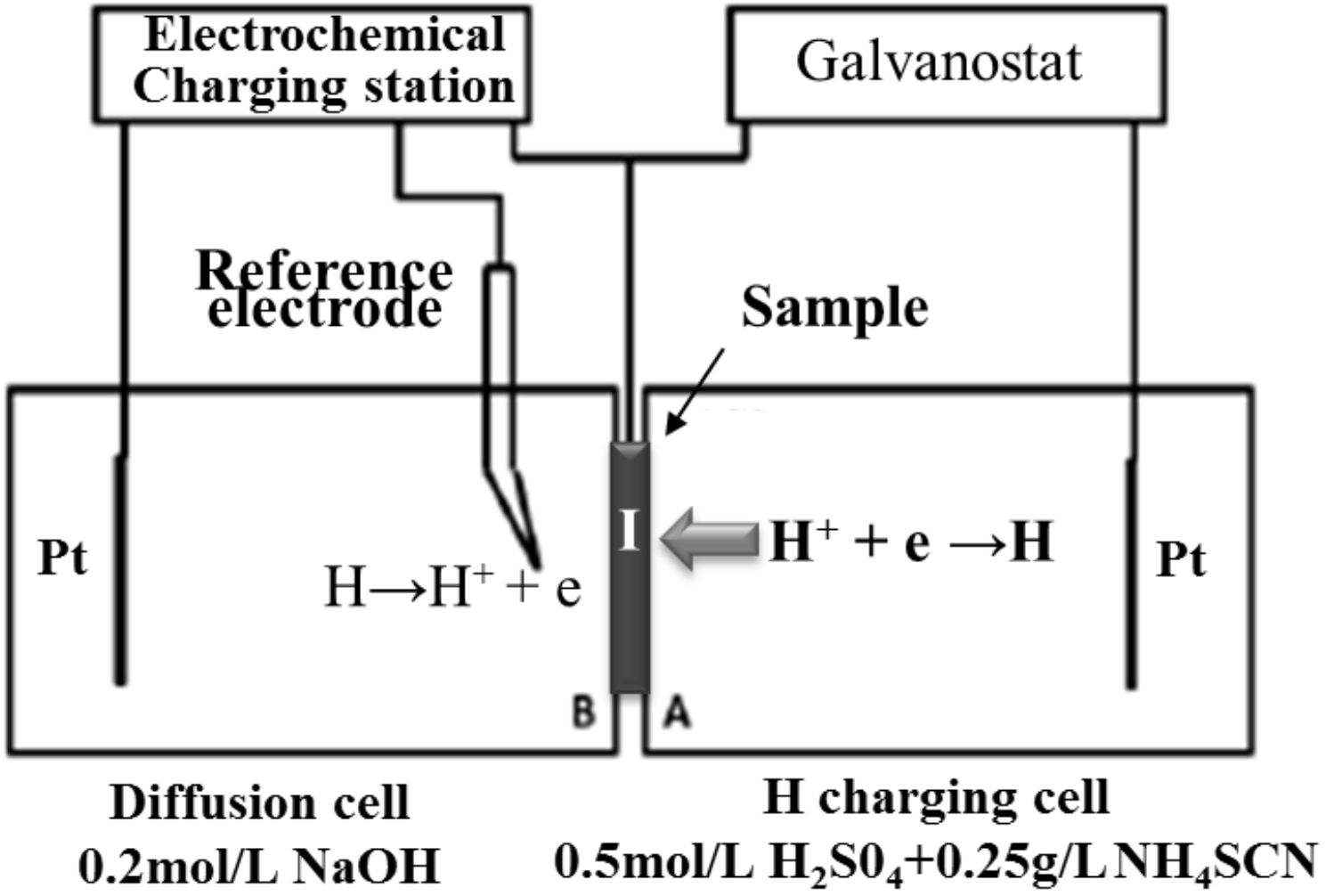
Nb microalloying increases resistance of PHS against [HIC] cracking under the test conditions

