HKU Super Steel project attains unprecedented levels of fracture resistance with collaborators at Berkeley Lab

香港大學「超級鋼」研究夥拍柏克萊國家實驗室獲得抗斷裂能力重大突破

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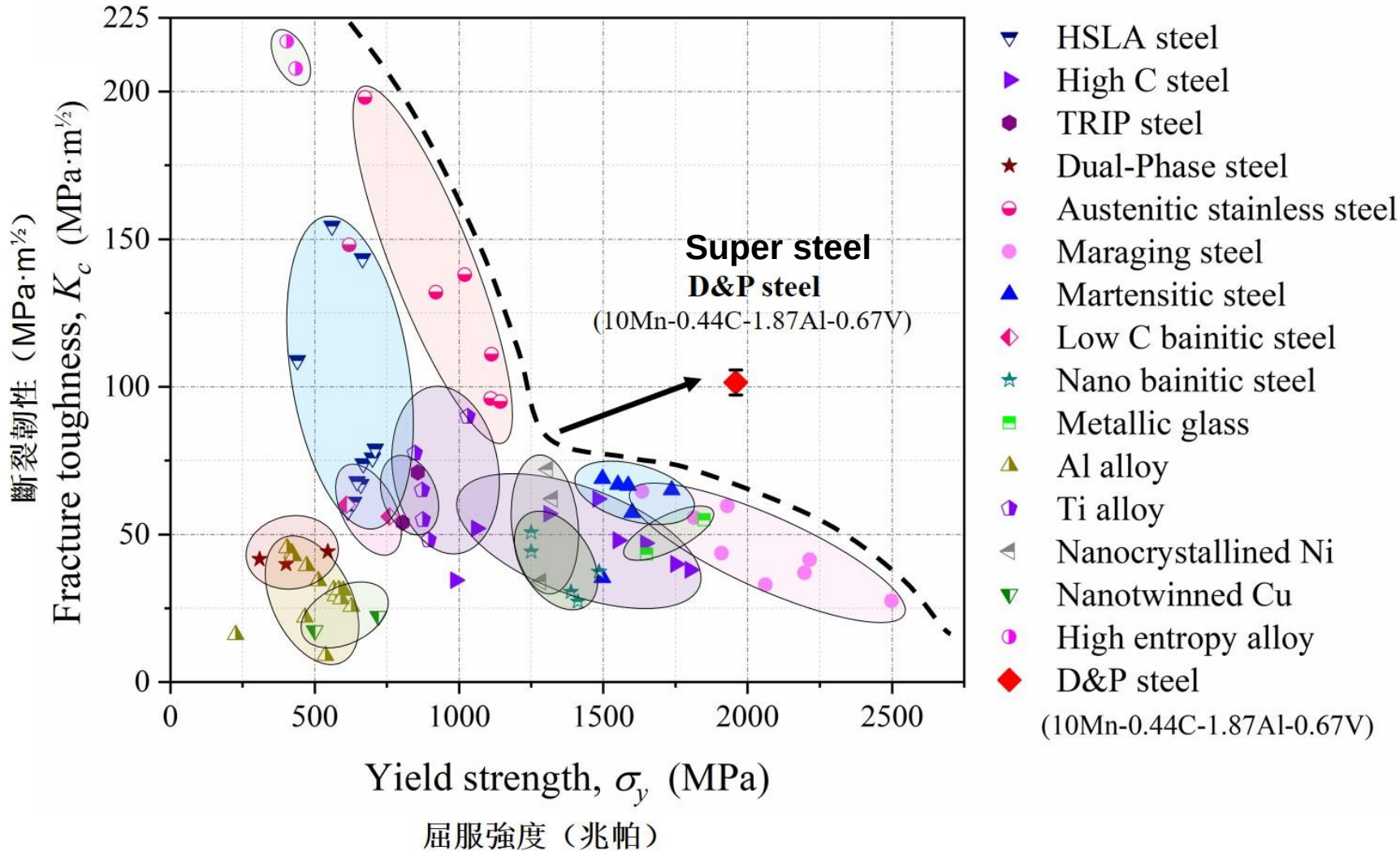
Strength-toughness trade-off
強度與韌性：魚和熊掌的關系

