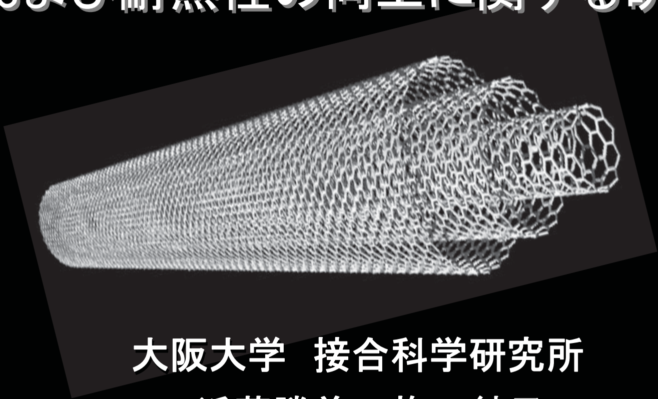
宇宙航空研究開発機構・国産旅客機高性能化技術研究開発事業　公募型研究発表会（2011年12月26日）

CNT単分散化によるチタンの静的・動的強度および耐熱性の向上に関する研究



大阪大学　接合科学研究所

近藤勝義・梅田純子

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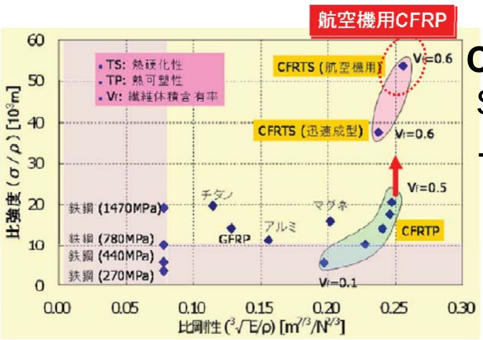
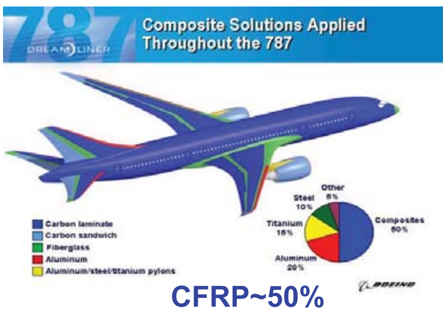
Titanium and its alloys necessary for weight reduction of airplanes





CFRP~50%

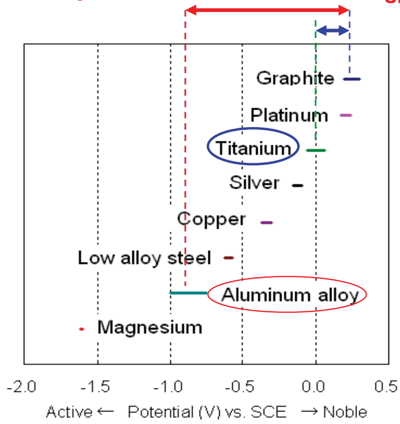
Al~20%, Ti~15%

CFRP:

Specific high Young's modulus + strength

→ Fuel efficiency improvement and CO_2 gas emission reduction

Surface potential difference, V_{SPD}



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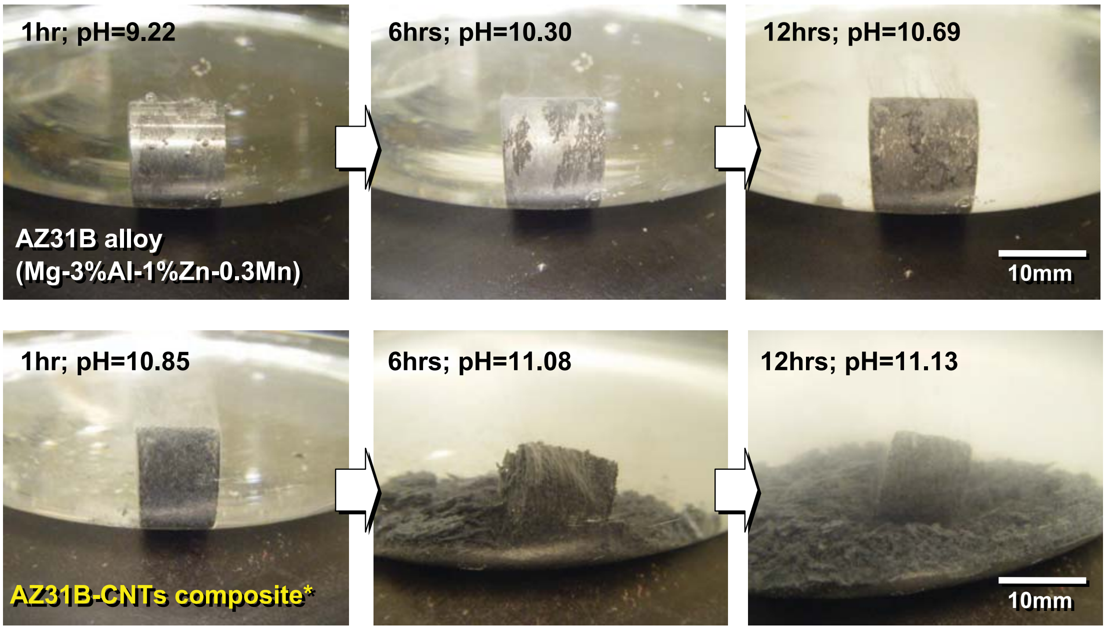