σ_{HIC} : Critical fracture stress after 100h [H] charging under constant load

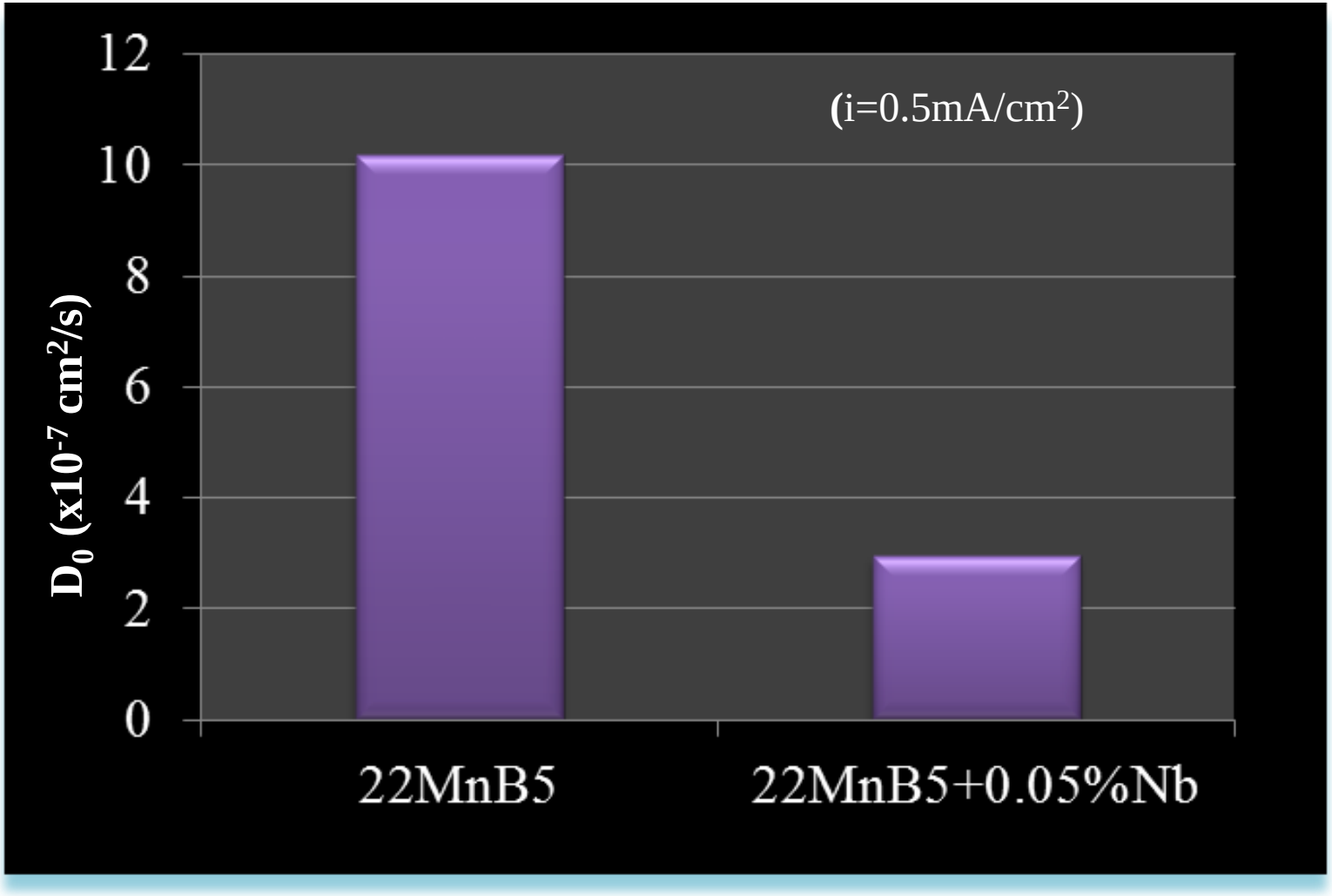


Nb addition makes PHS less susceptible to [H] embrittlement

Hydrogen permeation test



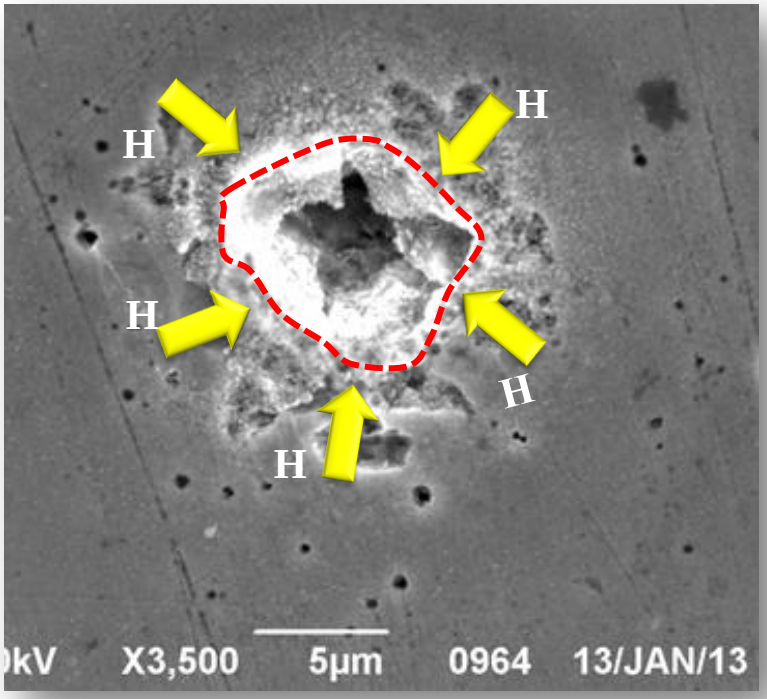
Influence of Nb microalloying on the diffusivity of hydrogen in PHS (22MnB5+Nb)