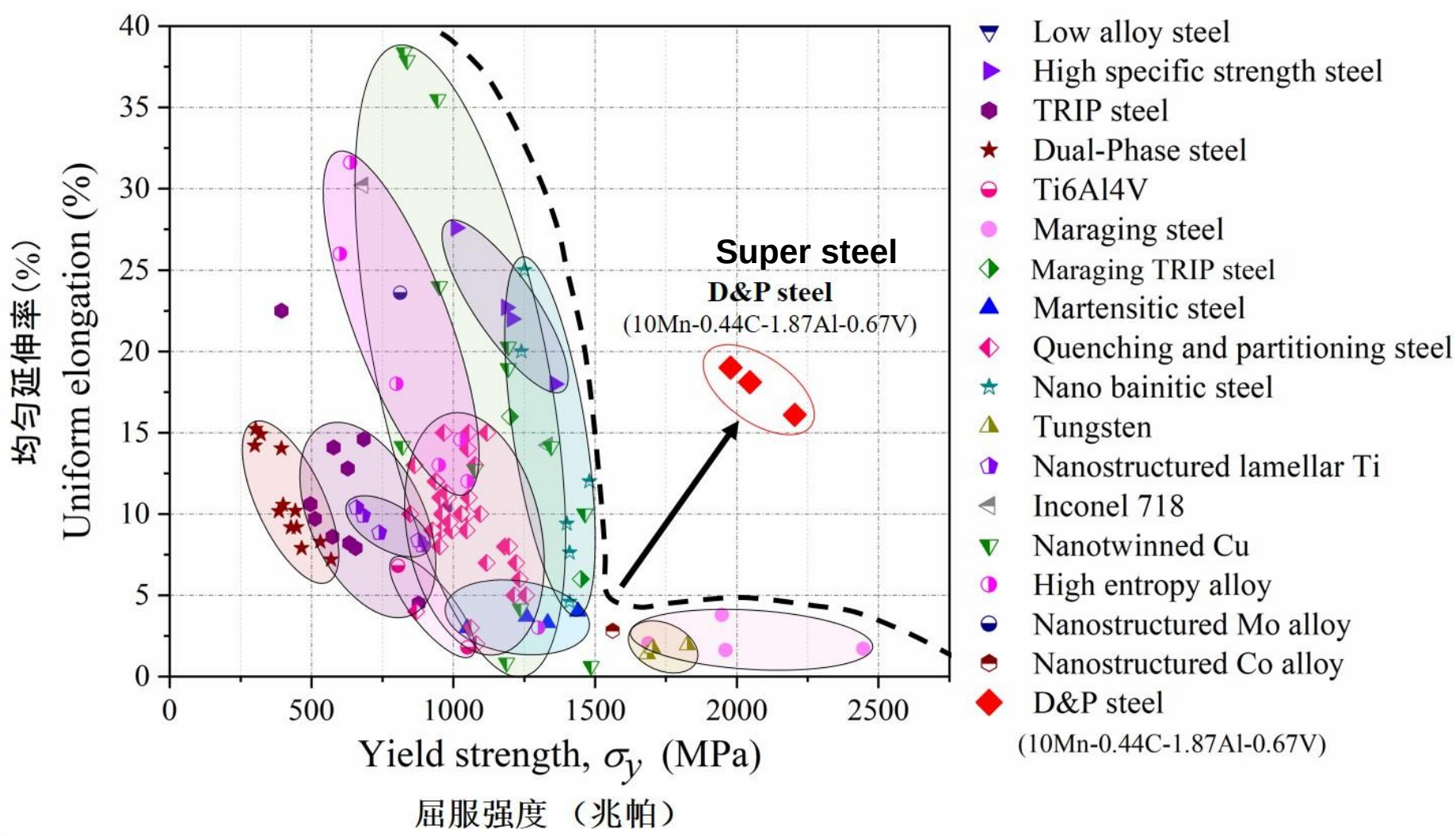
屈服強度-韌性組合世界紀錄



Strength-elongattion trade-off

強度與延展性：魚和熊掌的關系

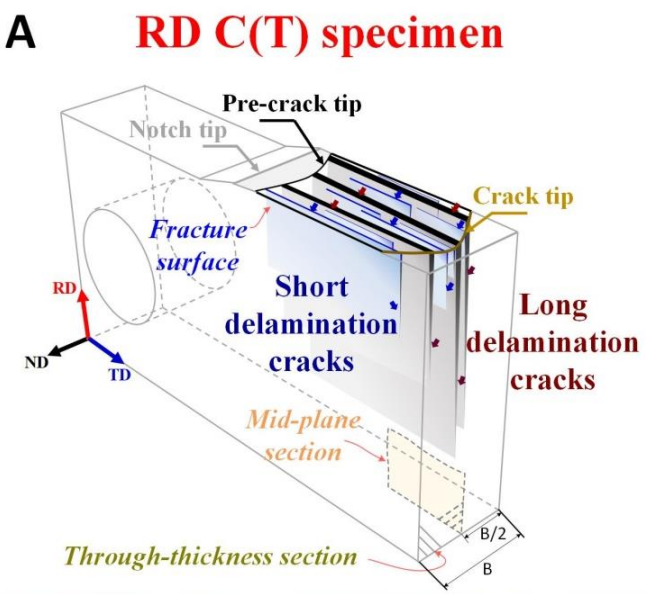
屈服強度-延展性組合世界紀錄

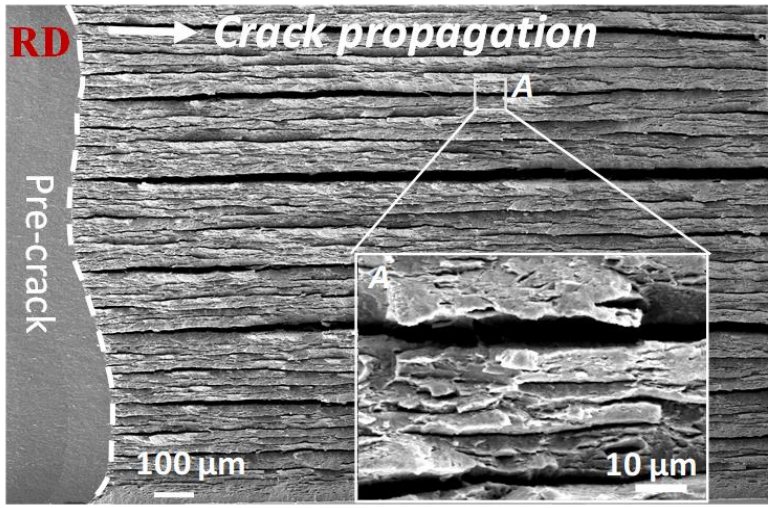


New Science 新的科學發現

The super steel has a unique fracture feature in which multiple micro-cracks are formed below the main fracture surface, through a novel “high-strength induced multi-delamination” toughening mechanism. These micro-cracks can effectively absorb energy from externally applied forces, resulting in the steel’s much higher toughness resistance compared to existing steel materials.

團隊發現D&P鋼材具有非常獨特的斷裂方式 - 在主裂紋下方形成很多微小裂紋，這些微小裂紋能有效吸收由外力引致的能量，從而大幅提高鋼材的斷裂韌性，遠高於目前使用的鋼材料。團隊開創性地提出「晶界分層開裂增韌」的概念，通過增加材料屈服強度以啟動新的增韌機制，大幅提高鋼材料的韌性。