• Salt water immersion test at 35C (NaCl concentration; 3%)

H. Fukuda, J. A. Szpunar, K. Kondoh, R. Chromik, Corrosion Science, 52, (2010), 3917-3923.

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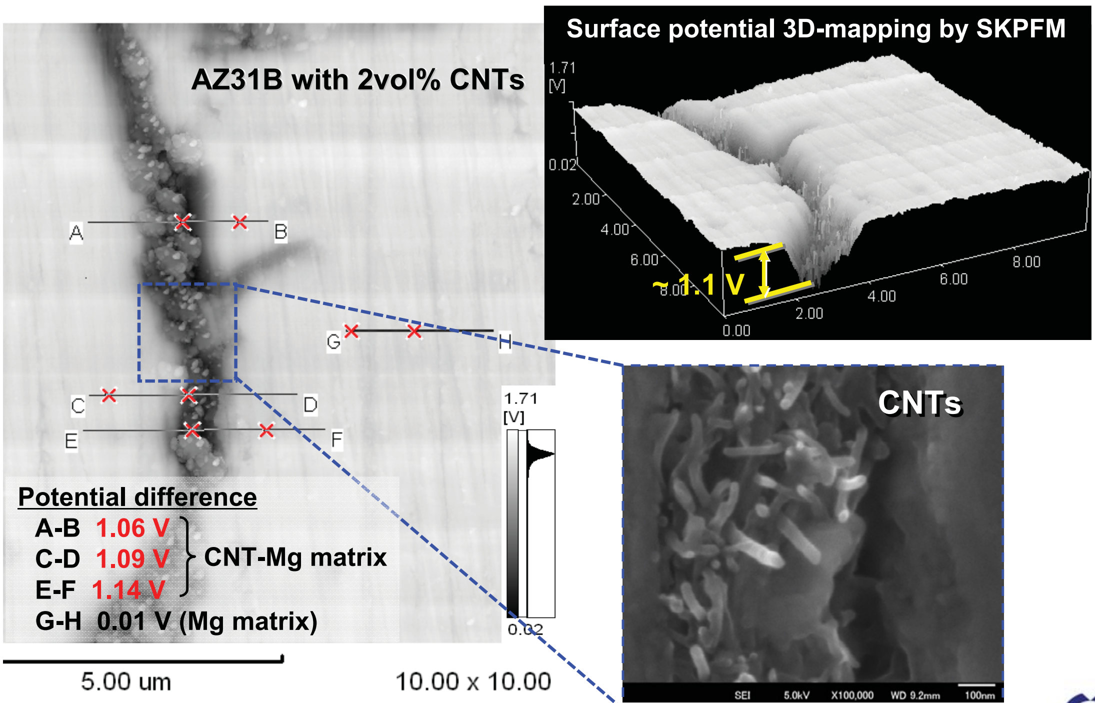

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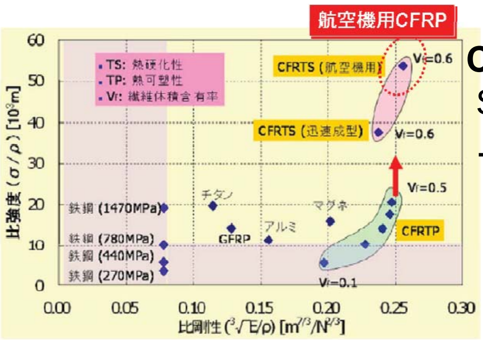