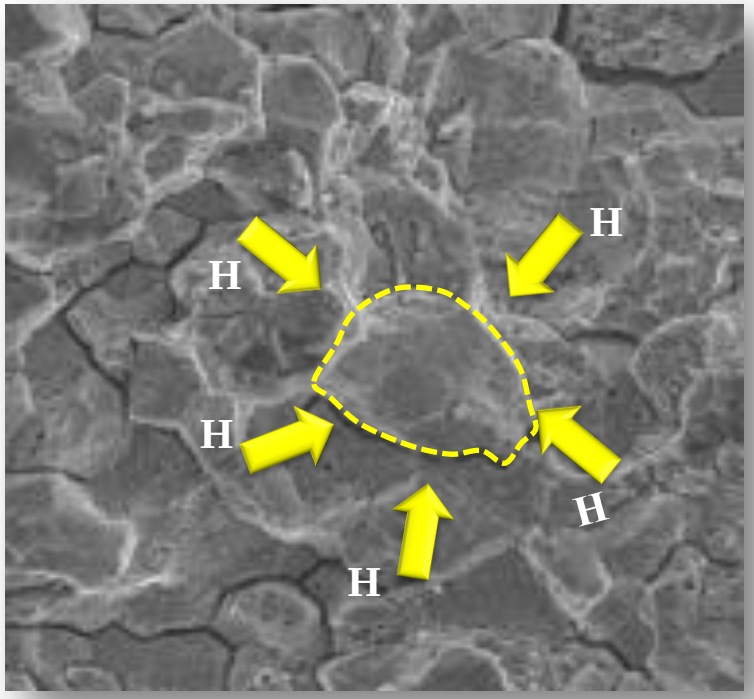
Hydrogen is trapped by Nb precipitates

Mechanism of improvement to [HIC] cracking of PHS by Nb microalloying

Nb microalloying reduces the diffusivity of [H] in the PHS and prevents the segregation of [H] around inclusions and grain boundaries to cause damages

