

# Advanced High Strength Steels (AHSS) in BAOSTEEL

**R&D Centre, BAOSTEEL**  
**June 20, 2014**

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**1. Introduction**

**2. 1<sup>st</sup> Gen AHSS**

**3. New Gen AHSS**

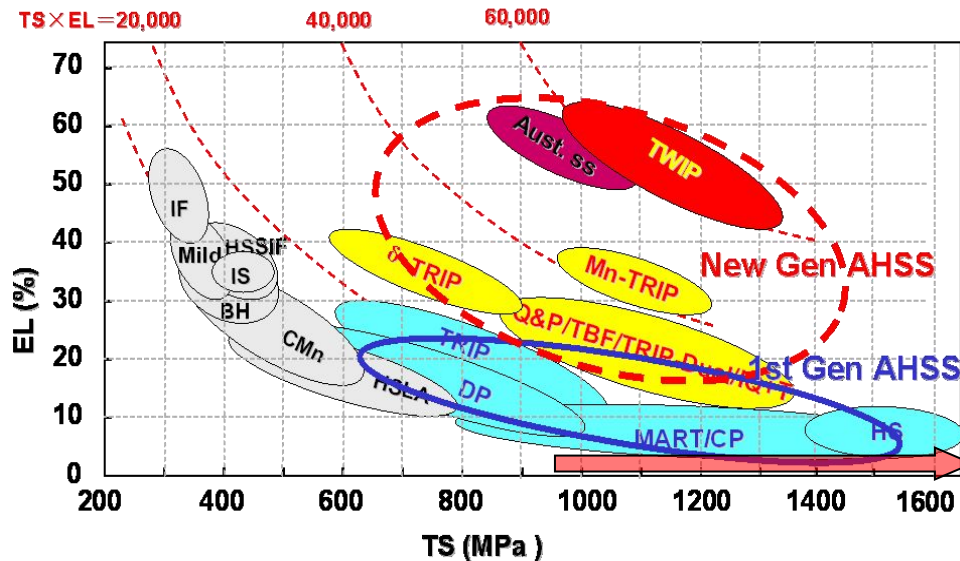
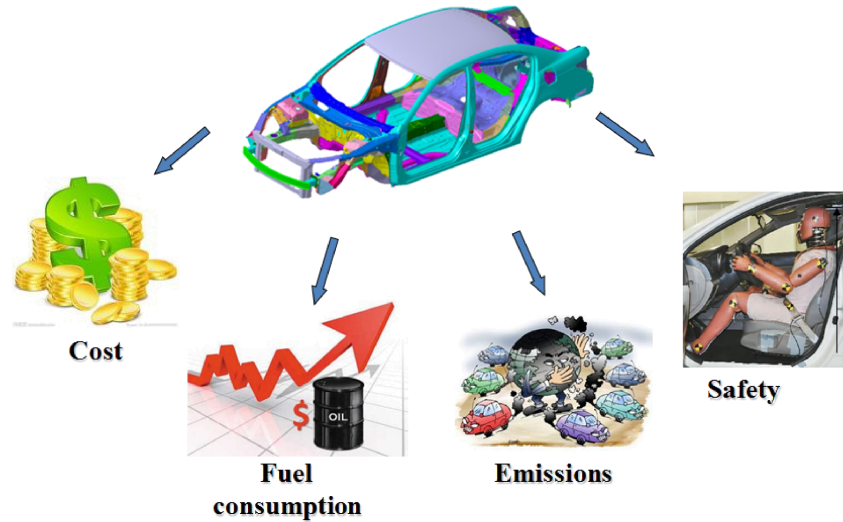
**4. Concluding Remarks**

● **AHSS: one of the most important development directions of automotive materials**

- New materials
- New technologies

● **Focus of R&D:**

- **Materials: Higher strength, better formability**
- **Application technology: Forming, Welding, Painting**



2nd Gen AHSS

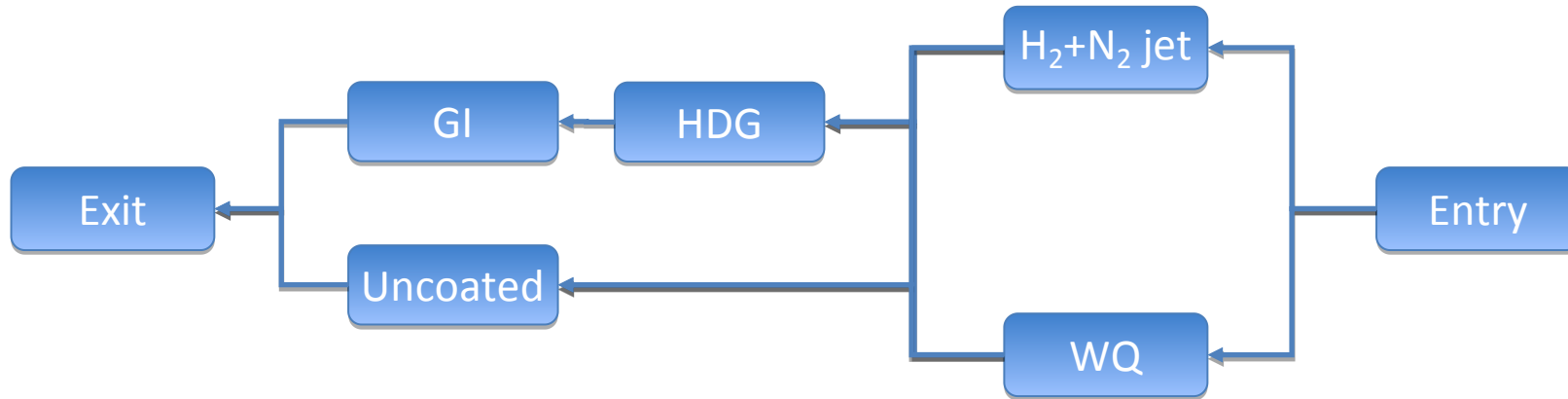
3rd Gen AHSS

1st Gen AHSS



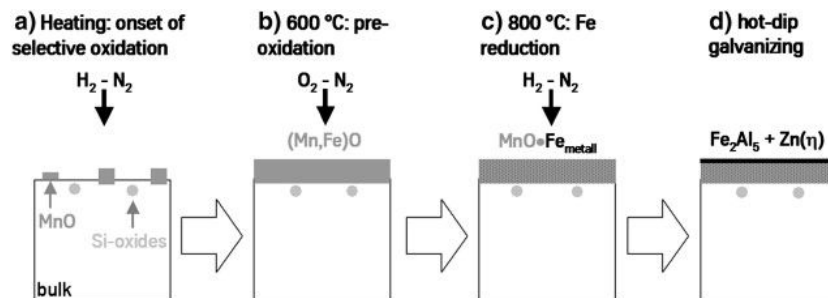
**New Gen AHSS**

# CAL/GI line for UHSS of BAOSTEEL



● **Facility: A specially designed CAL line for UHSS was launched in march 2009**

- **Flexible line: Multi-purpose switch**
  - ✓ **Varieties: Uncoated or GI**
  - ✓ **Cooling medium: H<sub>2</sub>+N<sub>2</sub> or water**
- **Innovative GI technology: pre-oxidation**





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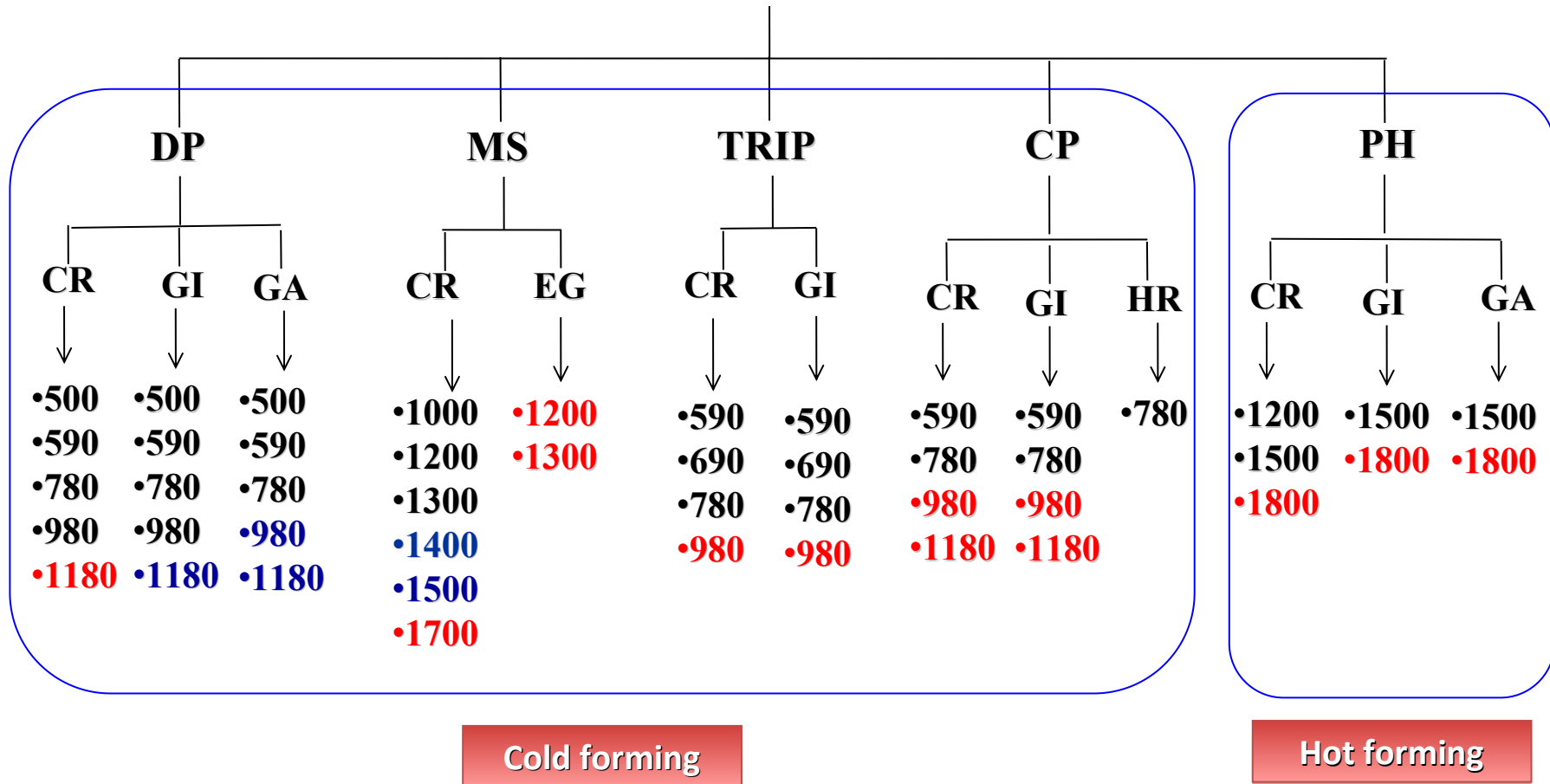
**1. Introduction**