CFRP:
Specific high Young's modulus + strength
→ Fuel efficiency improvement
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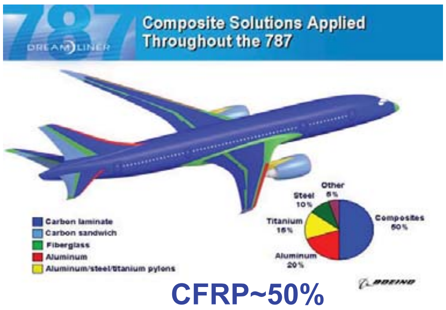
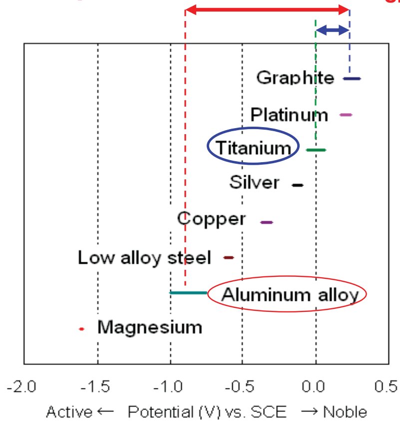


CFRP~50%
Al~20%, Ti~15%



CNT単分散化によるチタンの静的・動的強度および耐熱性の向上に関する研究

【目的】

CFRPとの表面電位差が小さいチタン（Ti）を対象に，粉末冶金法を基調としたCNTの単分散法によりCNT強化チタン複合材の作製と疲労強度・耐熱性に関する基礎データ採取，さらにはプロトタイプ素材の試作・性能評価を実施する．

【課題】

①両性イオン界面活性剤によるCNT単分散化溶液を用いたチタン粉末表面へのCNTの均一被覆法の確立

②CNT/Ti複合粉末の固相焼結固化条件の最適化

③静的強度評価と強化機構の解明
（炭素固溶強化，CNT/TiCナノ粒子複合分散強化，Ti結晶粒微細化）

④疲労強度・耐熱性の評価

⑤直径15～20mm，全長3m以上のプロトタイプ素材の試作および特性評価

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Carbon nanotubes (CNTs) benefits to all materials

- **High-strength light metal (Al, Mg, Ti) composites reinforced with MWCNTs effective for weight reduction**
- **Energy saving and Environmental benign materials**

Properties	Single-walled	Multi-walled	Steel
Specific gravity	0.8 g/cm^3	1.4 g/cm^3	7.8 g/cm^3
Tensile strength	**50~500 GPa**	**10~60 GPa**	400~1500 MPa
Young's modulus	**1.4 TPa**	**1 TPa**	210 GPa
Electric resistivity	**~1000 /μΩ cm**	**~200 /μΩ cm**	9.7 /μΩ cm
Thermal conductivity	**3 kW/m K**	**3 kW/m K**	80 W/m K

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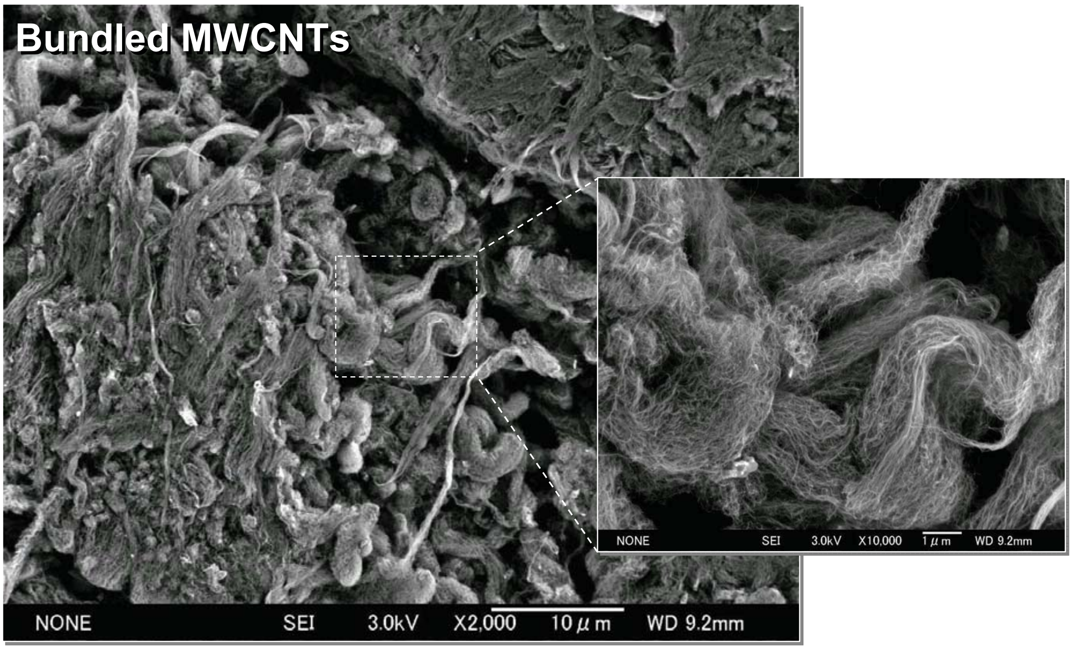
Segregation of bundled Multi-Walled CNTs due to Van der Waals force



