

An Overview of Taiwan's Titanium Industry







Outline

1. **Market information**
2. **Highlights of Taiwan's Ti Industry**
 - **Golf clubs head business**
 - **Aerospace & biomedical business**
 - **Industry, Architecture & Tableware business**
3. **Conclusions**

Yeong-Tsuen Pan

**New Materials R&D Dept.
China Steel Corp., Taiwan**

Industrial Materials Business

 CSPM	<p>Main products include Titanium alloy, Nickel alloy, Tool and mold steel, Special stainless steel, Ti seamless alloy tube etc.</p>
 TTMC	<p>Main products include conductive paste for silicon wafer-based solar cells and the sputtering targets(Al, Ag, Cu, Ti, Ni, Cr, Mo, Ta, ITO, AZO...) for thin film processing. Gas atomizing alloys powders are also available.</p>
 BETACERA	<p>Main products include thermistors (PTC Thermistor and NTC Thermistor) and electronic ceramics (Dielectric Ceramic and Piezoelectric Ceramic).</p>
 HIMAG	<p>Main products include high-purity iron oxide, soft ferrite powders with high-permeability and low-loss, garnets for the communication industry, electromagnetic absorbers for RFID/NFC & catalysts for ECO-equipment.</p>
 CSAC	<p>Major products include aluminium plates, sheets, coils, foil, drops, zinc alloy ingots, etc.</p>
 CSCC	<p>Main products include coal chemicals (Coal tar and light oil are distilled into soft pitch, creosote oil, refined naphthalene, benzene and toluene) and Anode Materials for Li-ion Battery.</p>

An illustration of a hand holding a scroll. The scroll is white with a blue line graph on it. The graph starts at the bottom left and goes up to the top right. The background is a blue cityscape.

1. Market information

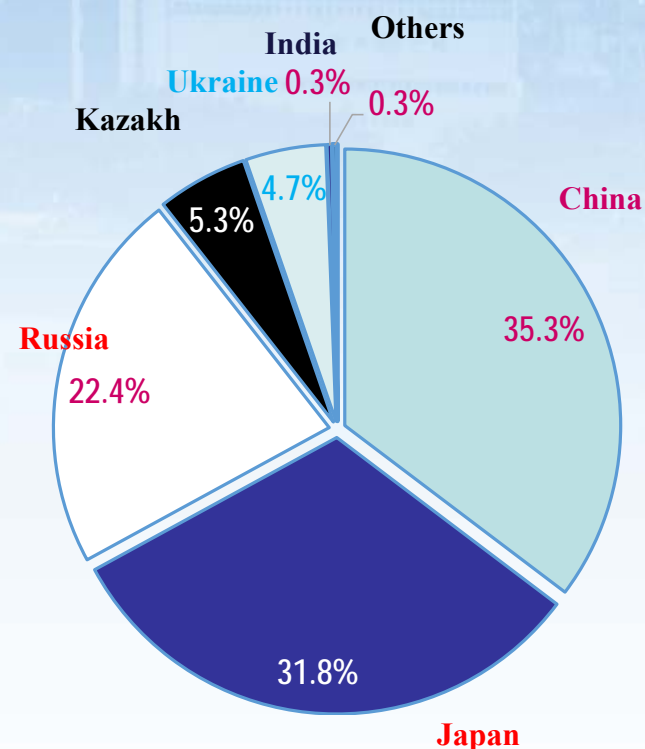
1. Market - Global

- The global Ti sponge yield increases from **155,376 MT** (2008) to **170,000 MT** (2017, CAGR 1.0%), Price decreases from **15,640 USD/MT** to **10,711 USD/MT** (CAGR -4.1%) .
- The yield ranking order of Ti sponge in major nations(2017): **China(35.3%)** 、**Japan(31.8%)** 、**Russia(22.4%)** 、**Kazak(5.3%)** 、**Ukraine(4.7%)** 、**India(0.3%)** 。

Yield and Price of Global Ti Sponge
(2008~2017)



Yield of Global Ti Sponge (2017)



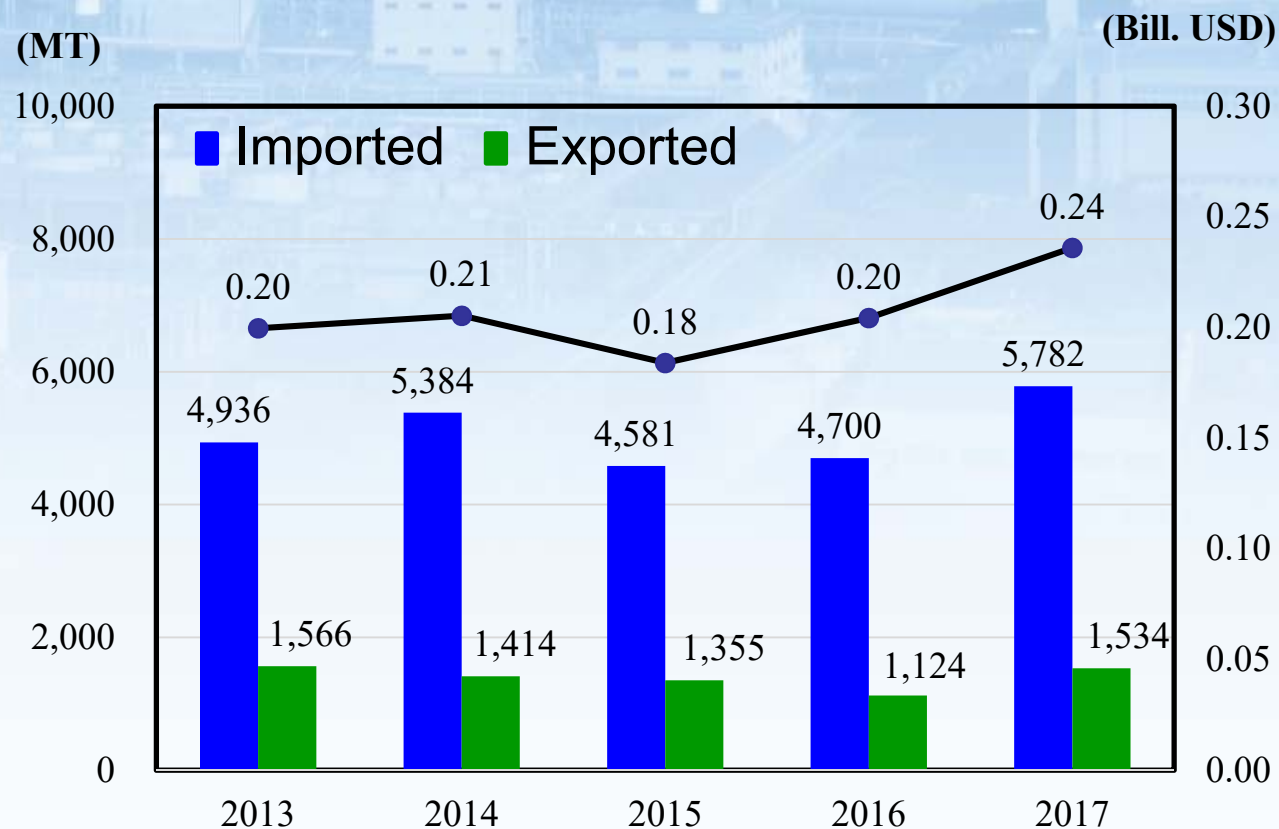
Global Ti Market- Region (2017)