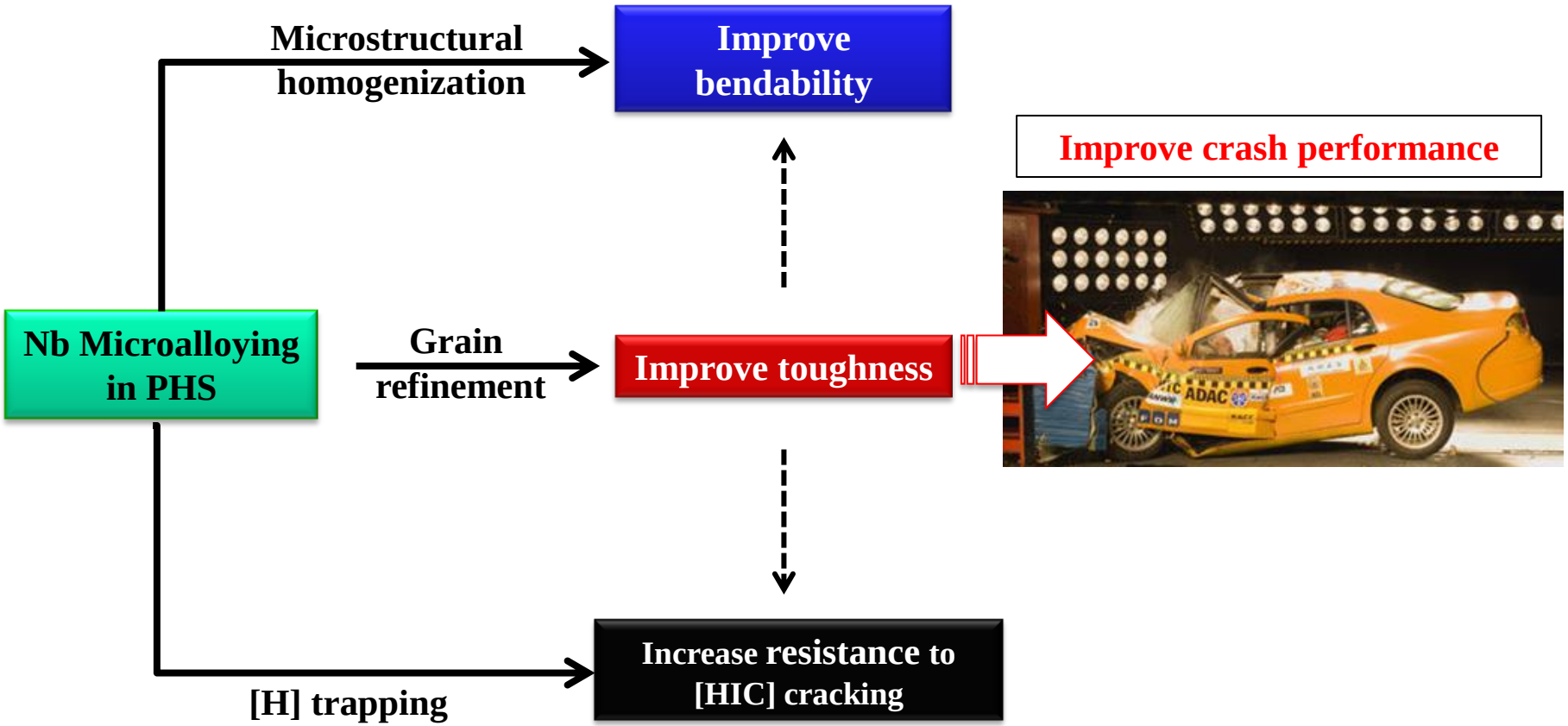


Local damage caused by [H] enrichment



Intergranular fracture caused by [H] embrittlement

Overall improvement of crash relevant material properties by Nb microalloying



With gram improves ton (Nb alloyed steel)

