Materials Science Research
Composites and its application

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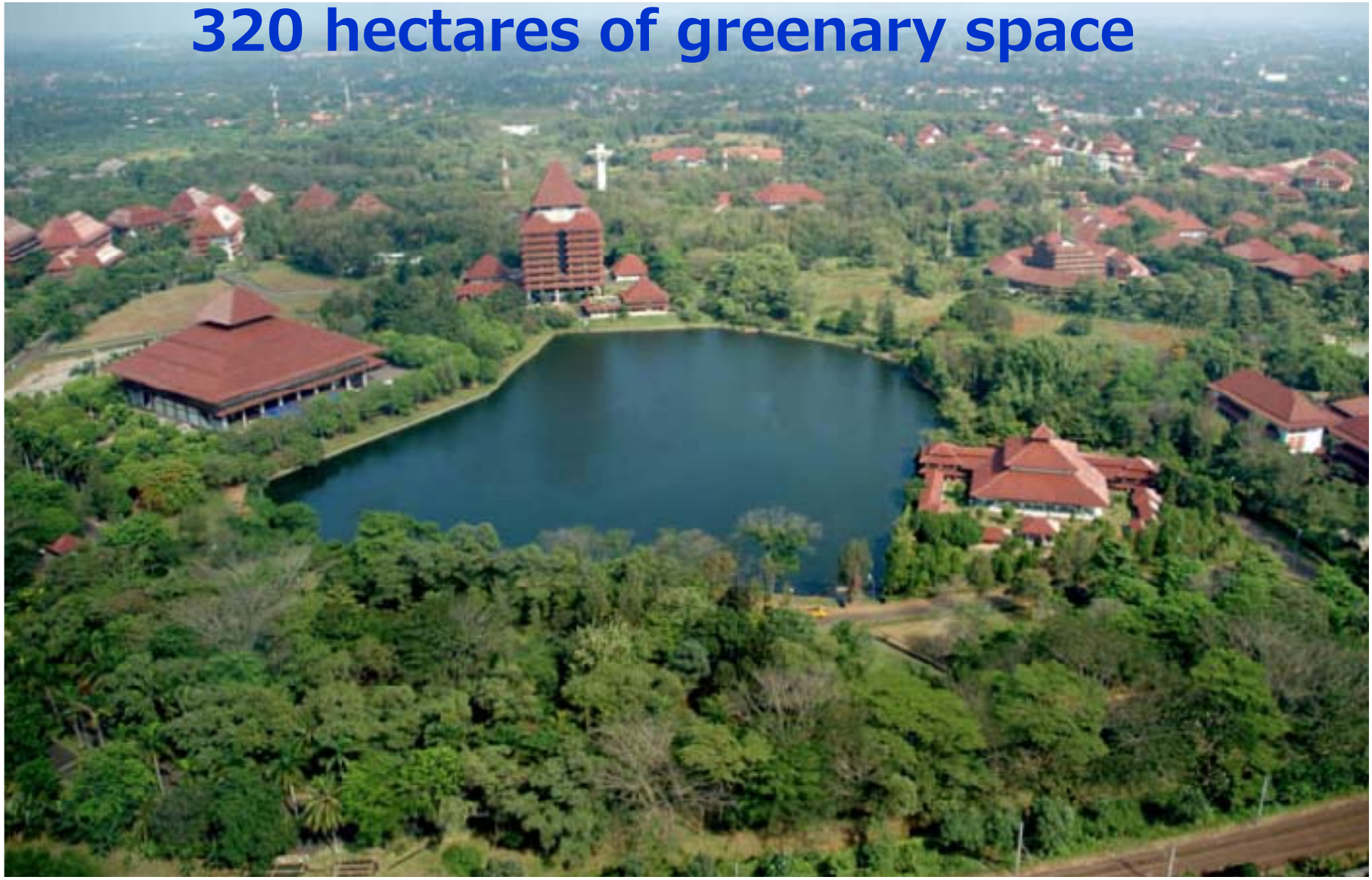
UNIVERSITAS INDONESIA (UI)
DEPOK CAMPUS

- 49.181 students 6.000 faculty members (full and adjunct faculties)