Rank	Region	Imported Qnt (MT)	Ratio	Region	Exported Qnt (MT)	Ratio
1	USA	58,088	23.73%	USA	45,345	20.1%
2	UK	26,536	10.84%	Japan	44,154	19.6%
3	Germany	20,732	8.47%	Russia	29,427	13.1%
4	France	19,657	8.03%	Germany	16,820	7.5%
5	S. Korea	13,362	5.46%	UK	15,878	7.0%
6	China	11,722	4.79%	France	11,807	5.2%
7	Estonia	9,148	3.74%	Estonia	11,336	5.0%
8	Malaysia	8,833	3.61%	Malaysia	6,851	3.0%
9	Italia	8,172	3.34%	Italia	6,630	2.9%
10	Canada	8,081	3.30%	Dutch	6,554	0.0%
11	Taiwan	5,782	2.36%	15 Taiwan	1534	
	Sub sum	190,213	75.3%	Sub sum	194,802	86.5%
	Total	244,746	100.0%	Total	225,239	100.0%

Net in Taiwan~4260MT (Imp. 5782MT, Exp. 1534MT)

Taiwan Market

- Ti Market is booming due to **the return of Golf clubs business** and **the establishment of local supply chain of raw materials**, thus promoting the formation of emerging Ti industry clusters, ex. tableware and architecture.
- The Ti production value comes to 0.24 billion USD in 2017 (CAGR4.3%)。

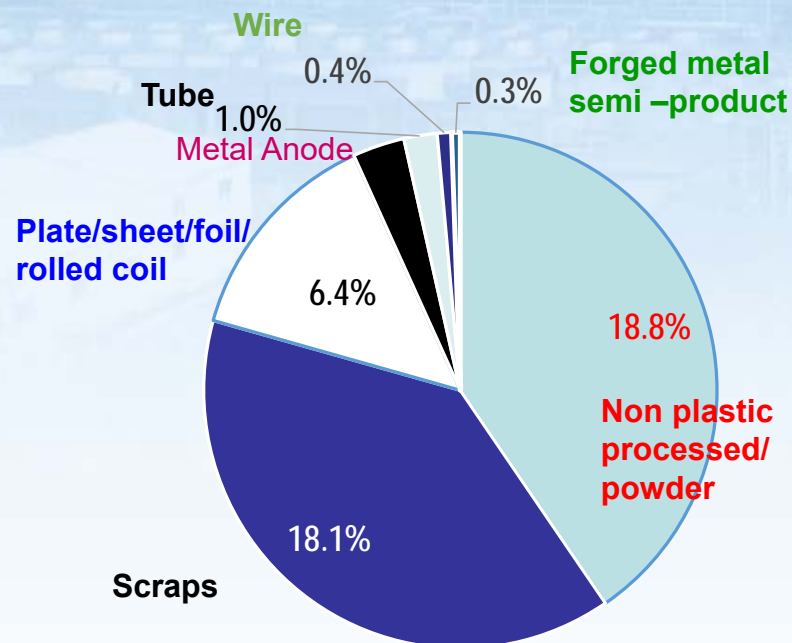


Taiwan Market- Summary (2017)

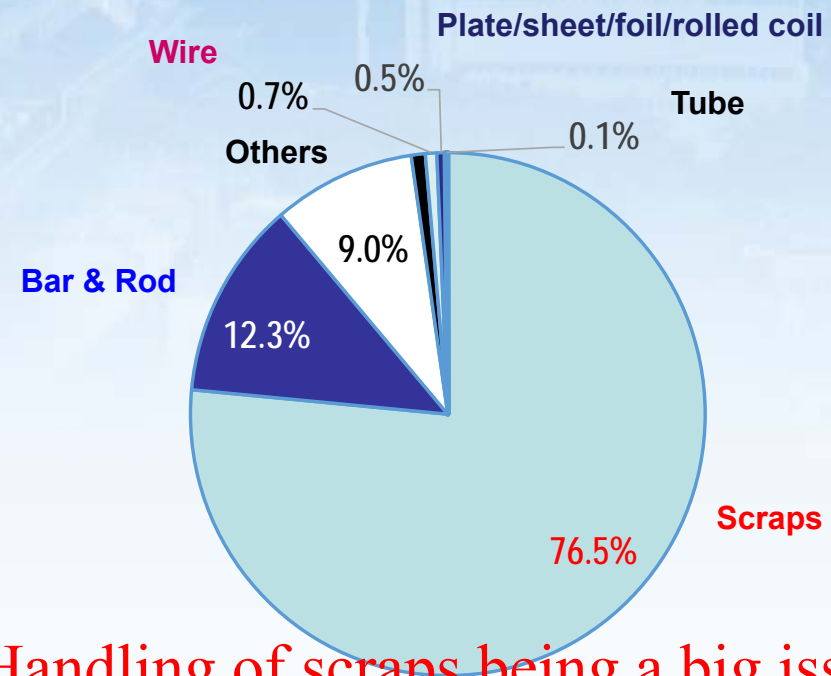
■ Main Imported items: **non-plastic processed Ti & powder** (18.8%) , **Scraps** (18.1%).

■ Main Exported items: **Scraps**(76.5%), **Bar&Rod** (12.3%).

2017 Imported Ti (Taiwan)



2017 EXported Ti (Taiwan)



Handling of scraps being a big issue due to the ban of China since 2019.