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Previous Studies in CNTs Reinforced Metal Matrix Composites (MMCs)

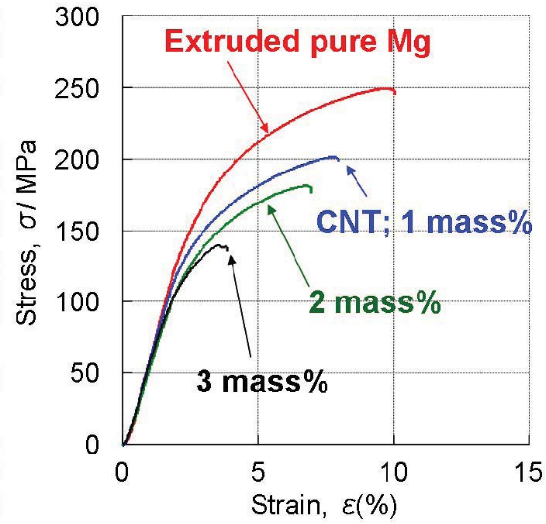
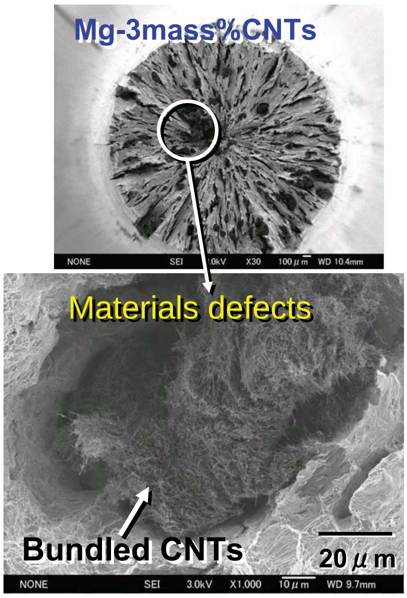


Fig: Stress-strain curves of P/M pure Mg composite reinforced with MWCNTs.



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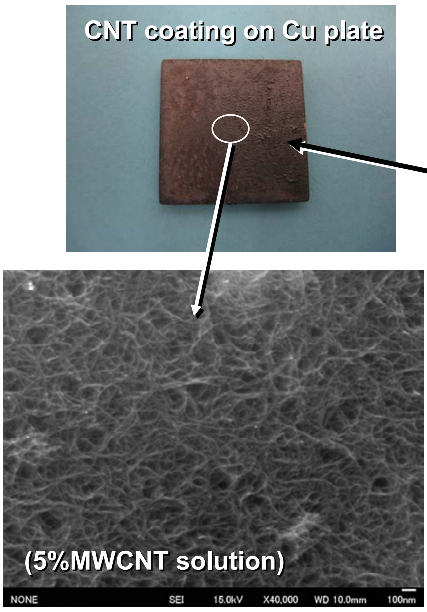
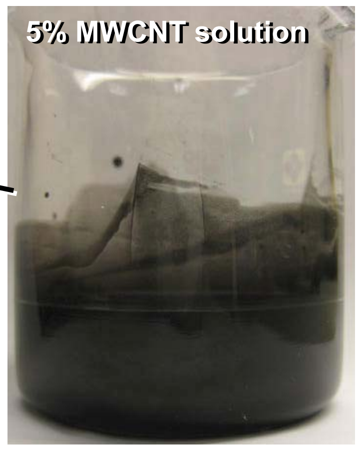
Un-bundled CNTs formation in zwitterionic surfactant solution





CNTs distributed in water
with zwitterionic surfactants
(in 2 weeks)