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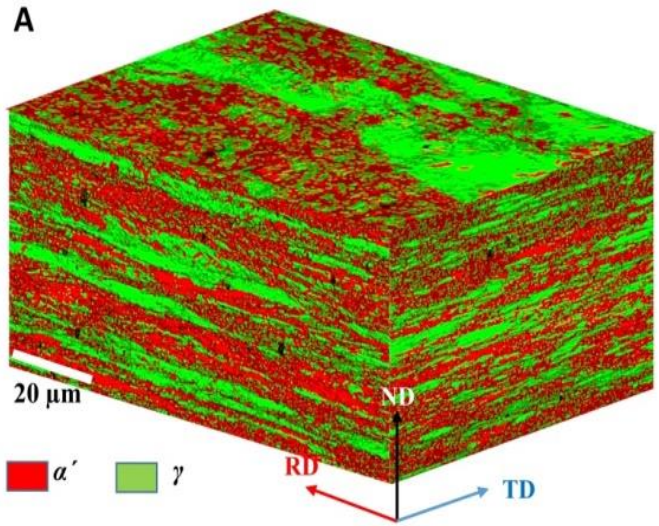
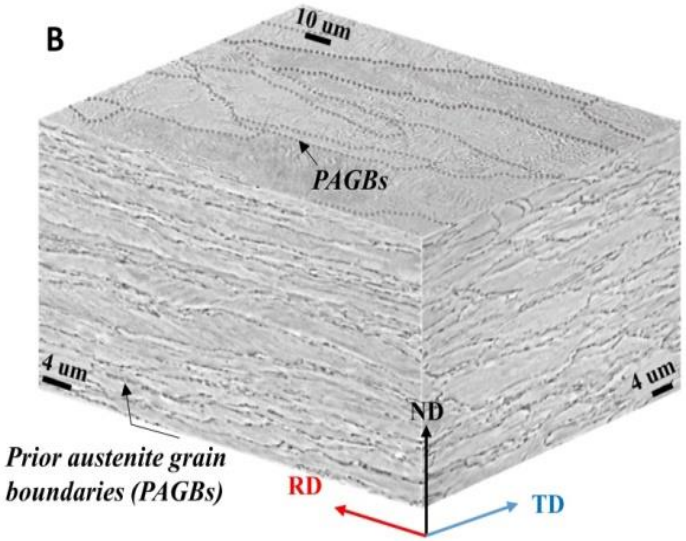
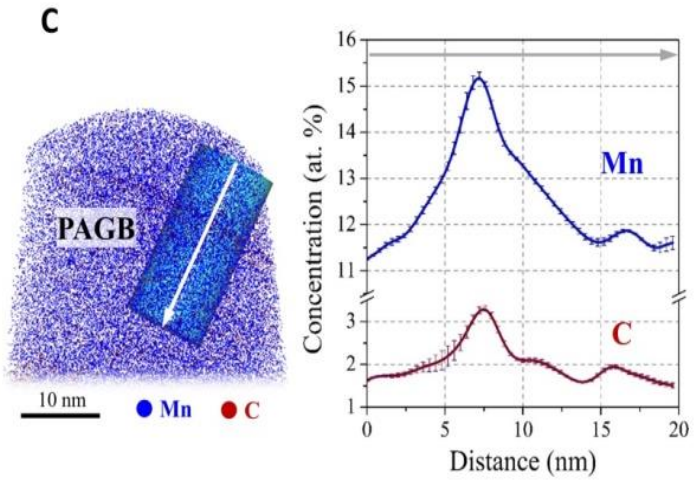
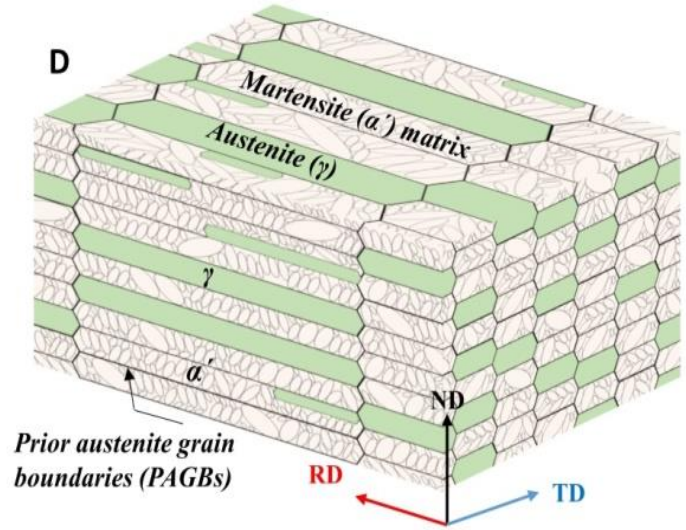
New Science 新的科學發現