**2. 1<sup>st</sup> Gen AHSS**

**3. New Gen AHSS**

**4. Concluding Remarks**

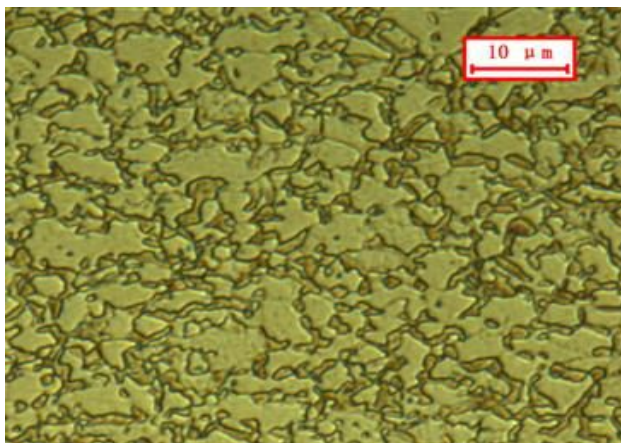
## Main grades of 1st-Gen AHSS in BAOSTEEL



Black: Commercial; Red: Developing; Blue: Trail production

● **Dual phase (DP) steels**

➤ **Products microstructure and properties**



Steel grade	YS, MPa	TS, MPa (minimal)	El, % (minimal)	Availability
HC280/590DP	280~380	590	22	Yes
HC340/590DP	340~440	590	20	Yes
HC550/690DP	550~660	690	12	Yes
HC420/780DP	420~550	780	14	Yes
HC500/780DP	500~650	780	10	Yes
HC550/980DP	550~730	980	7	Yes
HC700/980DP	700~900	980	7	Yes
HC820/1180DP	820~1130	1180	3	Prototype

➤ **Application cases: Good comprehensive properties, suitable for press forming of most auto-parts of BIW**



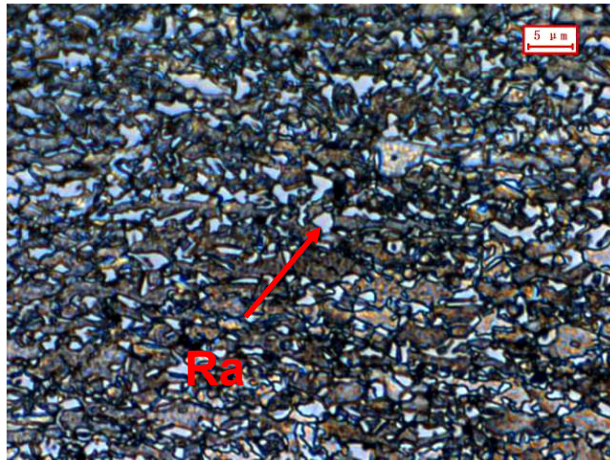
**Bumper,**  
HC700/980DP (thickness: 1.6mm)



**Door beam,**  
HC550/980DPD+Z (Coating thickness:  
50/50g/m<sup>2</sup>, thickness: 1.2mm)

## ● Transformation induced plasticity (TRIP) steels

### ➤ Products microstructure and properties



Steel grade	YS, MPa	TS, MPa (minimal)	EL, % (minimal)	Availability
HC380/590TR	380~480	590	29	Yes
HC400/690TR	400~520	690	24	Yes
HC420/780TR	420~580	780	20	Yes
HC450/980TR	450~700	980	14	QP980

### ➤ Application cases: Good ductility, suitable for **press forming of complex shape parts**



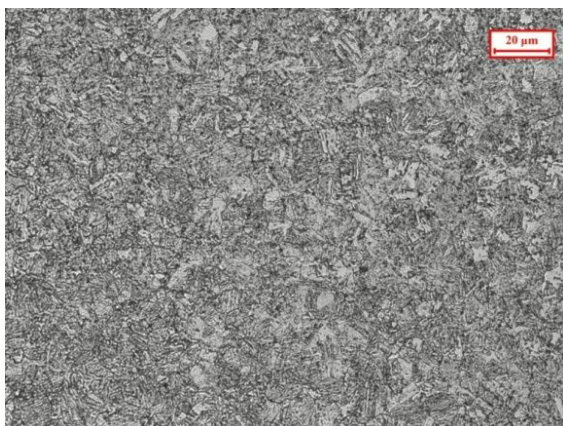
**B-pillar reinforcement,  
HC420/780 (Thickness: 1.8mm)**



**Side panel reinforcement, TWB  
HC420/780 (Thickness: 1.6mm)**

## ● Complex phase (CP) steels

### ➤ Products microstructure and properties



Steel grade	YS, MPa	TS, MPa (minimal)	EL, % (minimal)	Availability
HC350/600CP	350~500	600	16	Yes
HC500/780CP	500~700	780	10	Yes
HD680/780CP (CR, HR)	680~830	780	10	Yes
HC700/980CP	700~900	980	7	<b>Prototype</b>

### ➤ Application cases: Auto parts produced by roll forming, flanging, and hole expansion, etc.

#### ➤ Characters

- ✓ Ultrahigh strength
- ✓ Higher yield ratio: ~0.9
- ✓ Better bendability
- ✓ Good Stretch flangeability

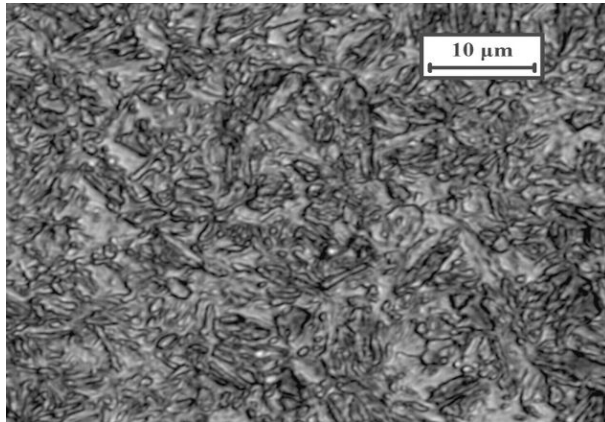


Seat rails, HC700/980CP (Thickness: 1.2mm)



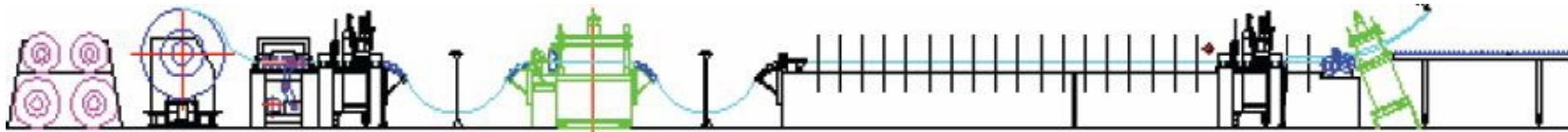
## ● MS (Martensitic steels)

### ➤ Products microstructure and properties



Steel grade	YS, MPa	TS, MPa	EL, %	Availability
HC700/980MS	830	1020	7	Yes
HC950/1180MS	1050	1270	6	Yes
HC1030/1300MS	1100	1350	5	Yes
HC1150/1400MS	1200	1450	4	Prototype
HC1200/1500MS	1300	1550	4	Prototype

### ➤ Application cases: roll forming or press forming of simple parts



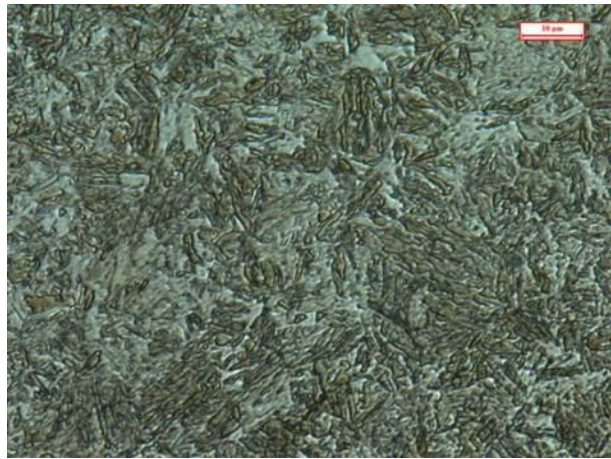
Rear bumper,  
HC700/980MS (thickness: 1.6mm)