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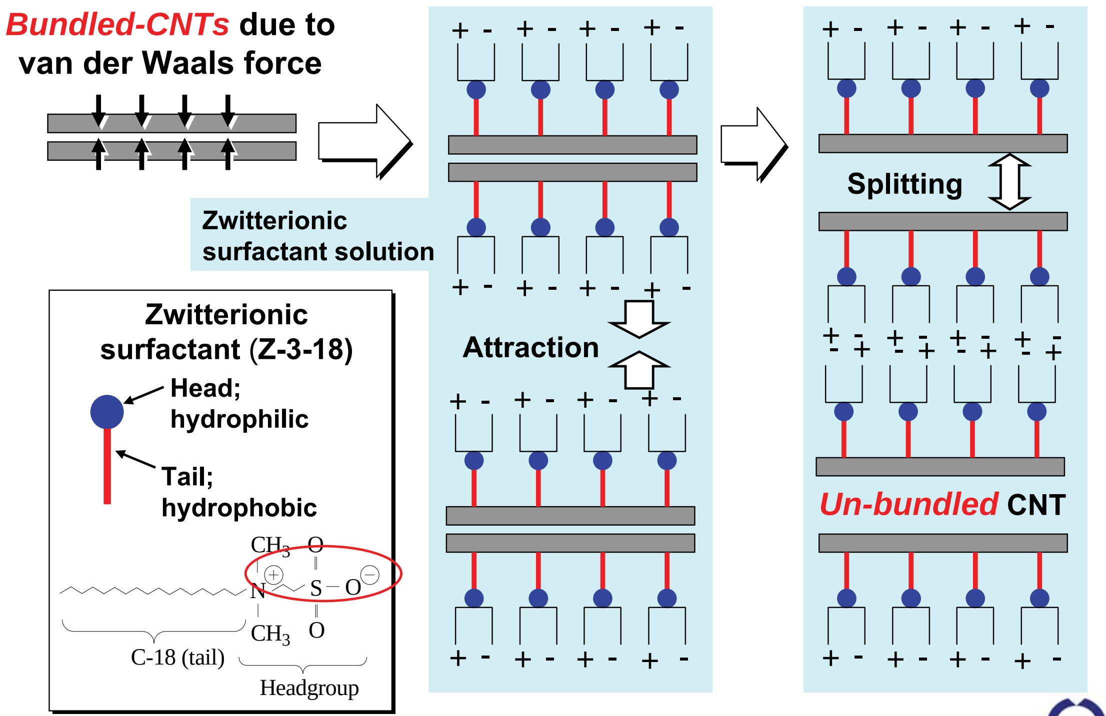
Un-bundled CNTs formation in zwitterionic surfactant solution



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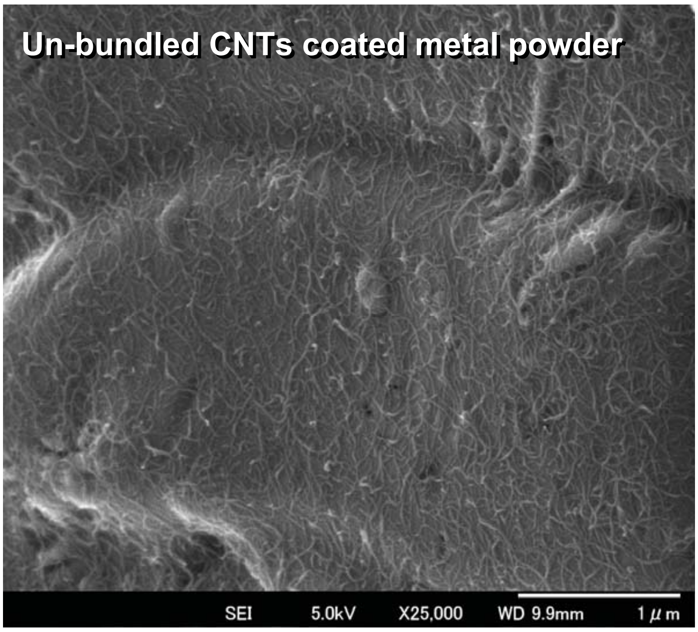
Preparation of composite powders coated with un-bundled CNTs

Un-bundled CNTs dispersed in solution



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Tensile stress transfer at interface of matrix/CNTs by TiC formation