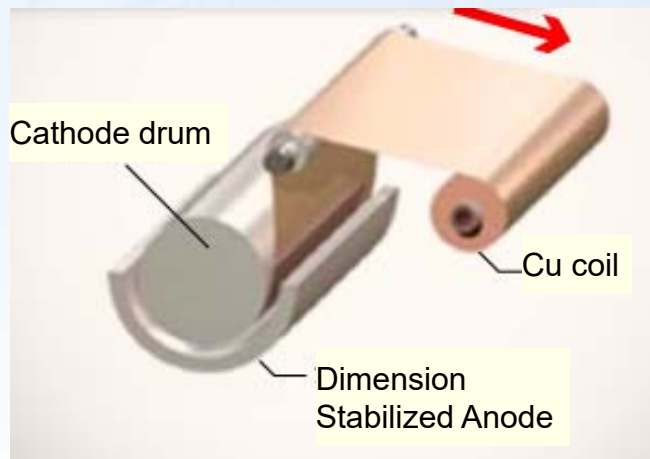
2. Highlights of Taiwan's Ti Industry

Titanium industry in Taiwan

- Golf clubs head business
- Aerospace & biomedical business



- Industry, Architecture and Tableware business



Ti industry in Taiwan- **Golf clubs head business**

Table Supply of Golf clubs (2014~2017)
(including the amount produced overseas)

		2014		2015		2016		2017	
	Country	Amount 10 ³ pc	Global ratio	Amount 10 ³ pc	Global ratio	Amount 10 ³ pc	Global ratio	Amount 10 ³ pc	Global ratio
No.1	Taiwan	40,690	81.3%	30,300	80.7%	30,900	81.0%	31,500	81.1%
No.2	China	2500	5.0%	2350	5.1%	2300	5.2%	2250	5.0%
No.3	Thailand	1450	2.9%	1300	3.2%	1250	3.0%	1350	3.1%

Main producers in supply amount order:

- 1) 50% * Precision 2) 12%



- 3) 12% 4) 6%



- 1st Ti club by Joy Co.(1990.03)
- Club in the driver and woods segment of the market: Ti (40%), SS(59%), and others(1%)
- Callaway (42%)、 Taylor Made (35%).
- **Ti head:>100,000 pc/y (Taiwan)**

Previously OEM dominant, Now OEM/ODM.

Status of Titanium Golf clubs head in Taiwan

- For club head **body**, **VAR precision casting** is dominant (**The Top 4 supplier equipped**), **Forging/stamping & arc welding** is minor.
- ✓ The Titanium alloy plates for clubs head face **are all imported**.



Body:
Ti-64 prec. casting
Face:
Ti-64 rolled plate



Body:
Ti-64 prec. casting
Face:
SP700HM plate



Body & Face:
Ti-64 prec. casting
with W



Body:
Ti-811 prec. casting
Face:
Ti-64 forged plate

Ti industry in Taiwan- Aerospace business

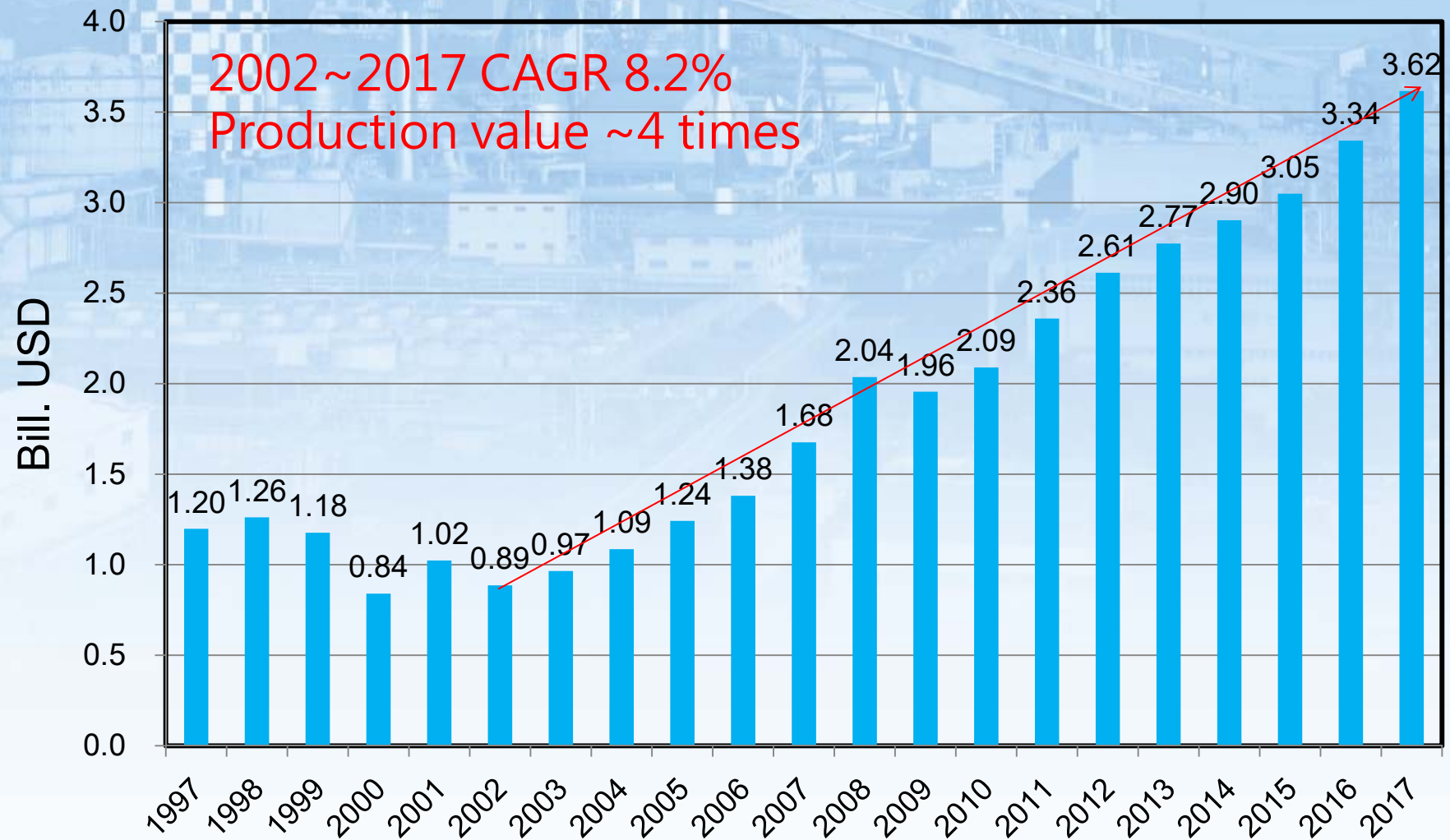
Top 10 countries by rank for aerospace attractiveness 2017 by PWC