Rear bumper,  
HC1030/1300MS (thickness: 1.6mm)

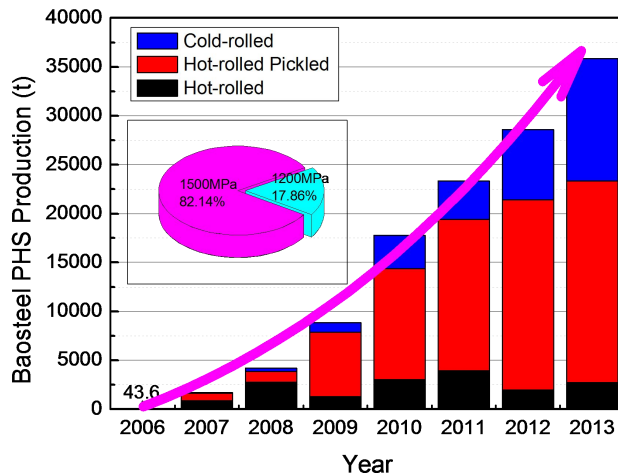
● Press Hardening (PH) steels - uncoated

➤ Products microstructure and properties



Steel grade	YS, MPa	TS, MPa	EL, %	Availability
BR1200HS	≥ 280	≥ 700	≥ 18	Yes
B1200HS	≥ 220	380 ~ 700	≥ 22	Yes
1200*	900 ~ 1200	≥ 1200	≥ 7	
BR1500HS	320 ~ 630	480 ~ 800	≥ 16	Yes
B1500HS	280 ~ 450	≥ 450	≥ 20	Yes
1500*	950 ~ 1250	1300 ~ 1800	≥ 5	
B1800HS	≥ 1100	≥ 1800	≥ 4	June, 2014

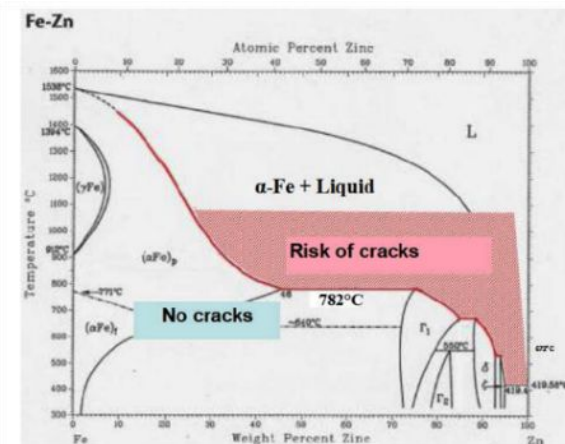
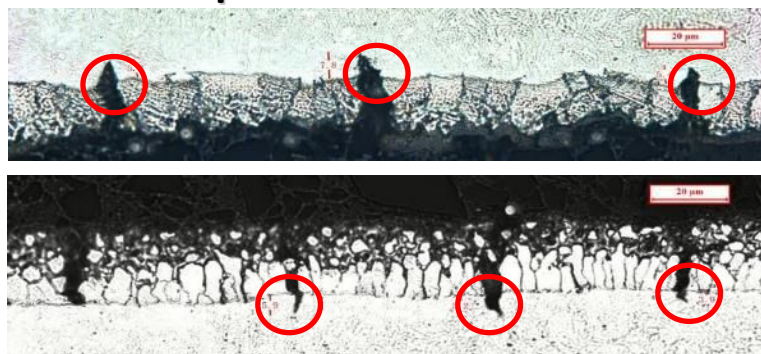
➤ Application cases: hot press forming of the parts with complex shape



B-pillar  
B1500HS (Thickness: 1.8mm)

● Press Hardening (PH) steels – Zn coated

**LME (Liquid Metal Embrittlement)**



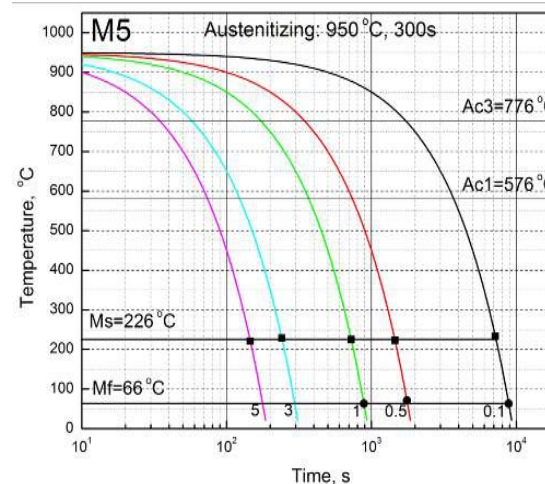
Potential solution

- ✓ Lower strain: Indirect hot stamping
- ✓ Lower austenite temperature: New materials

New PH steel by BAOSTEEL

**Ac<sub>3</sub>: 750~800°C**

YS, MPa	TS, MPa	EL, %
953	1,800	10.7

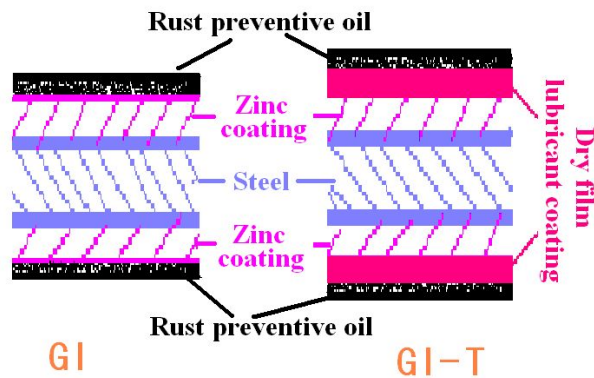


**Prototype available by June, 2015**

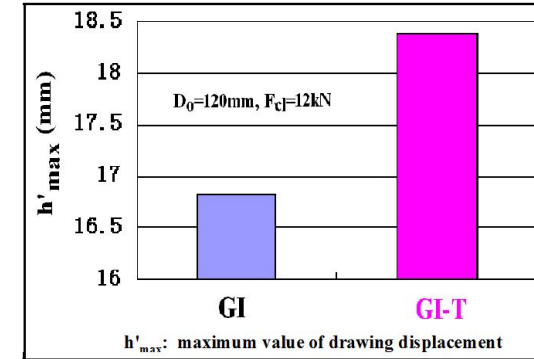


● **GI-T: Inorganic dry film lubricant coated galvanized steel sheet**

➤ **Structure and properties of GI-T products**



oil type	A	B	C
GI	0.144	0.135	0.126
GI-T	0.107	0.106	0.093
decrease of $\mu$ (%)	25	21	26



➤ **Advantages of GI-T**

- ✓ Lower friction coefficient
- ✓ Improved stamping behavior
- ✓ Reducing the die cleaning frequency
- ✓ Excellent spot weldability
- ✓ Good phosphate compatibility



hood inner



door inner



side panel



luggage compartment floor

# Contents

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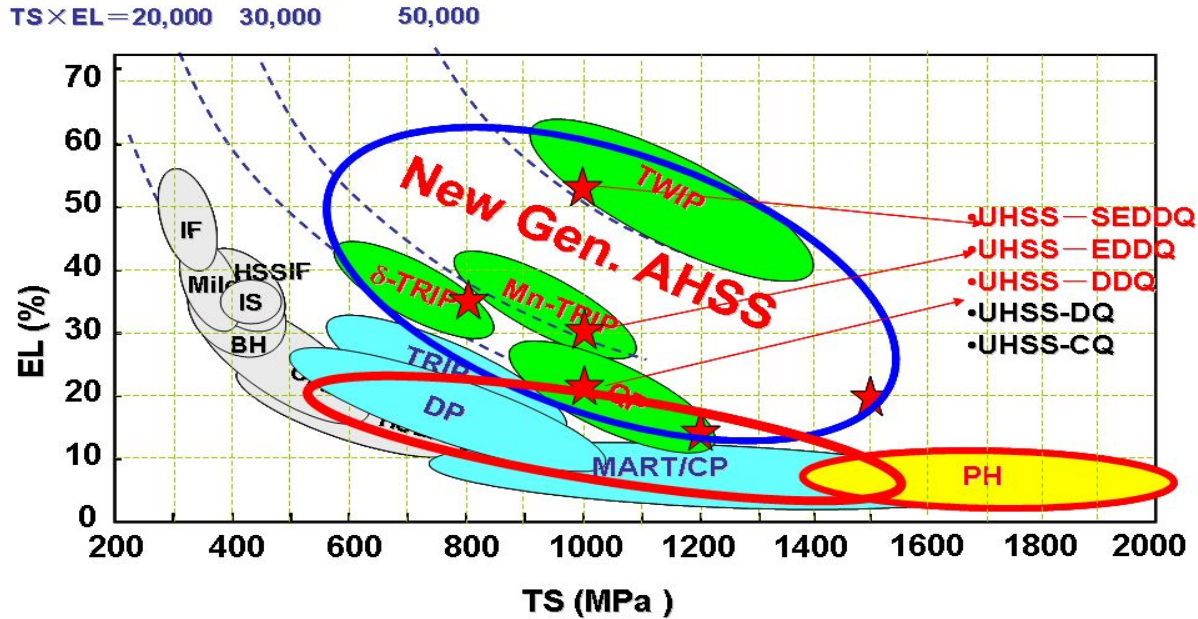
**1. Introduction**