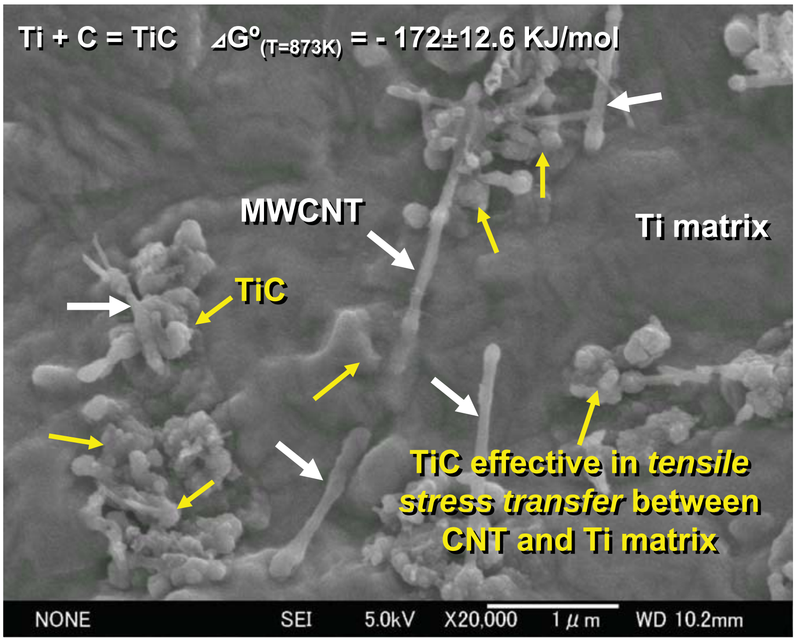

Fig: SEM observation on CNT/Ti composite powders after annealed at 873K in Ag gas.
(In-situ formed TiC particles detected between CNTs and Ti matrix)

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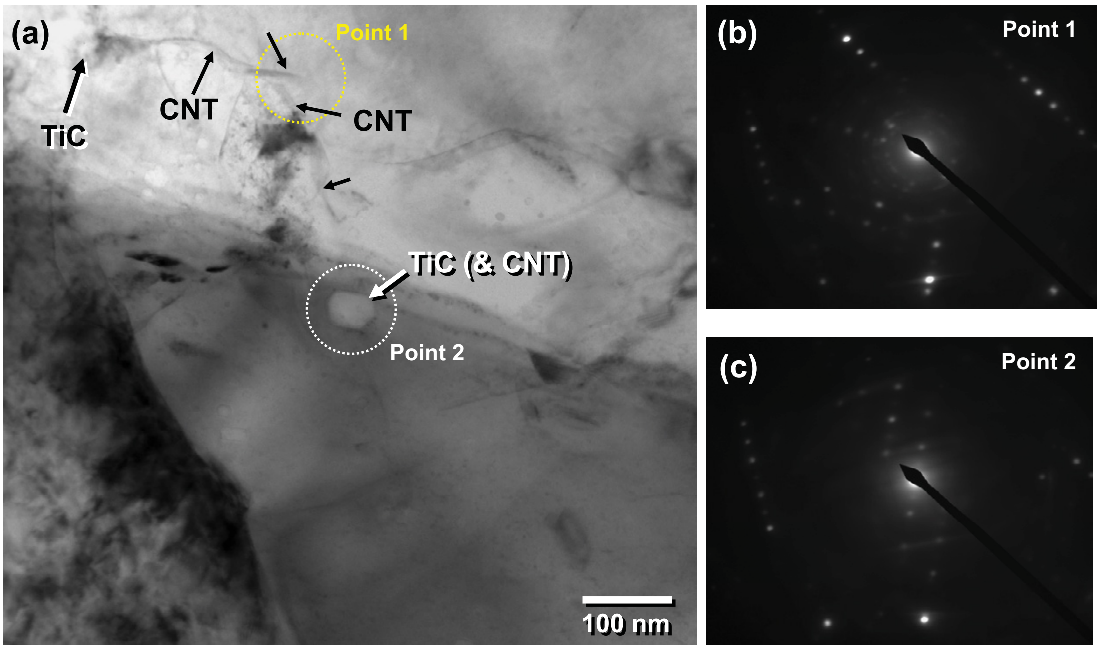
Microstructures of CNTs reinforced Ti composites



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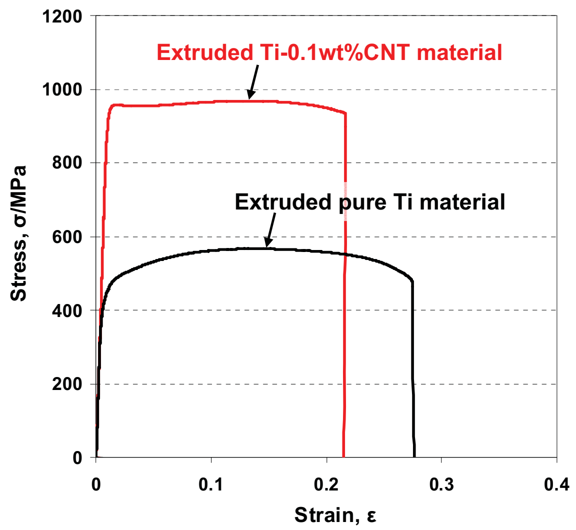
Mechanical behavior of CNTs reinforced Ti composites