Country	Overall Rank	Cost	Labor	Infra-structure	Industry	Geo-political Risk	Economy	Tax Policy
United States	1	11	2	6	1	2	16	36
Switzerland	2	18	9	11	18	5	7	18
United Kingdom	3	23	16	5	4	7	28	10
Australia	4	13	11	20	16	1	17	25
Canada	5	24	8	13	8	13	26	17
Taiwan	6	7	6	17	22	18	14	30
Hong Kong	7	16	18	1	18	39	20	3
Japan	8	8	3	10	6	10	12	70
Denmark	9	5	13	8	51	25	15	7
Germany	10	19	7	6	5	4	38	48

<https://aiamnow.com/pwc-2017-aerospace-manufacturing-attractiveness-rankings/pwc-ad-countries-table/>

Due to good machining capability and affordable cost.

Aerospace Production Value in Taiwan



Ti industry in Taiwan- Aerospace business

Under the leading of AIDC

- OEM machining for Ti aero engine parts



Fan blade

(CHPC)



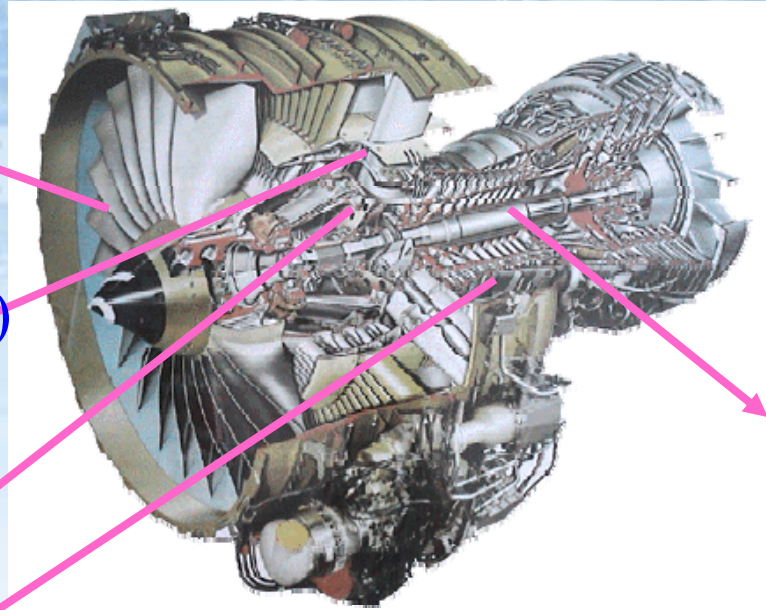
Thin Stru



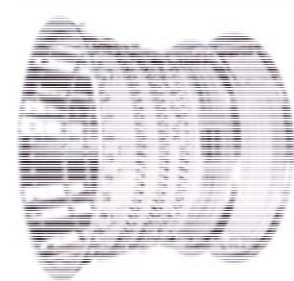
End Rod



Comp. Front Case



Air duct



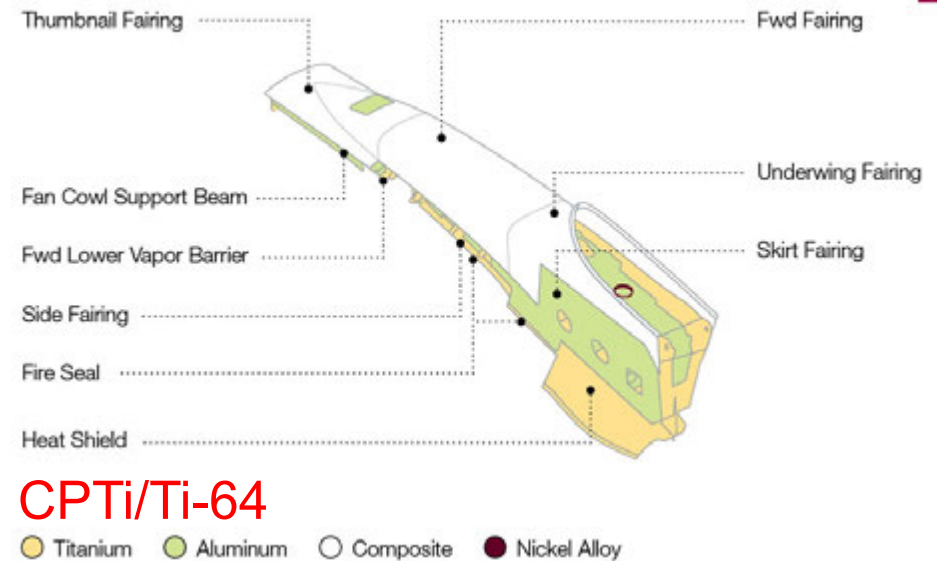
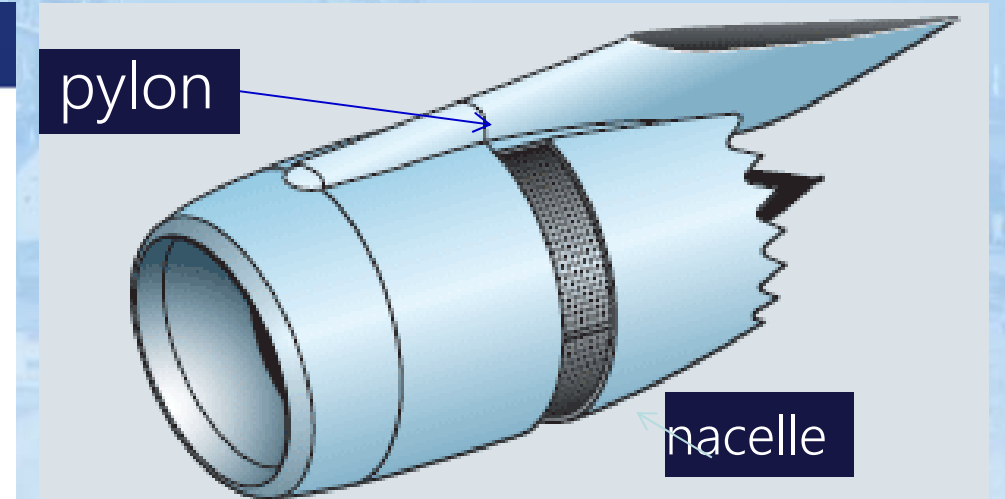
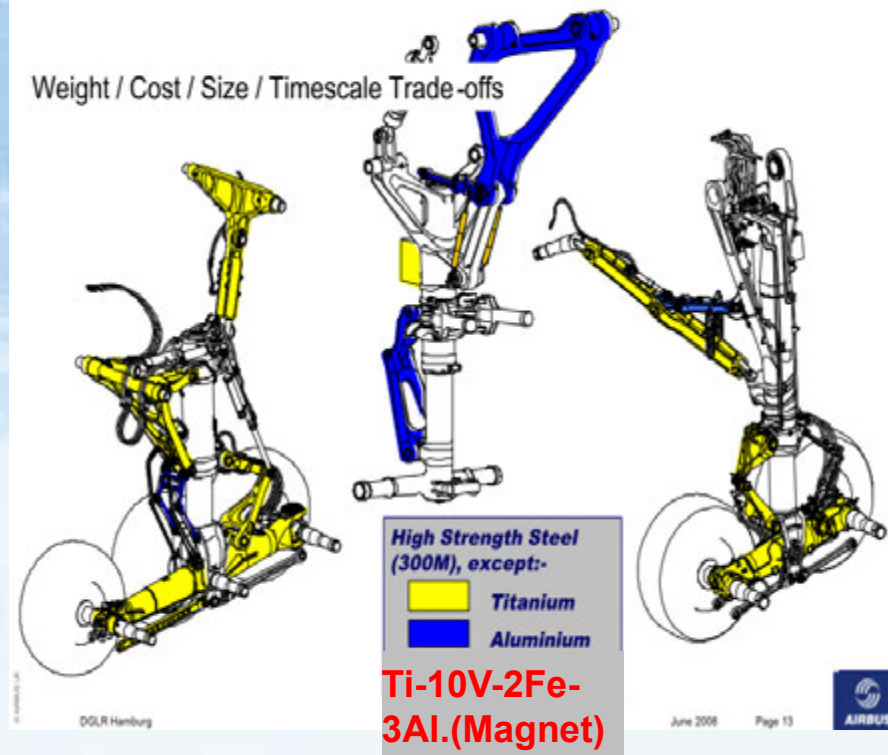
Comp. Rear Case