**2. 1<sup>st</sup> Gen AHSS**

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**4. Concluding Remarks**

Ultra-high strength + improved ductility

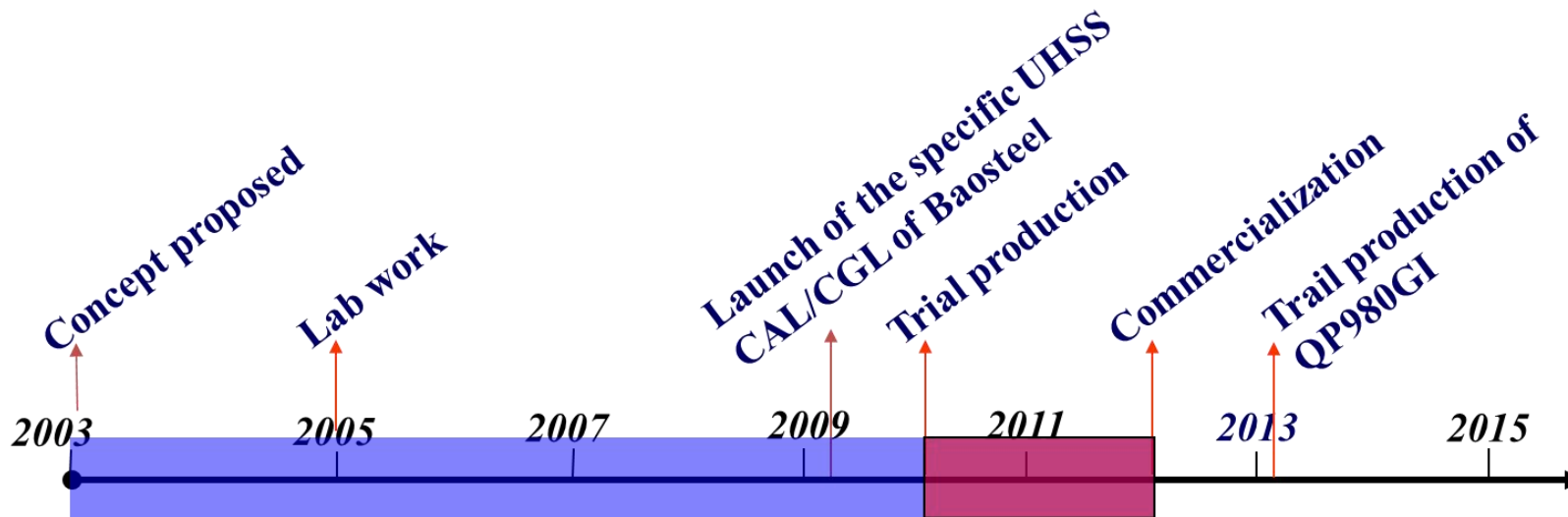
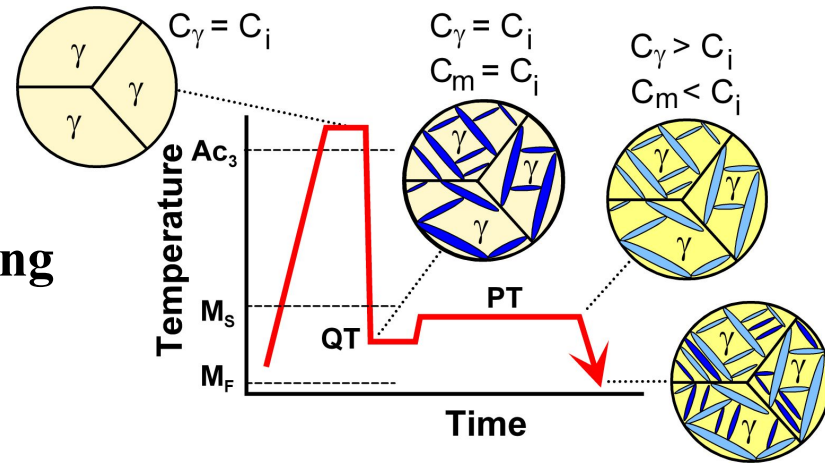


New Gen AHSS in BAOSTEEL

Q&P(DDQ)		Mn-TRIP(EDDQ)		TWIP(SEDDQ)		delta-TRIP(EDDQ)	
CR	GI	CR	GI	CR	GI	CR	GI
•980	•980	•980	•980	•980	•980	•590	•590
•1180	•1180	•1180	•1180	•1180	•1180	•780	•780
•1300	•1300					•980	•980
20%@1000MPa		30%@1000MPa		50%@1000MPa		30%@800MPa	

## ● Concept and history

- Concept: Prof. J Speer
- Q&P: Quenching and partitioning
- Technique: one step & two step
- Industrialization : world first



*\*Speer JG, Matlock DK, De Cooman BC, Schroth JG. Carbon partitioning into austenite after martensite transformation. Acta Mater. 2003;51:2611-22.*

## ● Characters of Q&P steels

- Chemical compositions (wt.%)
- Products available

C	Mn	Si
~0.2	<3.0	<2.0

✓ Dimension: (Thickness: 1.0~2.1) × (width: 700~1250)mm

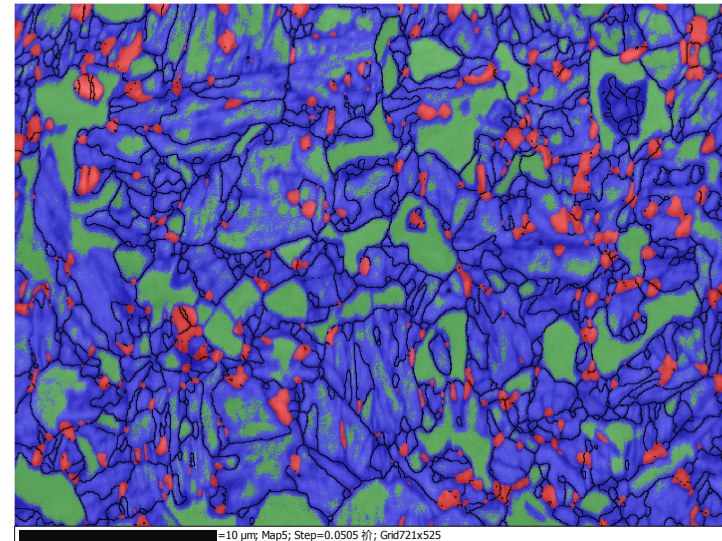
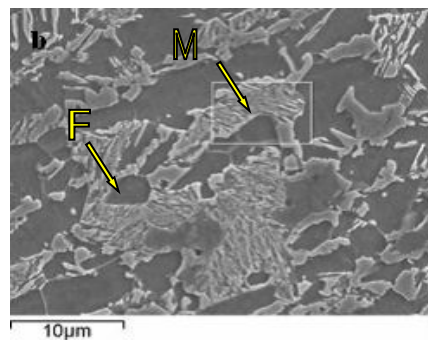
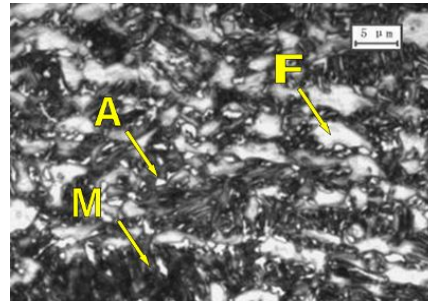
✓ Type: CR / HDG

- Microstructure:

✓ Martensite (~70%)

✓ Ferrite (~20%)

✓ Retained austenite (~10%)



Green: bcc (F)    RED: fcc (γ)    BLUE: bcc (M)

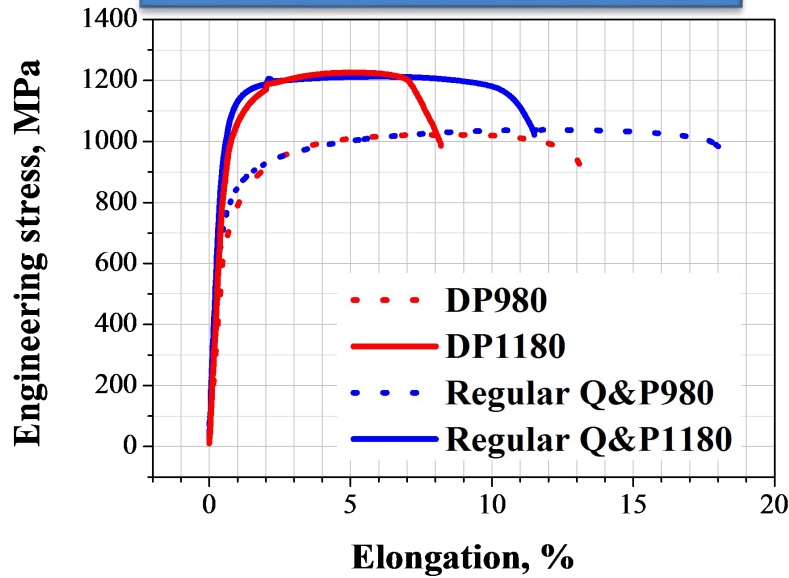


● **Two families of Q&P steels with different ductility**

**Regular Q&P**

Steel Grade	YS(MPa)	TS(MPa)	EL (%)
980	650~800	980~1050	15~20
1180	950~1150	1180~1300	8~12