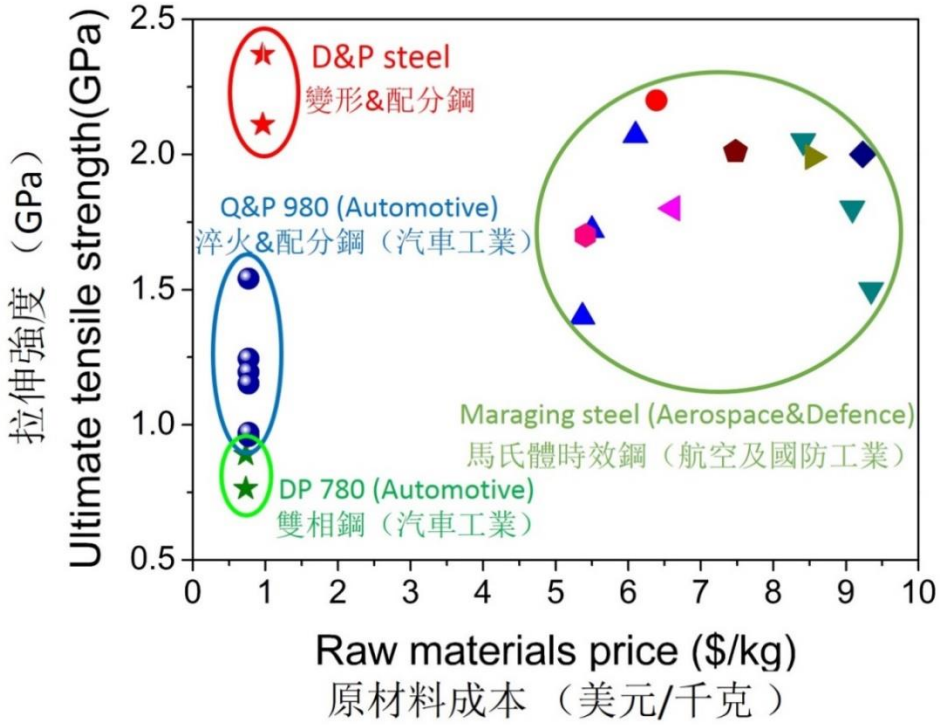


Advantages of the super steel
超強鋼的優點

合金成本較低。本發明的超強鋼是成分簡單的中錳鋼成分體系，含有10%錳，0.44%碳，1.87%鋁，0.67%釩（V）（質量百分比），這些都是現在廣泛使用的鋼材料中常見的合金元素。

Low raw-materials cost. The chemical composition of this breakthrough steel belongs to medium manganese (Mn) steel, containing 10% manganese, 0.44% carbon, 1.87% aluminium, 0.67% vanadium (mass percent), the balance is iron. All of these alloying elements have been widely used in the conventional steels.