Ti-64/Ti-6242: All imported

(CHPC, Magnet, ChenFull Intn'l Co.)

Ti industry in Taiwan- Aerospace business

A380 Landing Gear & Systems – An Overview Landing Gear Structure



- OEM machining for Ti aero parts
- All Ti raw materials are imported

Ti industry in Taiwan- Aerospace business

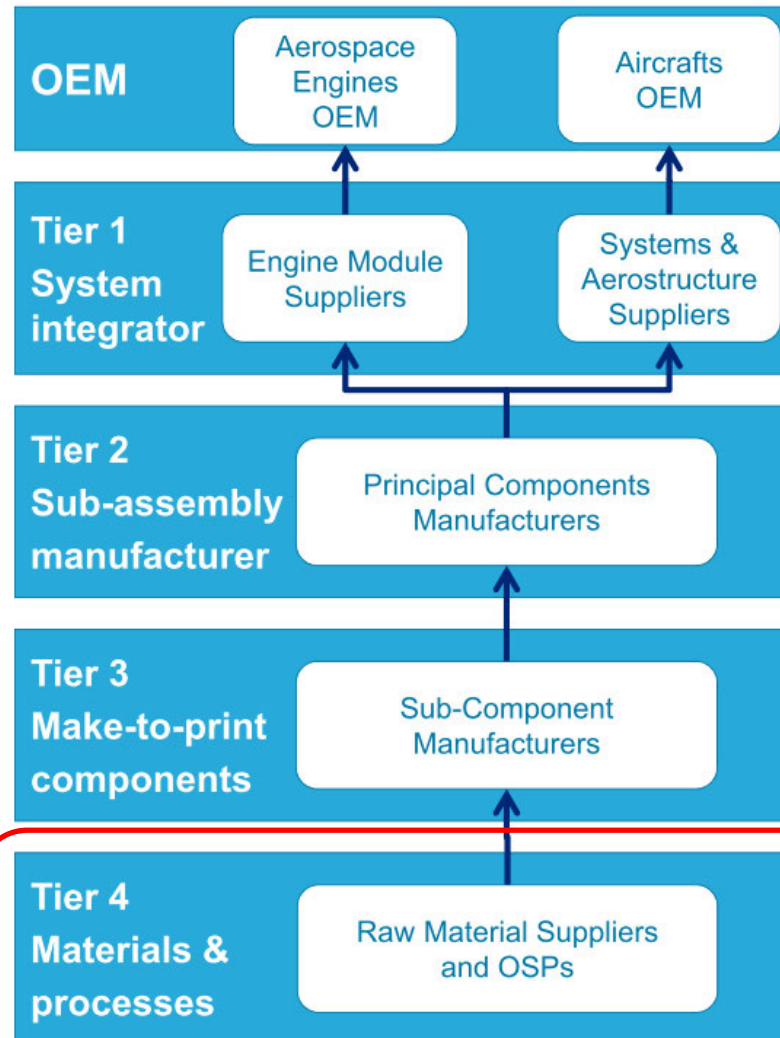
- **NAFCO** is the only specialty alloy aero fastener maker in Taiwan.(mainly Ni-base, minor **Ti** ~3 MT/y).



All Ti raw materials are imported due to DFARS
(Defense Federal Acquisition Regulation Supplement)

Ti industry in Taiwan- Aerospace business

Aerospace Supply Chain



GE/RR



Boeing/Airbus



AIDC



MBD/ UTC
(Goodrich)



Magnet
/ChenFull



Sumitomo
Precision
Products



JSPCO



Magnet/DPI



PCC/Alcoa



PCC/Alcoa

All Ti raw materials are imported

Ti industry in Taiwan- **Biomedical business**

- Same as aero business, Taiwan is one of the OEM partners of well-known biomedical device companies (Striker, JMM, Biomet etc.), due to the high competitive **machining and forging capability**. Recently, we also developed our-own brand products.



- **Asia Plate & Screw Implants** (own Ti product)



- Various Orthopedic Ti products (own brand)

United Orthopedic Co.