Commercialized

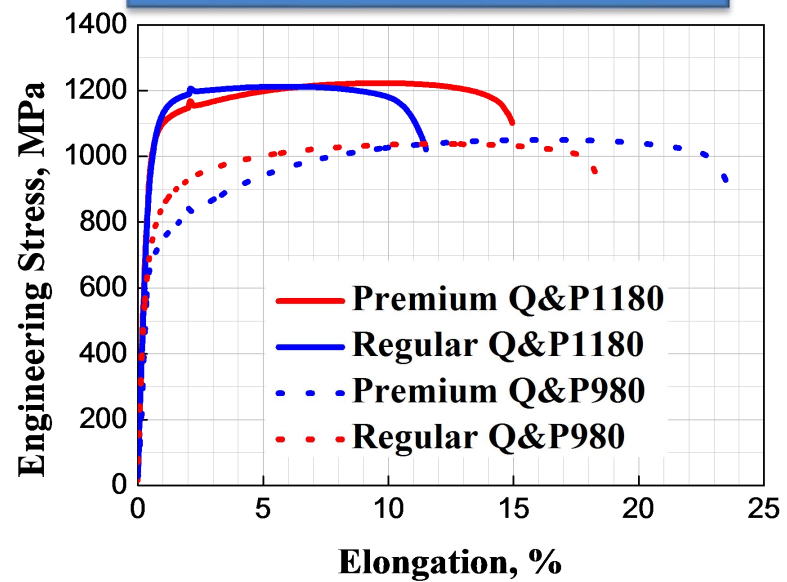


For upgrading from 780MPa or lower grades

**Premium Q&P**

Steel Grade	YS(MPa)	TS(MPa)	EL (%)
980	550~750	980~1050	21~25
1180	850~1050	1180~1300	14~18

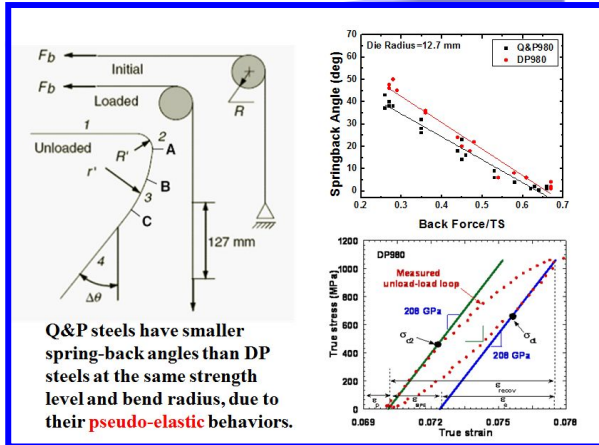
Prototype available



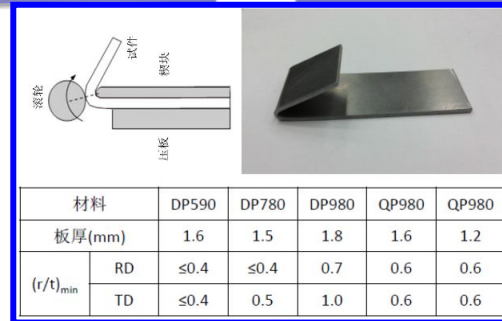
Providing an alternative solution to PHs

➤ Properties evaluation of commercialized Q&P steels

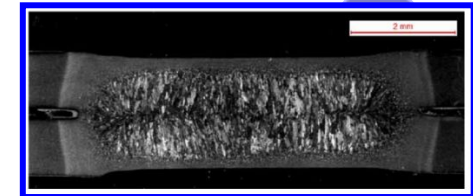
Spring back



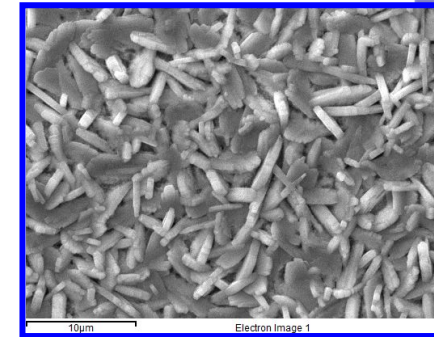
Bending



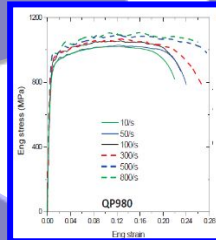
Welding



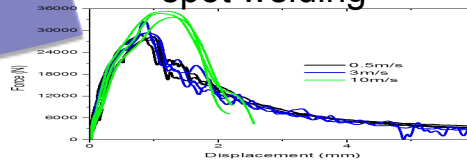
Phosphatizing



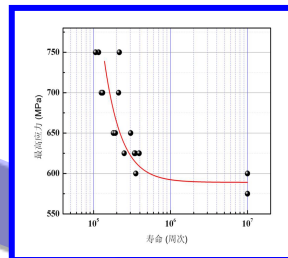
Dynamic fracture



Dynamic test for spot welding



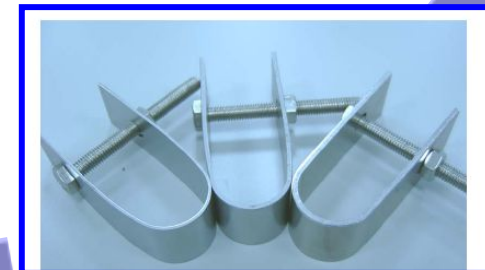
Fatigue



HER

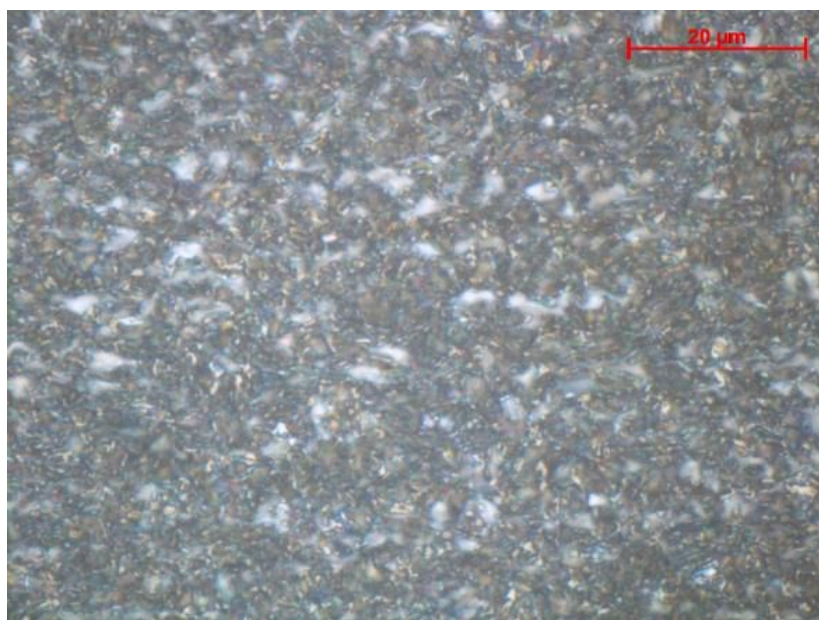


Delayed Fracture



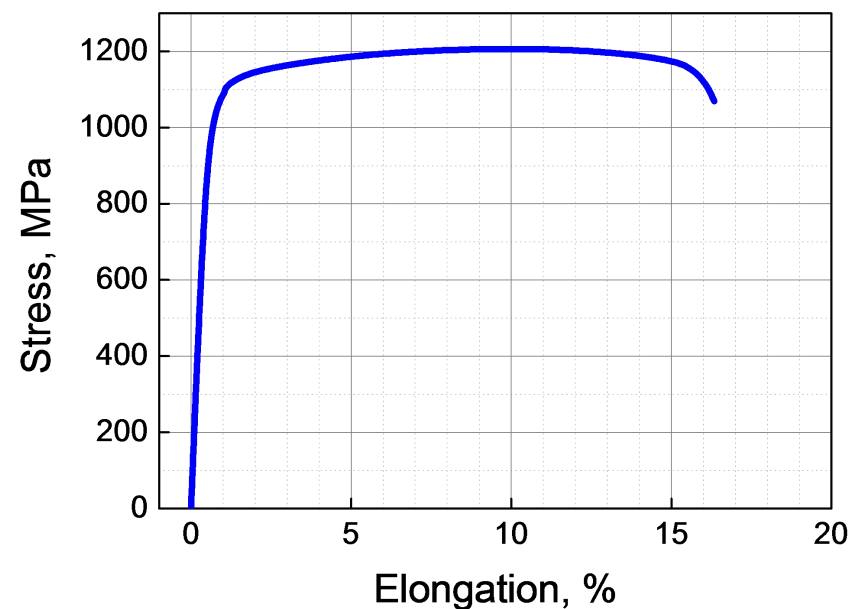
## Prototype of Premium QP1180-CR

Mechanical properties	YS MPa	TS MPa	UEL %	EL %	HER %	R/t
HE1180-CR	1006	1206	9.4	15.8	46	1.5