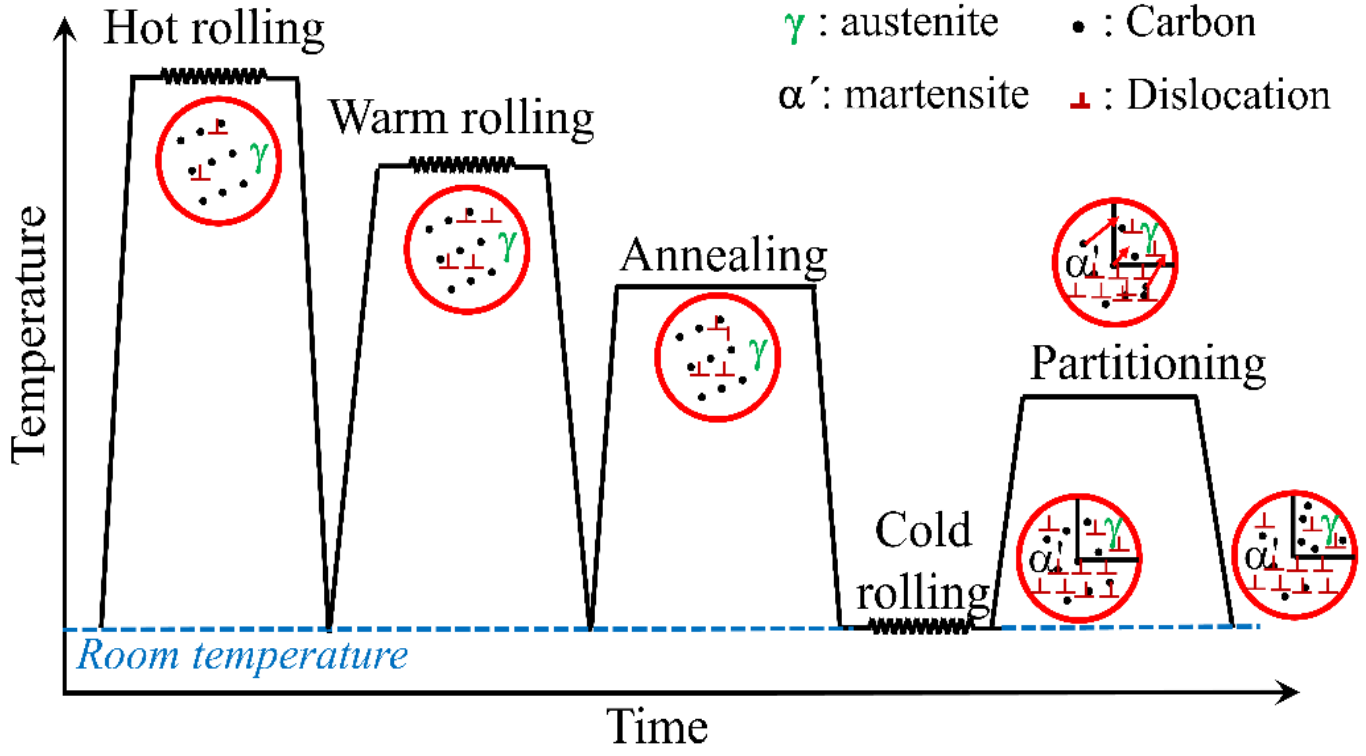
Raw material cost
~20% of maraging steel (aerospace)
原材料成本大約為航空用的馬氏體時效鋼的20%



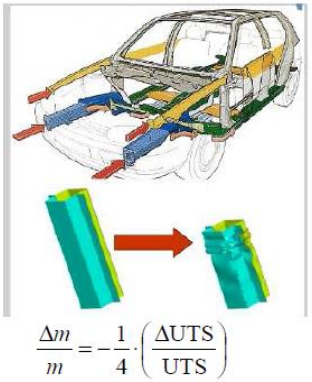
Advantages of the super steel
超強鋼的優點

該超強鋼通過在工業界廣泛使用的加工工藝來制備，如熱軋、溫軋、冷軋、熱處理等常規工業制備工藝，具備直接在鋼鐵企業進行百噸級規模工業化生產的巨大潛力。

This super-steel is developed by using the conventional industrial processing routes including hot rolling, warm rolling, cold rolling and annealing. It is expected that the present super-steel has a great potential for industrial mass production of hundreds of tons.