- Various dental Ti products (own brand **AZURE dental-Zimmer** as reseller for C/P concerned countries)



- Dental Ti products (own brand)

All Ti raw materials are imported

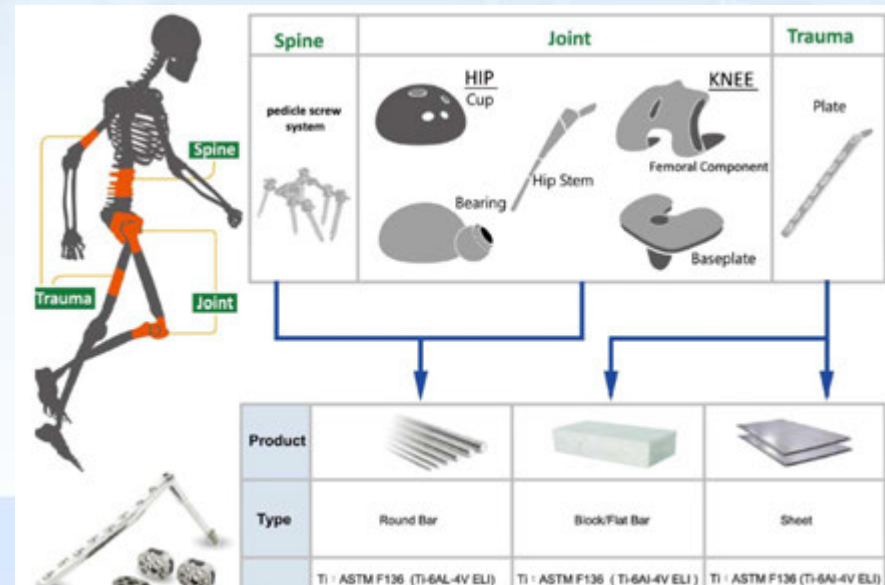
Ti industry in Taiwan- **Biomedical business**

- **S-Tech**, a subsidiary co. of GMTC, was founded in 2002 aiming to produce Ti alloys for bio and aero applications.
- **S-Tech** acquired certificates from **Striker, Zimmer etc.** since 2006



- **500+ MT/y** of **S-Tech** Biomedical Ti Bars were exported by 2015.

Product				
Type	Long bar	Column	Square forged plate	Disc
Size	Dia 4-12mm	Dia 4-50mm	100x100*15~20 or by customer's requirement	Ø98*15~20 by customer's requirement
Spec.	Ti: ASTM F67 Gr.1-Gr.4 (Pure Ti) ASTM F136 (Ti-6Al-4V ELI) ASTM F1472 (Ti-6Al-4V) AMS 4930 (Ti-6Al-4V ELI) Co: ASTM F1537 (Co-28Cr-6Mo)	Ti: ASTM F67 Gr.1-Gr.4 (Pure Ti) ASTM F136 (Ti-6Al-4V ELI) ASTM F1472 (Ti-6Al-4V) AMS 4930 (Ti-6Al-4V ELI) Co: ASTM F1537 (Co-28Cr-6Mo)	Ti: ASTM F67 Gr.1-Gr.4 (Pure Ti) ASTM F136 (Ti-6Al-4V ELI) ASTM F1472 (Ti-6Al-4V) AMS 4930 (Ti-6Al-4V ELI)	Ti: ASTM F67 Gr.1-Gr.4 (Pure Ti) ASTM F136 (Ti-6Al-4V ELI) ASTM F1472 (Ti-6Al-4V) AMS 4930 (Ti-6Al-4V ELI)

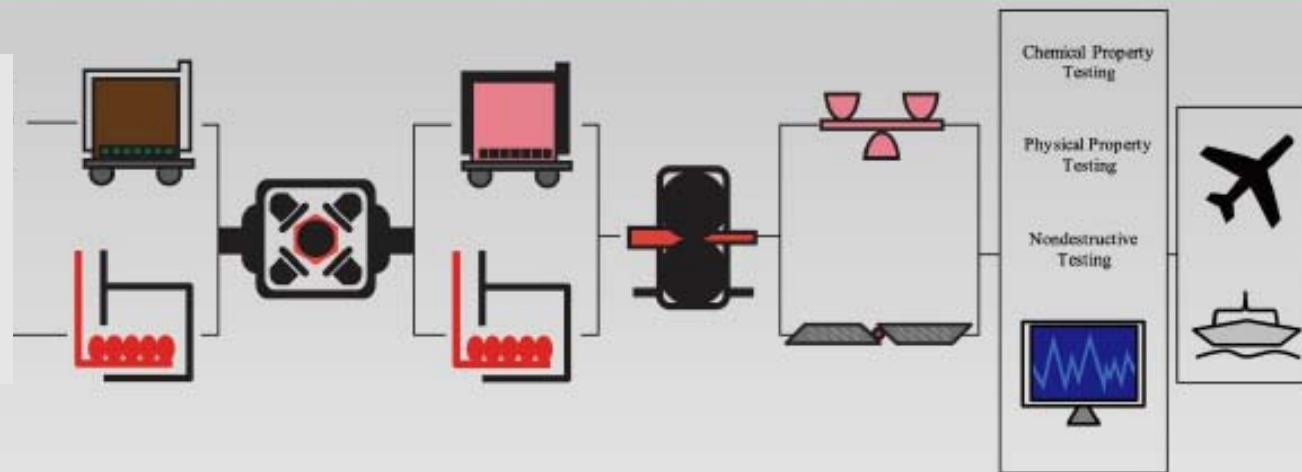


Ti industry in Taiwan- **Biomedical business**

- **S-Tech** can supply the Ti **long products** for Biomedical and consumer applications

MANUFACTURING PROCESS

Ingots
from
VSMPO,
Timet



Melting — Furnace — Forging Machine — Annealing Furnace — Cross Mill — Finish — Inspection — Shipping