Prototype available

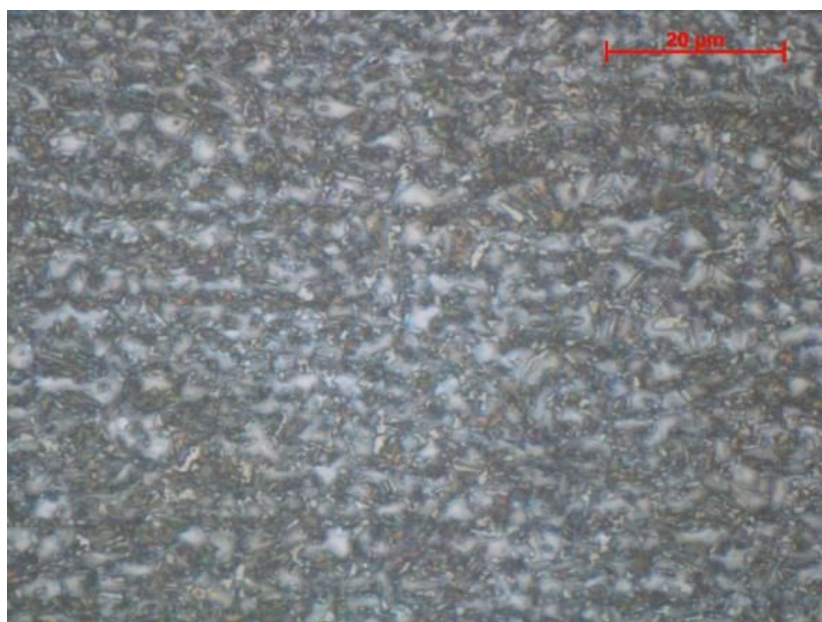
Gauge (mm):  
1.0×1100×C





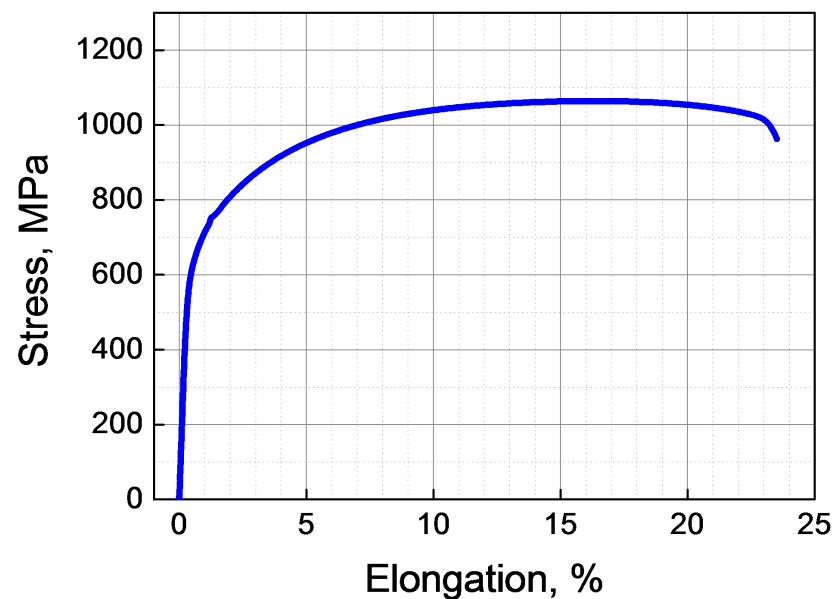
## Prototype of Premium QP980-CR

Mechanical properties	YS MPa	TS MPa	UEL %	EL %	HER %	R/t
HE980-CR	665	1041	15.4	22.4	41	1.5



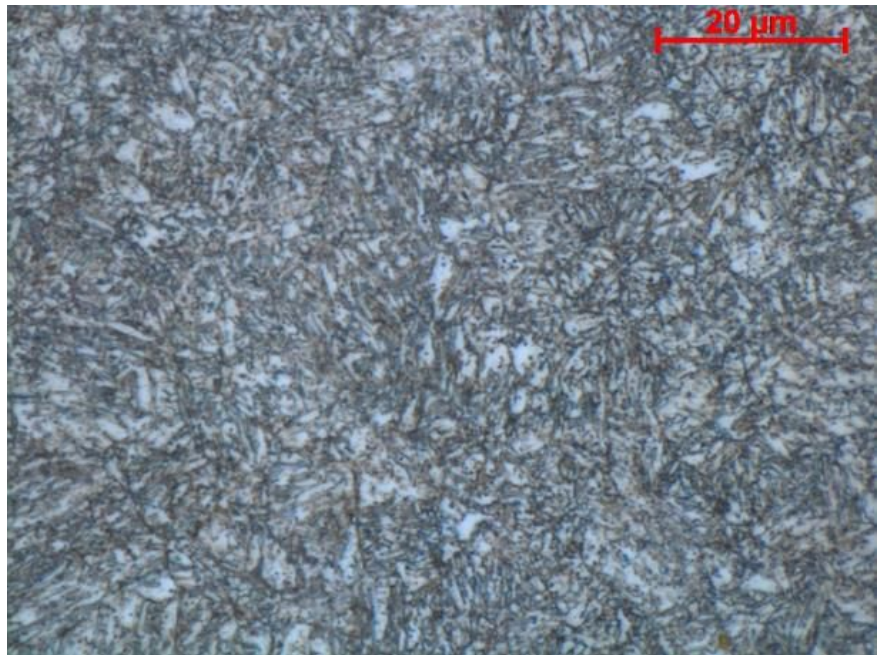
Prototype available

Gauge (mm):  
1.0/2.0×1100×C



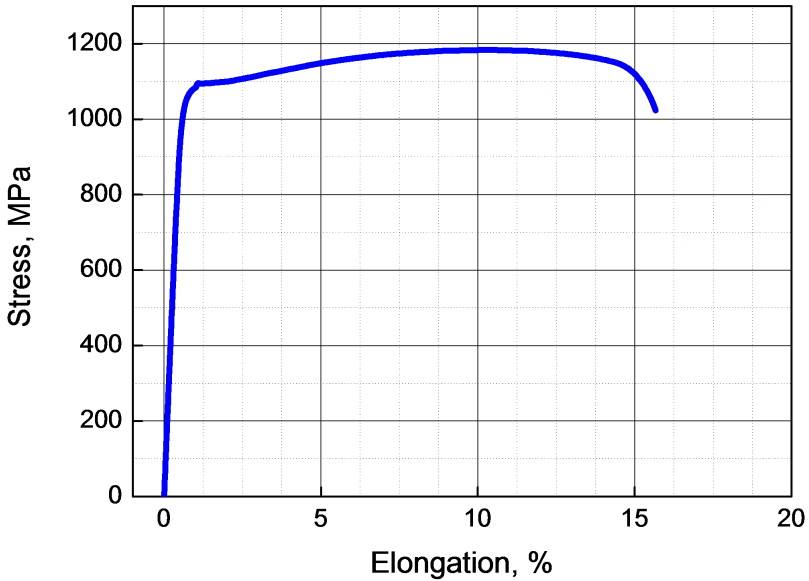
## Prototype of Premium QP1180-GI

Mechanical properties	YS MPa	TS MPa	UEL %	EL %	HER %	R/t
HE1180-GI	1054	1192	10.1	16.0	40	1.5



Prototype available

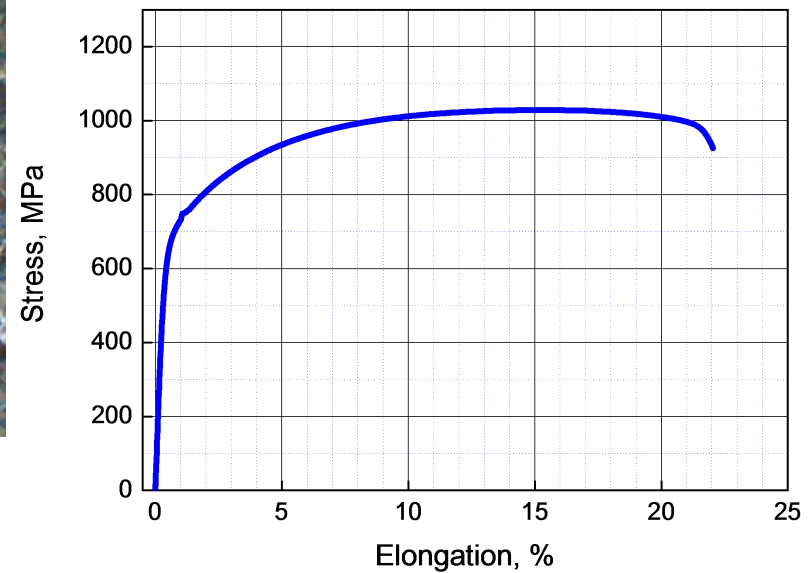
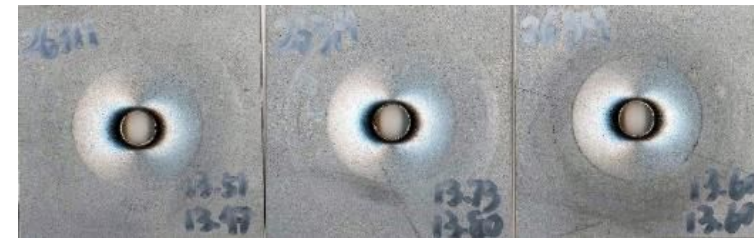
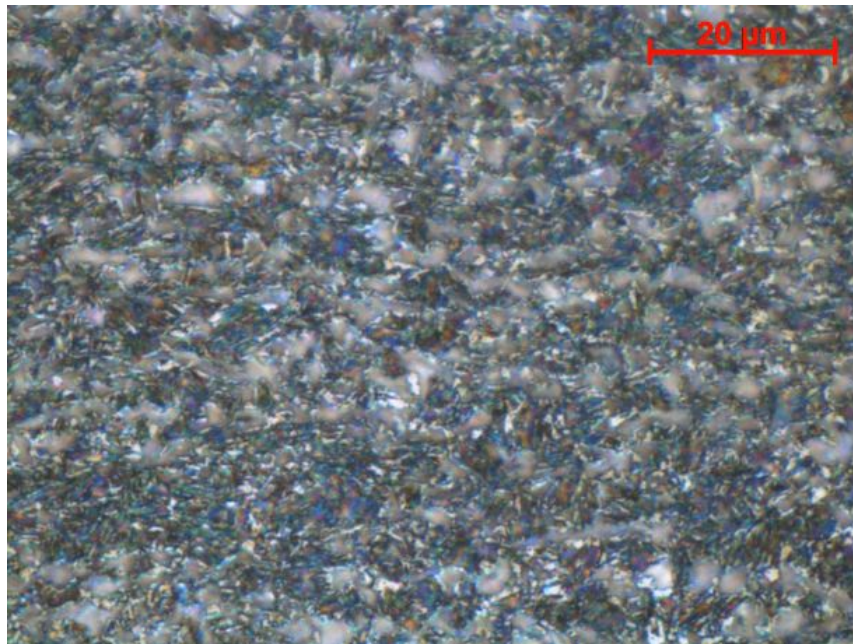
Gauge (mm):  
1.2×1100×C