Nb alloyed press hardening steel has become reality

Mark	C	Si	Mn	B	others
1800	0.30	0.2	1.8	0.002	Nb: 0.08%

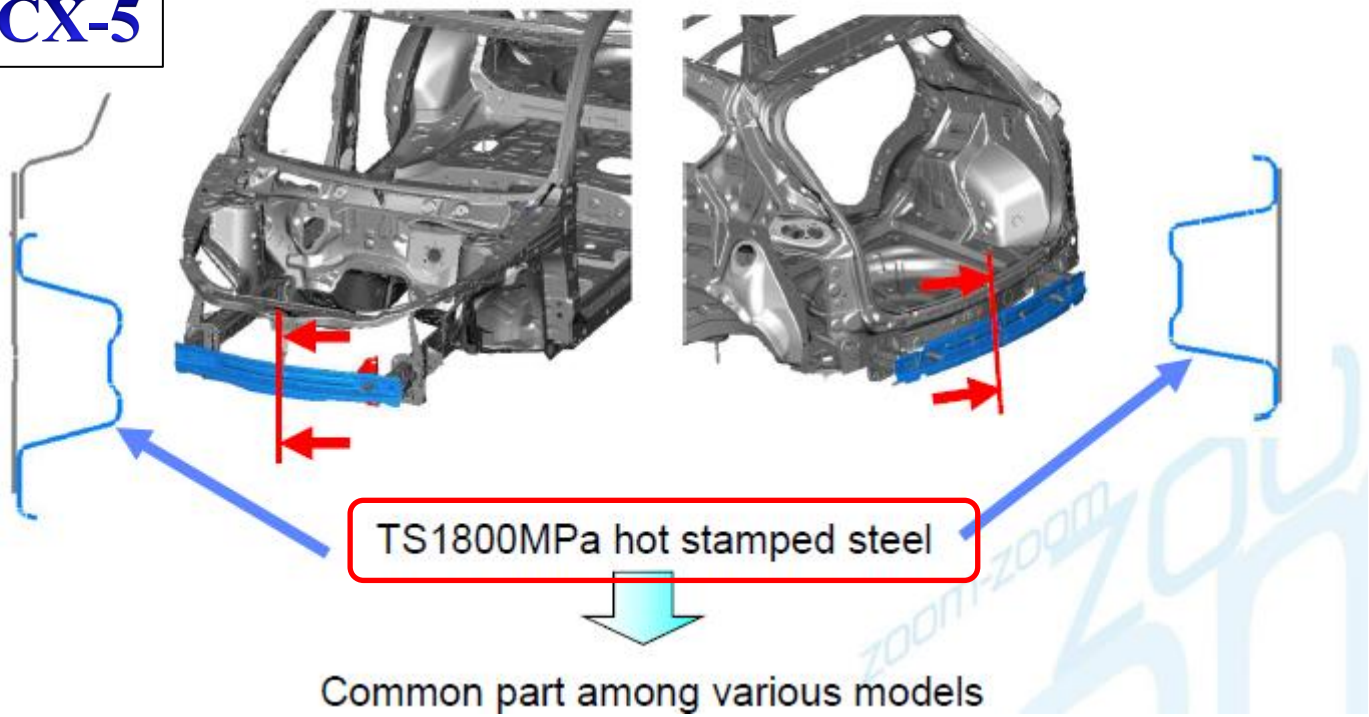
■ **1800MPa Hot Stamped Steel (World's First Mass Production*)**