Coil



Round Bar



Flat Bar

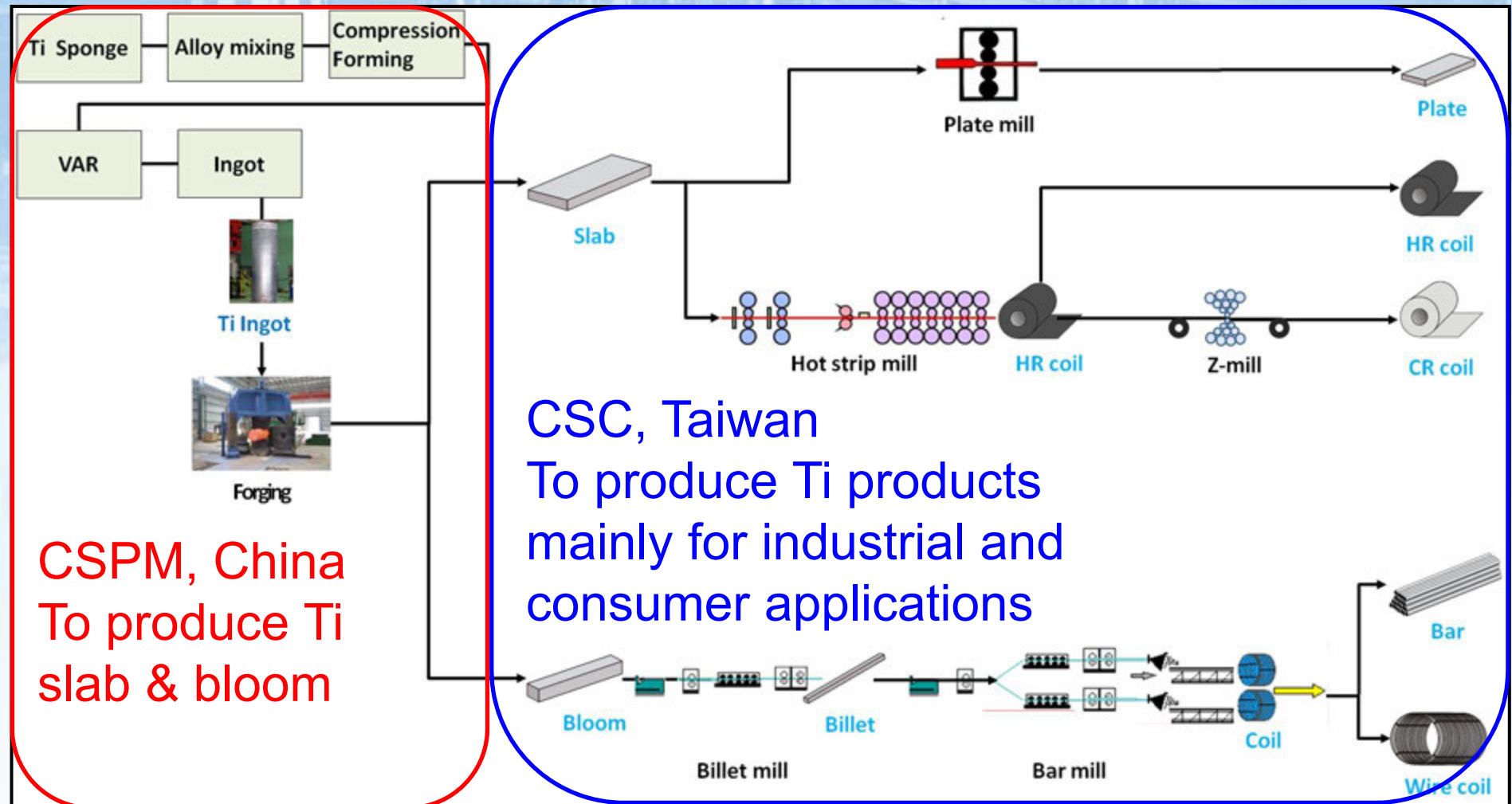


Square Bar



Special Shape Parts

Ti industry in Taiwan- Industry & consumer business



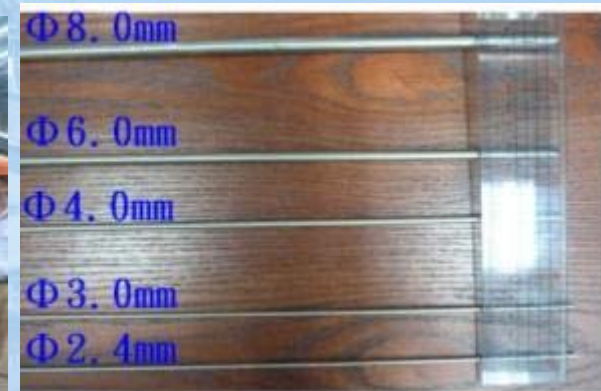
Ti Alloy Products available from CSC



Thick Plate



Rod/Wire



Peeled Wire



HR AP Coil



CR AP Coil

- A series of Ti products, including plate, bar/rod, HR/CR coil, have been successfully produced.

Production of Heavy Unit Weight GR.5 Rod



Blooms



Billet rolling



Rod rolling & coiling



600-1200kg/coil (CSC)

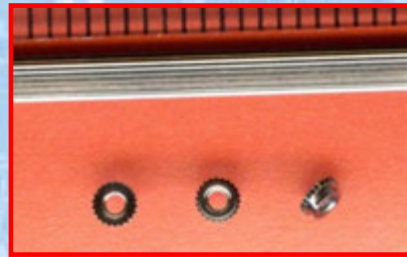


30~60kg/coil(China)

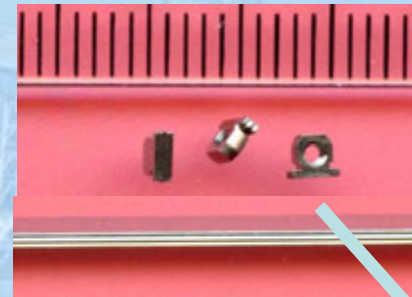
- **Merits of large size coils: uniform and stable qualities, higher production efficiency in the down stream processes.**

CSC's GR.5 Nuts inside iPhone

Round nut



Shaped nut

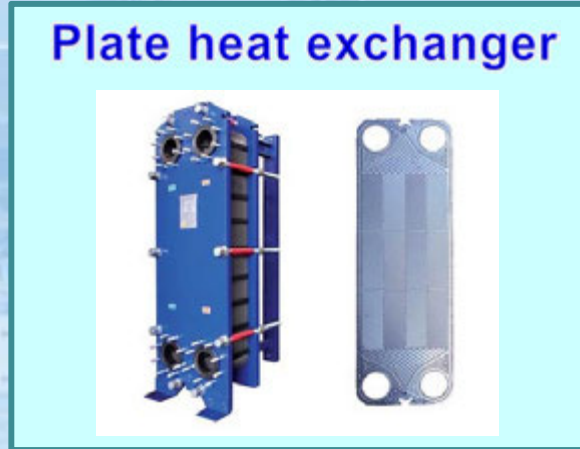


iPhone5 inner component

iPhone6 inner component

- 50% + Gr.5 Ti wires for iPhone 5 and iPhone 6 nuts are supplied by CSC group.