## Prototype of Premium QP980-GI

Mechanical properties	YS MPa	TS MPa	UEL %	EL %	HER %	R/t
HE980-GI	653	1048	14.8	22.0	36	1.5

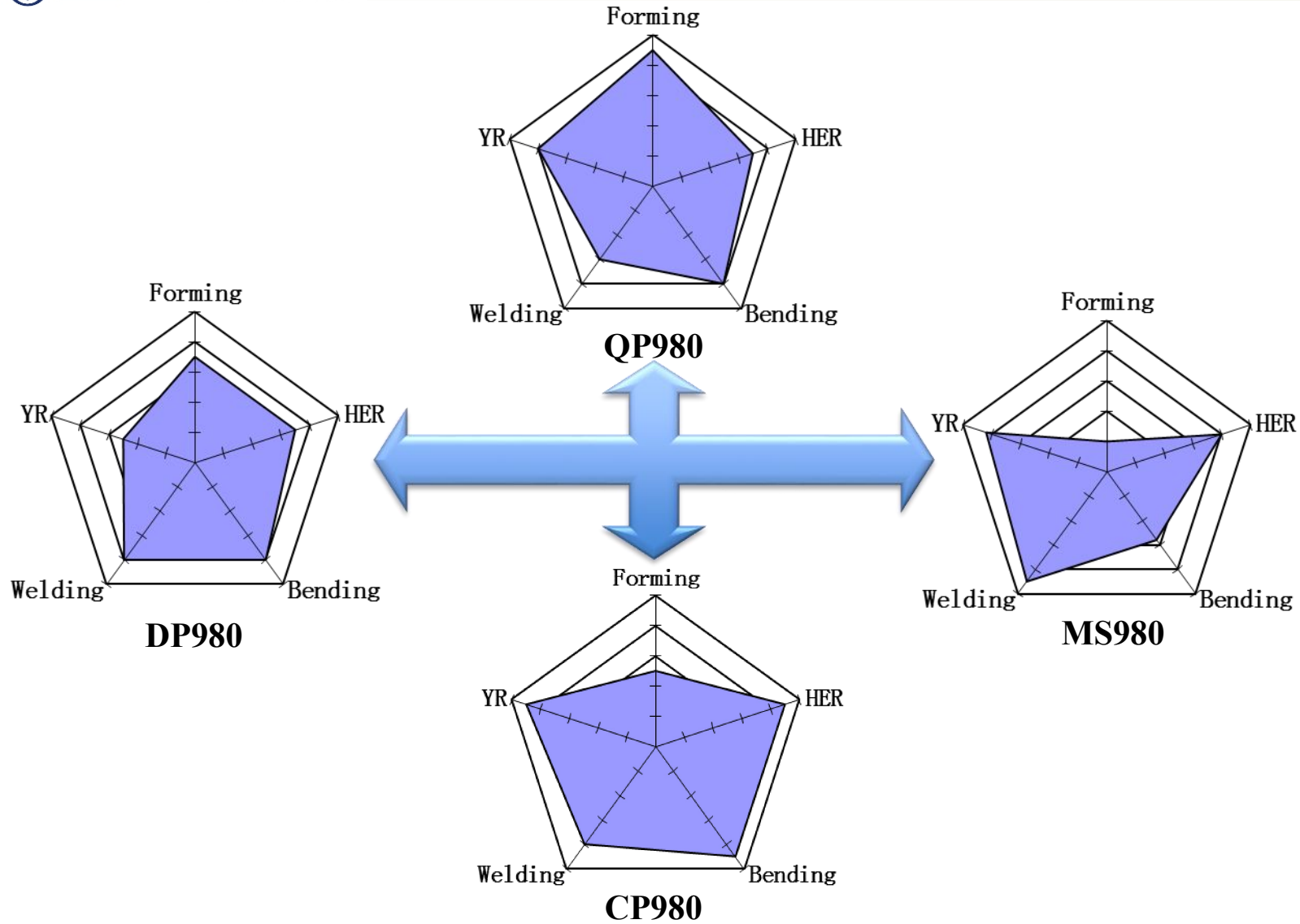
Gauge (mm):  
**1.0×1100×C**



Prototype available



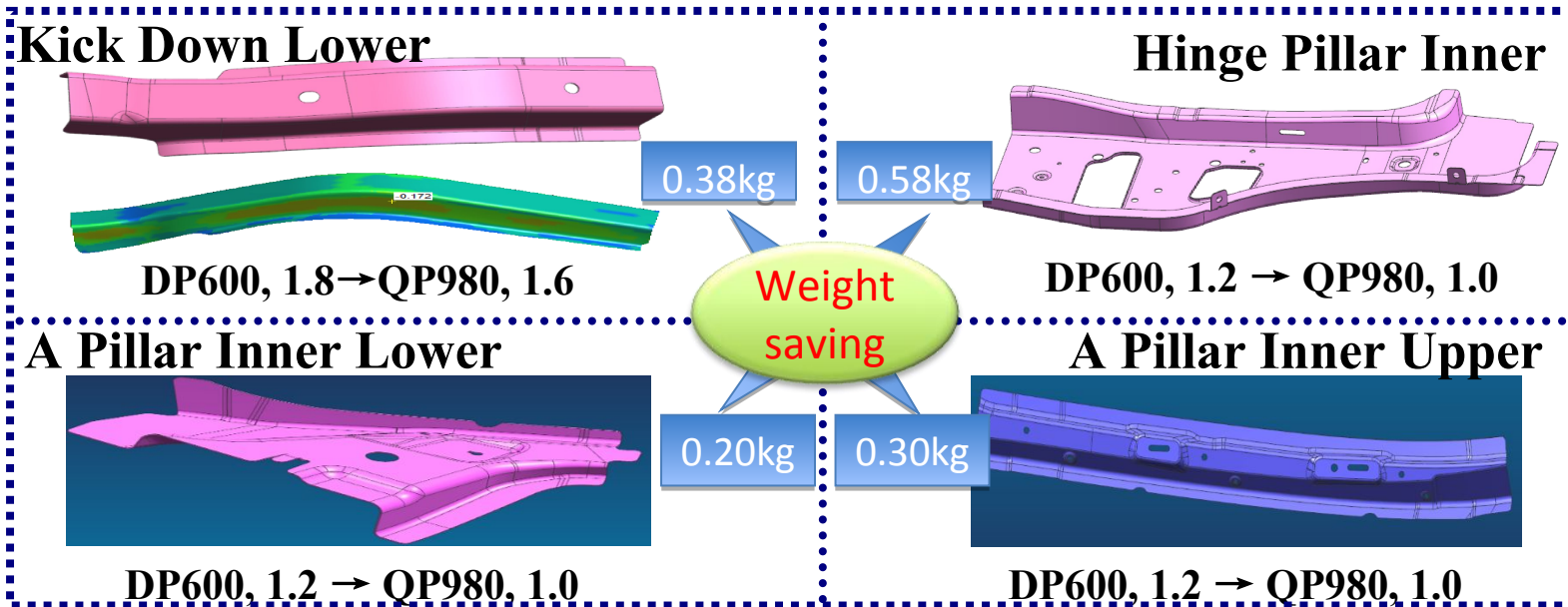
# Comparison among typical AHSSs



Right materials at right place



B pillar reinforcement of a self-owned brand car



## ● TWIP (Twinning Induced Plasticity)

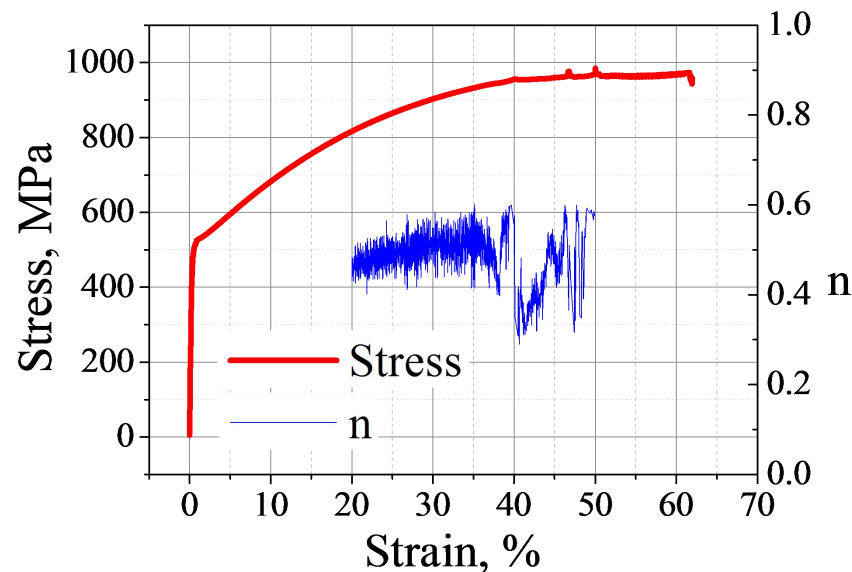
- ✓ Full austenite microstructure: **Austenite-stabilizing elements**
- ✓ Superior strain hardening capability