*according to our own research

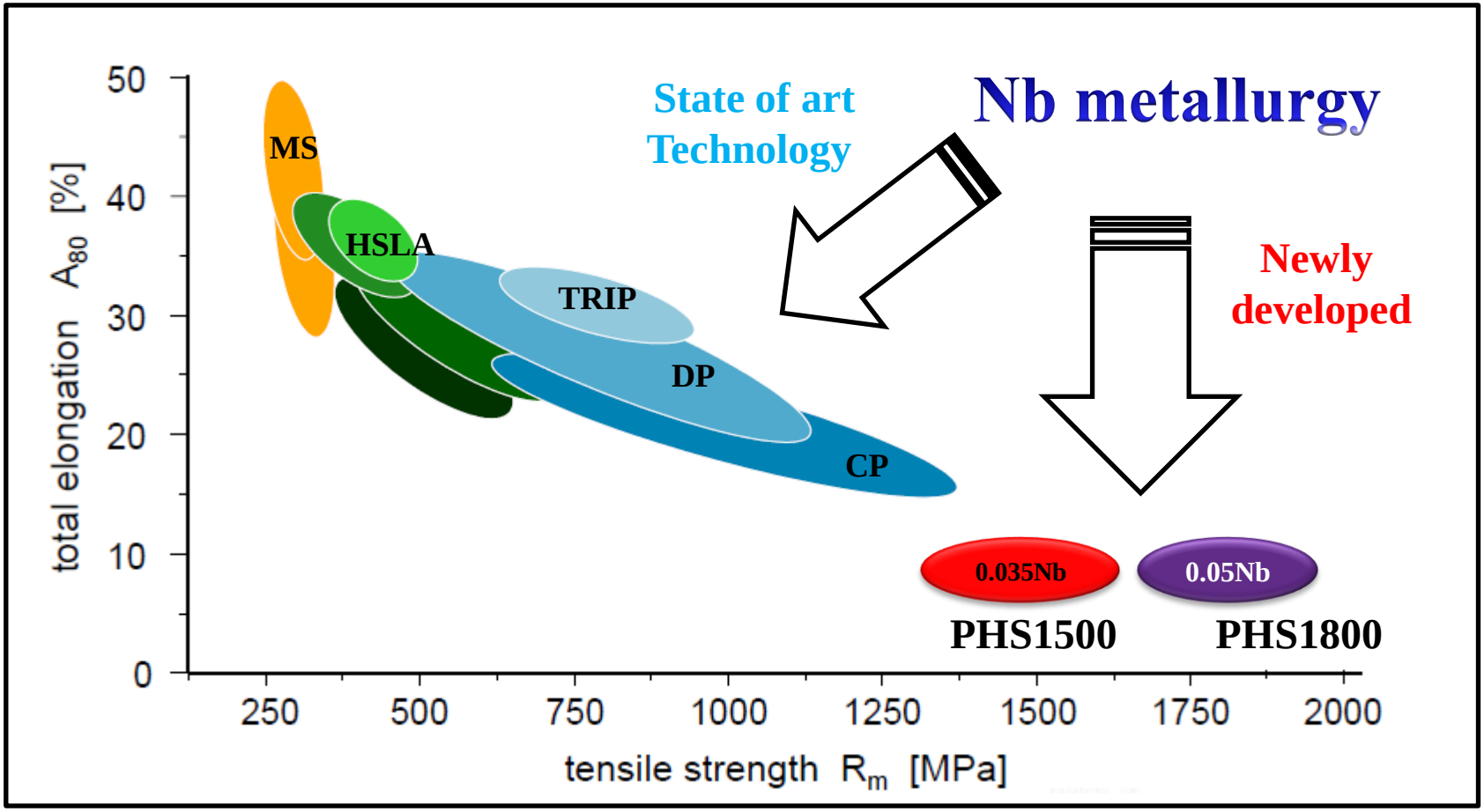
4.8kg weight reduction from current SUV

- 1800MPa hot stamping is applied to front / rear bumper reinforcements

Mazda CX-5



Baosteel made industrial trials to produce Nb alloyed press hardening steels



With gram improves ton (Nb alloyed steel)

Summary

- PHS has high potential in BIW application
- The conventional alloying concept (22MnB5) has high potential for further improvement
- Nb metallurgy can optimize the crash performance of PHS due to improvement in:

  impact toughness
  bendability
  resistance to [HIC] cracking

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Thank you for your atten

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