Down Stream Applications of Ti Alloys



- **9+** Ti alloys have been developed, such as Gr.1, 2, 4, **5**, 9, 12, 23, 15-3.
- Major applications in chemical industry, electronics, energy, architecture.
- Moving forward to **biomedical and aerospace applications**.

Down Stream Applications of Ti Alloys



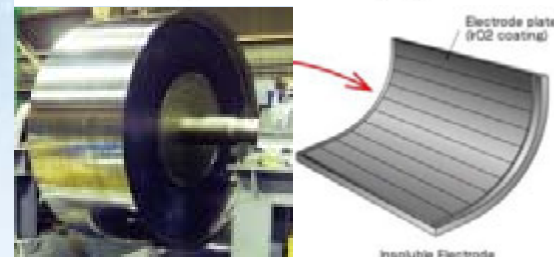
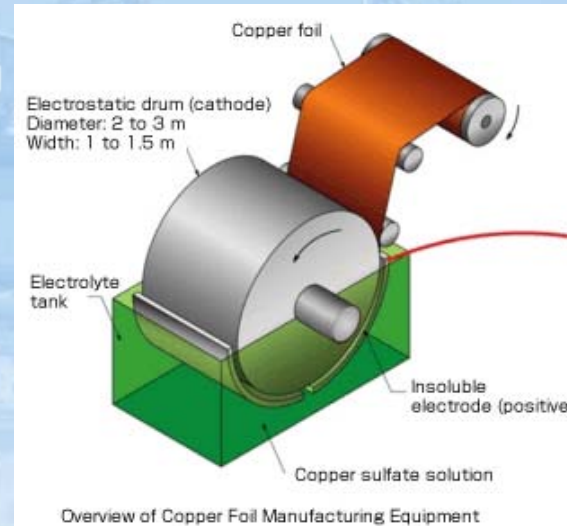
Cupware



Exhaust pipe



Fastener



Copper Foil DSA
Drum imported



Anode basket



Race car
spring

➤ **Ti-made goods has enter people's daily life.**

Down Stream Applications of Ti Alloys

Taipei dome



Dragon Steel Bld.



NTNU Campus Bld.



**Sunrui Wanji Bld.
China**



**Shanghai KCIS Bld.
China**



NTNU Art Bld.

Titanium industry in Taiwan- **Tube business**



Uncoiler

Welding
Jointer

Flat
Looper

TIG/Laser
Welder

Tube-
former

Induction
Heater

In-line
BA

In-line
ECT

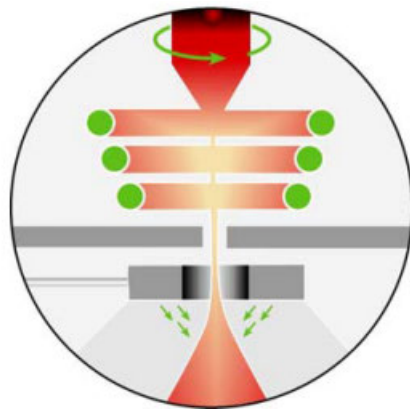


維佳工程有限公司
VEGA ENGINEERING CORPORATION

- No Tube-making line in Taiwan due to a limited demand.
- Tubes for exchanger are all imported, mainly from Japan & China, for desalination plant and power plant.
- **VEGA** Eng. Co. has exported 10+ Ti tube lines to China.

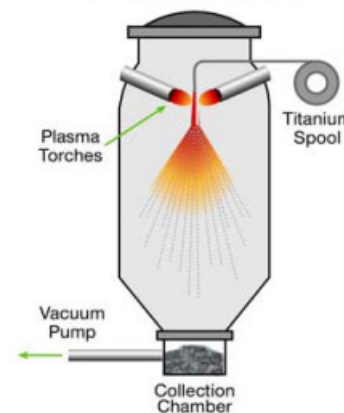
Ti industry in Taiwan- 3D printing powders

Crucible-free Atomization Process: Own-designed



- 'Crucibleless'
- Ar or Ni gas used for atomisation
- Yield within 20-125 micron (+600/-120 mesh) = approx 50-60%
- Suitable for small runs of reactive materials
- Satellites
- Internal Porosity

Plasma Wire Atomization Process: Turned key facility



- Low Porosity Powder
- Spherical Powder
- Size yield is adjustable, within 20-125 micron (+600/-120 mesh) = approx 50%
- Suitable for repeat production of reactive materials
- Wire Feed Stock required
- Low production rate

➤ Two atomization processes were introduced to produce Ti powders. The Gr.5 ELI Ti bar and coil can be supplied locally.



3. Conclusions

Conclusions

- The Ti industry in Taiwan is booming recently, mainly attributed from the shift back of golf clubs business and the wide use of Ti consumer products.
- 5700 MT Ti was imported (Top 11 in the world) and 1500 MT Ti was exported (Top 15) in 2017.
- Concerning the production of golf clubs, the Ti ingots were used to produce head body castings, whereas, the Ti alloy plates were used for head face. Both are imported.
- Taiwan is the sixth most-attractive aerospace manufacturing region in the world due to the strong machining capability for the fan blade and low pressure compressor of airplane engine. However, the Ti raw materials for aerospace are all imported.
- Same as aerospace application, biomedical Ti are all imported by 2006. S-Tech, Taiwan, is the qualified biomedical Ti bar supplier since 2006.

Conclusions

- To fulfil the lack of flat Ti products, China steel Corp.(CSC), Taiwan, established a subsidiary company (CSPM) to produce the Ti slabs and blooms in China, which are shipped back and rolled using the existing steel rolling facilities in CSC to produce plates, strips and bars for industry & consumer applications, such as petrochemical tanks, electrolytic anode, tank for electrodeposited copper foil, smartphone & racing car fasteners, cupwares, and architecture etc. since 2011, thus promoting the formation of Ti industry clusters.
- Taiwan also devoted to produce the Ti powders for additive manufacturing by using crucible-free gas atomization and plasma wire atomization technology.
- There is no Ti tube manufacturing business in Taiwan, although Taiwan can manufacture the Ti tube-making line.
- Taiwan aspires to cooperate with any partner in global Ti supply chain to make more value-added Ti products.

Thanks for your attention



CSC headquarter, Kaohsiung, Taiwan