### ➤ Target chemical composition (wt.%):

C	Mn	Al	X
0.5~1.0	14~18	1.5~2.5	~

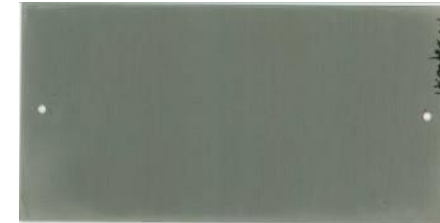
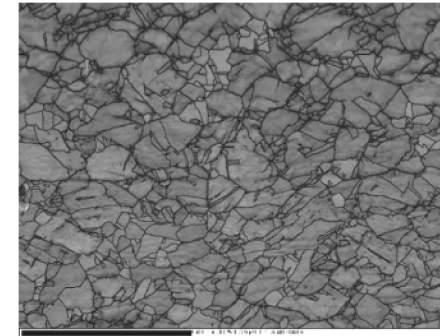
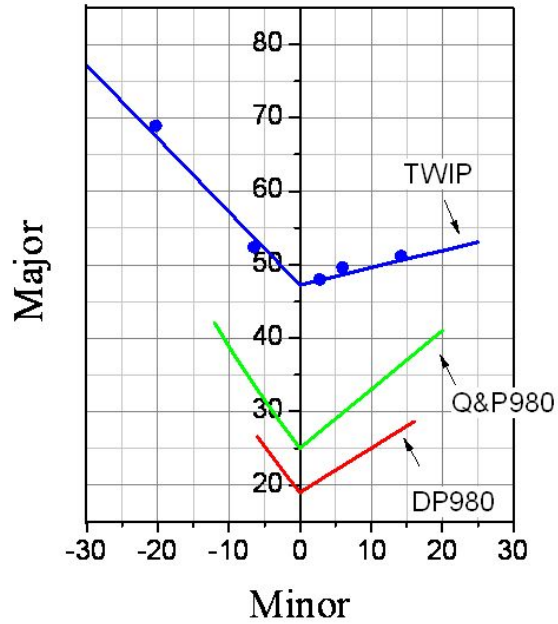
### ● Focus of R&D:

- Materials: Higher strength
- Galvanizing



Grade	TS, MPa	EL, %	Type	Availability
TWIP1000	≥980	≥45	Uncoated	Prototype
TWIP1000GI	≥980	≥45	Zn-coated	Prototype
TWIP1200	≥1180	≥35	Uncoated/Zn	By next June
TWIP1500	≥1470	≥20	Uncoated/Zn	By next Dec.

# R&D of TWIP steel





● **Medium Mn TRIP**

➤ **Chemical composition**

Element	C	SI	Mn
Content	0.10~0.4	0~1.0	5.0~10.0

➤ **Mechanical properties**

YS(MPa)	TS(MPa)	EL (%)
>800	>1000	>30

➤ **Technique procedure**

✓ **Austenite revert transformation**

➤ **Mechanical Properties (lab work)**

YS (MPa)	TS (MPa)	UEL (%)	EL (%)	TS × EL MPa%
781	1013	33.5	42.4	42951

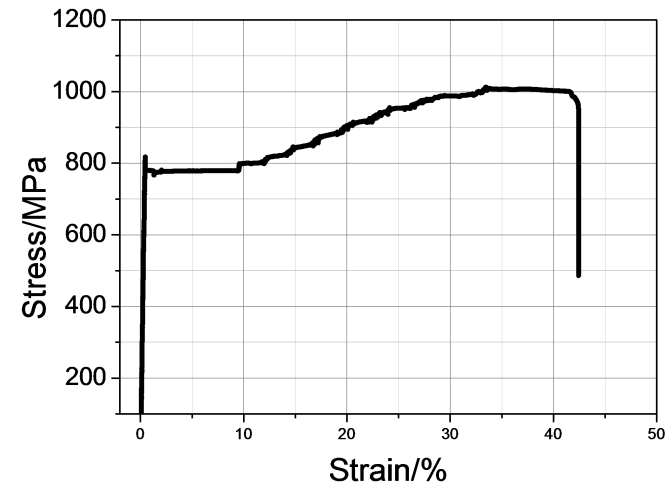
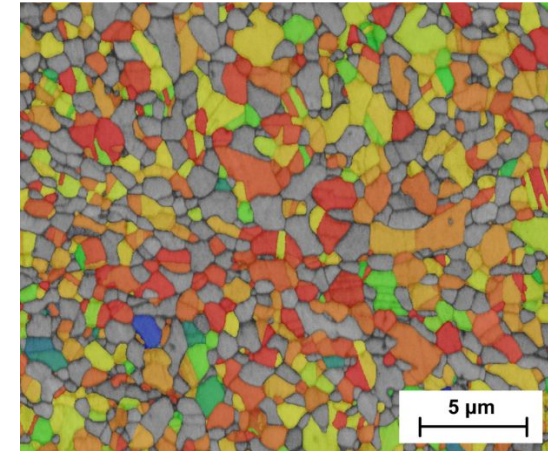


**Dimensions:**

Width: 1230 mm;

Thickness: 1.4 mm

**Ultra-fine Ferrite + Retained austenite**



**Prototype available**

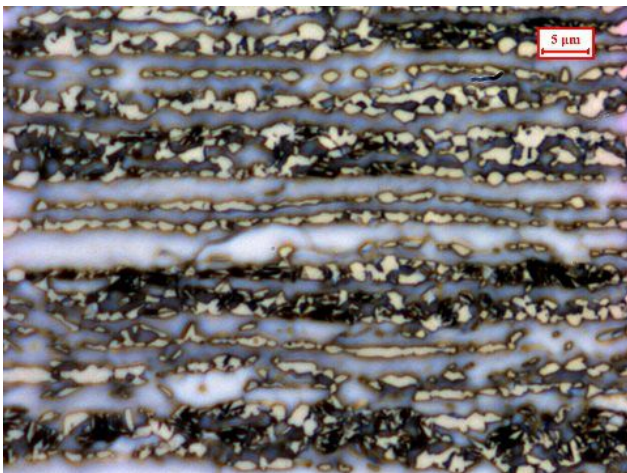


➤ Chemical composition

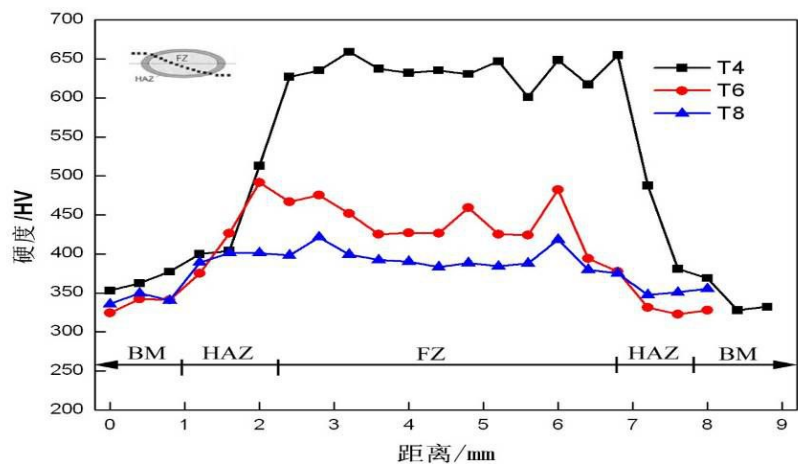
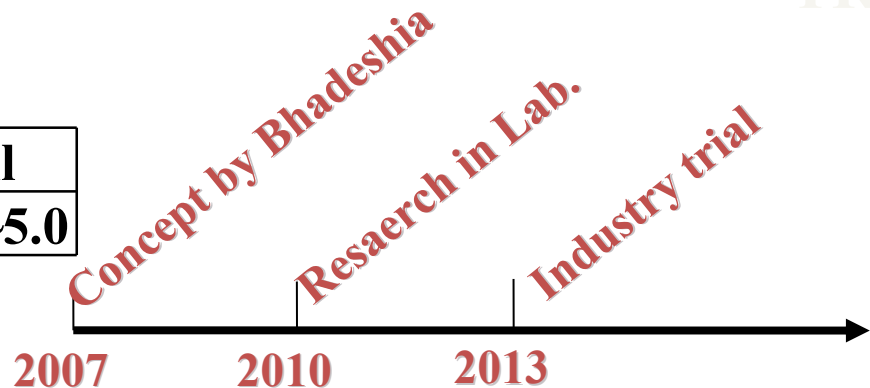
Element	C	SI	Mn	Al
Content	0.20~0.5	0.3~0.5	1.0~1.5	3.0~5.0

●  $\delta$  -TRIP

- ① High EL
- ② Good weldability
- ③ Low Density



Prototype available by June, 2015



No.	YS	TS	EL
$\delta$ -TRIP780	~500	~800	~35%
TRIP780	~470	~800	~26%

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**2. 1<sup>st</sup> Gen AHSS**

**3. New Gen AHSS**

**4. Concluding Remarks**

# Concluding Remarks

- 1. Mass application of AHSS in BIW is one of the most promising material solution of future vehicle.**
- 2. BAOSTEEL can provide large varieties of Auto steel sheets, ranging from 1st AHSS to 3rd AHSS.**
- 3. BAOSTEEL needs the collaboration and support of customers to promote the application of these newly developed AHSS products.**



# Thanks for your attention!

 **BAOSTEEL** 宝钢股份 | 构筑共享价值

**\*For more information, please contact:**

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**BAOSTEEL R&D center**  
**Email: [zhongyong@baosteel.com](mailto:zhongyong@baosteel.com)**