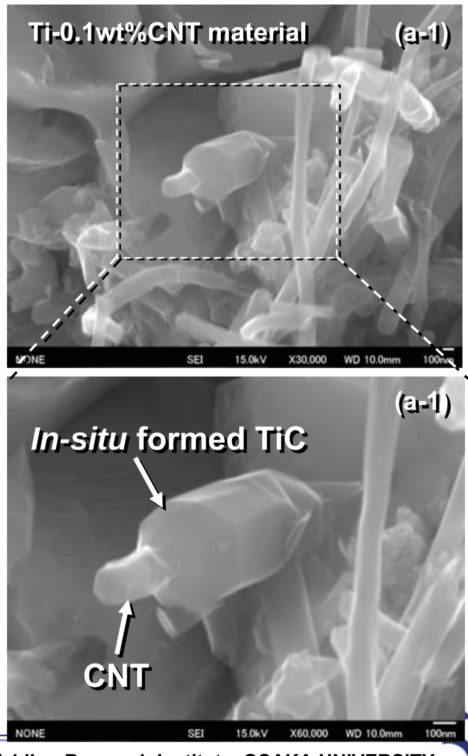


Fig: Stress-strain curves of extruded pure Ti powder material and its composite reinforced with CNTs, and SEM observation of fractured surfaces after tensile test

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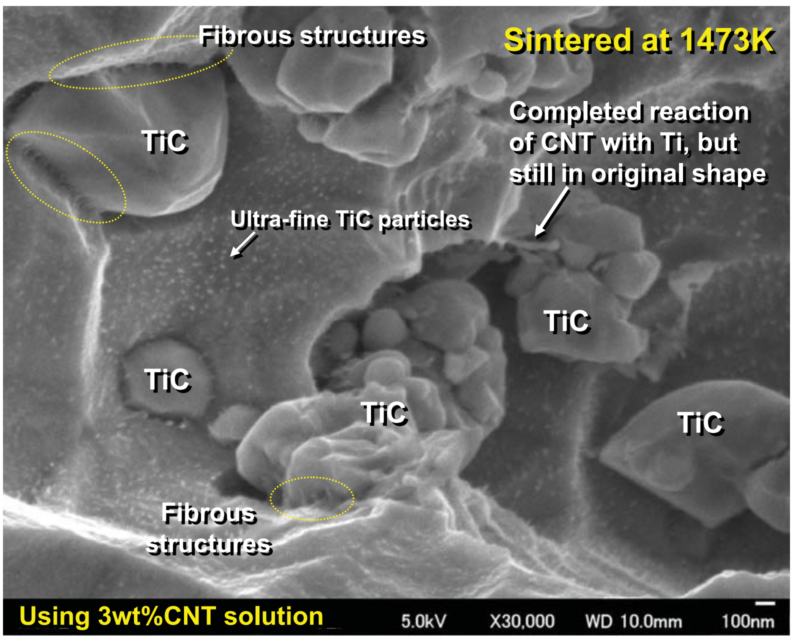
Mechanical behavior of CNTs reinforced Ti composites



TS; 918 MPa
YS; 886 MPa
ε; ~ 8%

Extruded Ti-CNTs powder composite material via SPS at 1473K.

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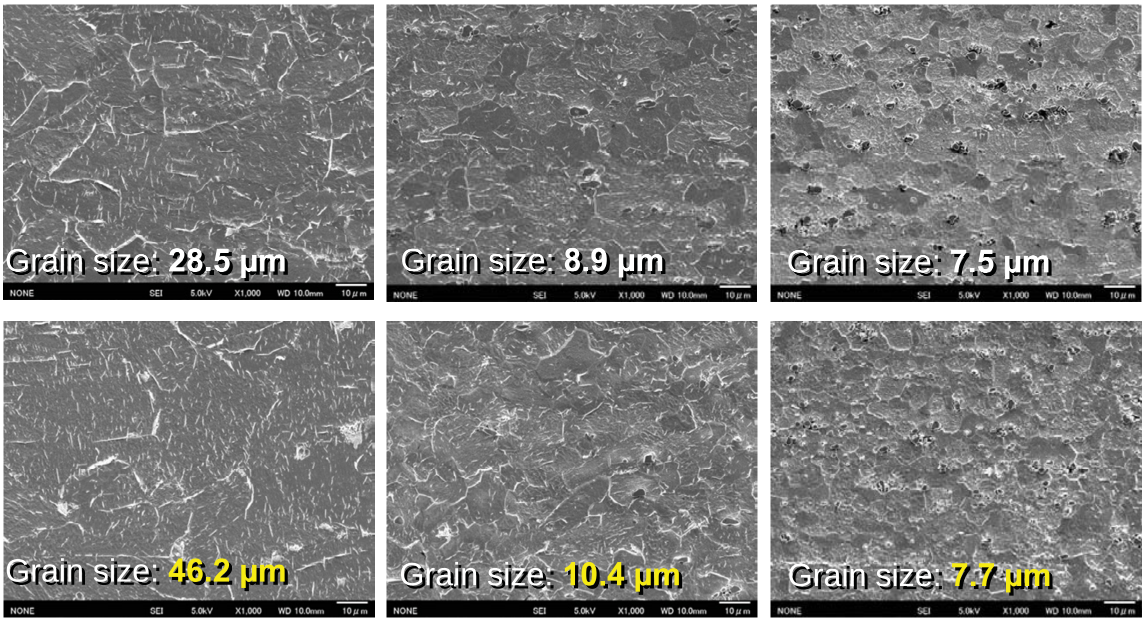
Thermal stability of CNTs reinforced P/M pure Ti composites