Application of super steel
超強鋼的應用領域



$$\frac{\Delta m}{m} = -\frac{1}{4}\cdot\left(\frac{\Delta \mathrm{UTS}}{\mathrm{UTS}}\right)$$

$$\frac{\Delta m}{m} = -\frac{2}{7}\cdot\left(\frac{\Delta \mathrm{YS}}{\mathrm{YS}}\right)$$

Lightweight cars
車身減重

Bridge cables
橋梁鋼纜索

Bulletproof vest
防彈衣

Lightweight military vehicles
輕量化裝甲運兵車

Aerospace application
航空應用

High strength bolts and nuts
高強螺栓和螺母

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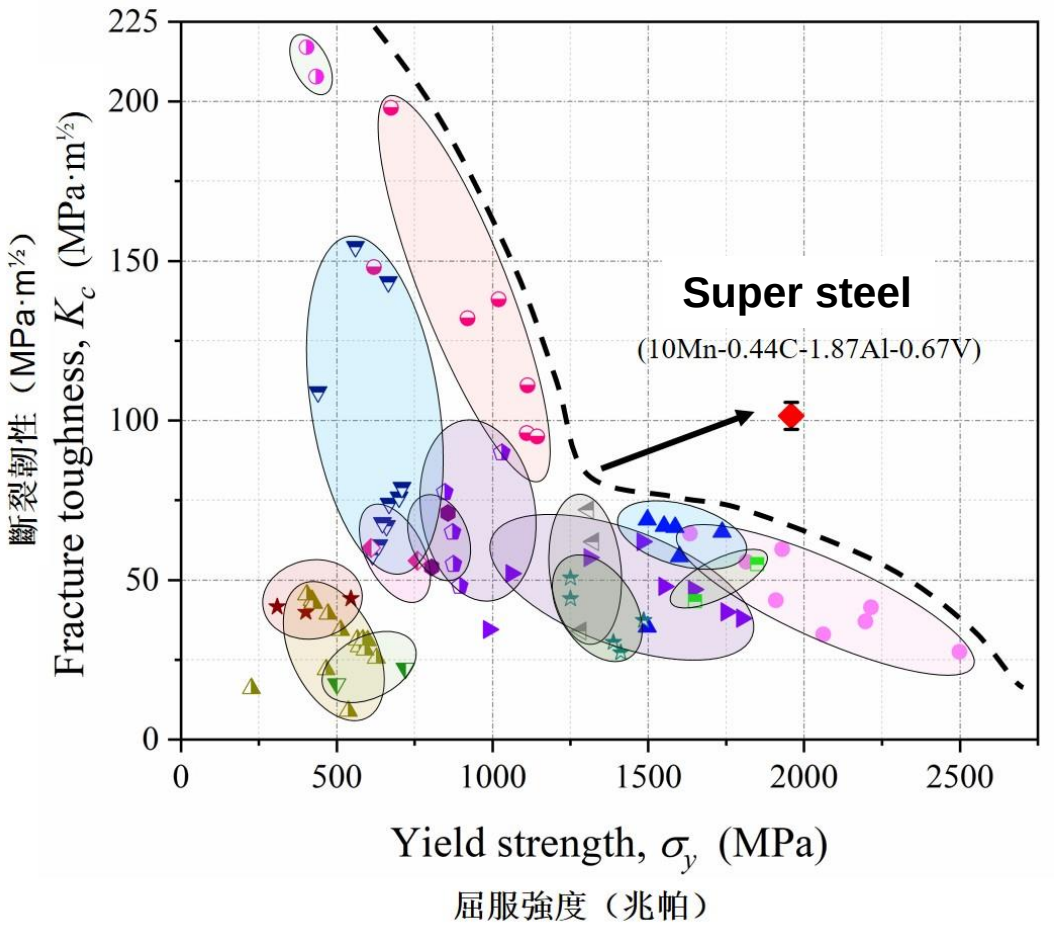
Google images.

Summary
結論



- A super steel
- Low cost
- Conventional pressing routes
- New toughening mechanism
- 超強鋼
- 低成本
- 常用的加工工藝
- 新的增韌機理

Thank you!

謝謝！