(a) Ti with no CNT (b) Ti -0.06wt%CNTs (c) Ti -0.1wt%CNTs



****Annealed at 300℃ (upper) and 400℃ (lower) for 10hrs***

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Thermal stability of CNTs reinforced P/M pure Ti composites

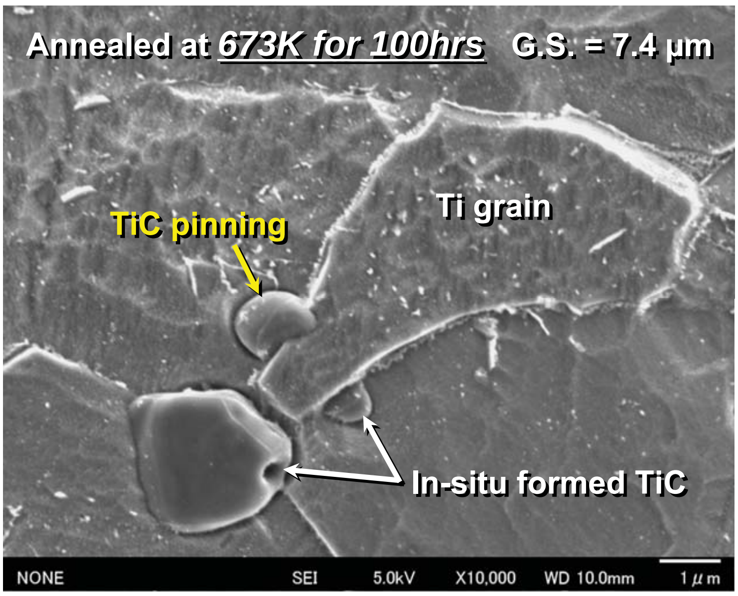

Fig: SEM observation on pure Ti powder composite with 0.1wt% CNTs after annealing at 673K for 100hrs. In-situ formed TiC dispersoids at grain boundaries are effective to obstruct Ti grains growth by their pinning effect.

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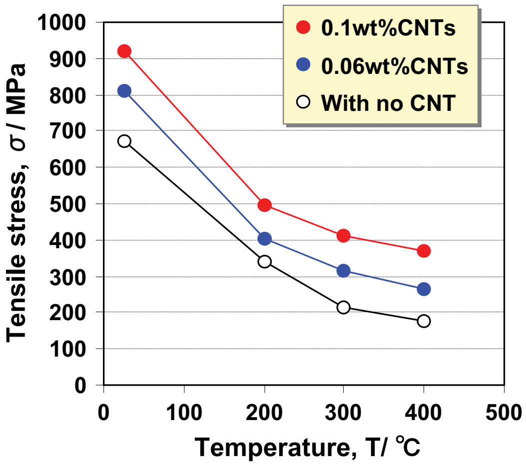
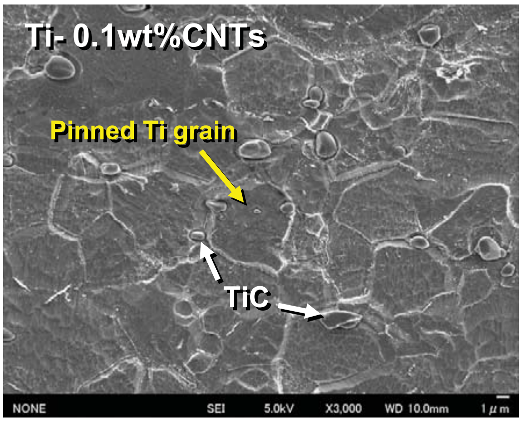
High-temperature property of CNTs reinforced P/M pure Ti composites

• **High-temperature strength improved by TiCs pinning effects**





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