320 hectares of greenary space



Major Scientific RESEARCH

Health Sciences

- Medicine
- Dentistry
- Public Health
- Nursing

Engineering & Natural Sciences

- Mathematics and Natural Science
- Engineering
- Computer Science & IT

Social Sciences & Humanities

- Law
- Economics
- Humanities
- Psychology
- Social and Political Science

Research Issues

National Strategic:

- Climate change and biodiversity
- Poor Tackling
- Renewable Energy
- Food Tenacity
- Nutricient and Tropical Deseas
- Mitigation and Disaster Management
- Nation Integration, Social harmony and Culture
- Advanced Materials
- Territory Autonomy and dicentralisation
- Art and Literature
- Infrastructure (green) and Eco-Architecture

University of Indonesia (10 focus) :

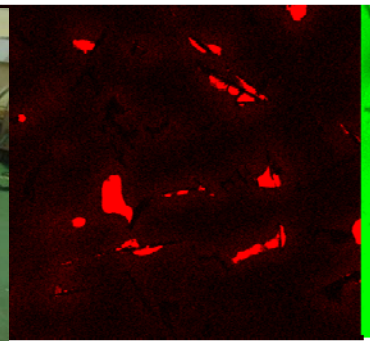
1. IT Studies (ICT)
2. Poverty Alleviation, Child family and Community
3. Genom Studies
4. Governance, Democratization & Public/sosial Policy
5. Energy
6. Restoring the Earth's natural Support System
7. Nano and Advance Technology
8. Culture
9. Indigeneous Studies
10. Urban Planning & Transportation.

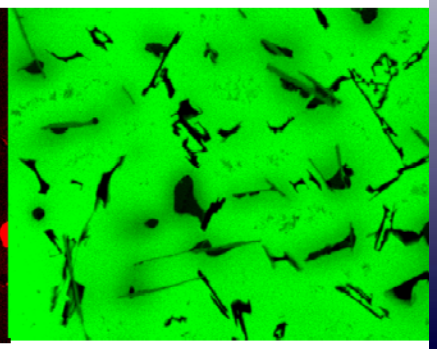
Materials and Metallurgy Research Areas

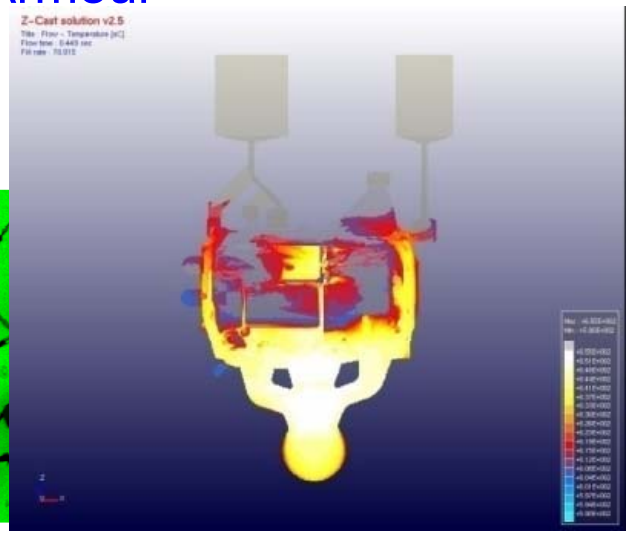
Existing Research Areas	Common Research Areas
1. **Mineral Processing** (Extractive Metallurgy and Recycling) upstream to downstream 2. **Automotive Component Manufacturing** (Casting, Welding, Forming and Heat Treatment, Aluminium composites ballistic 3. **Advanced Materials** for Renewable Energy Sources (Nano-particles, Nano-rod, Nano-tube, Nano / Micro Composites for Solar and Fuel Cells, Li-ion battery), Transportation (Light Weight Metal Matrix Composites); Infrastructure (Rapid Geo-polymer Cement) 4. **Corrosion & Materials Selection** 5. **Aerospace materials??**	Eco-based Materials Design and Process

Current Manufacture Materials Research Topics

- Development of nanoparticle in aluminum alloys
- Thermo-mechanical treatment on high-strength low alloy steel
- Advanced aluminum matrix composites for automotive application
- Residual stress and distortion in welded structures
- The fluidity of Al-Si alloy
- Die Soldering in Aluminum Die casting Process
- Improvement of Aluminum Melt Quality to Reduce Casting Defect
- Casting Design Simulation with Z-Cast Program
- Development of Squeeze Casting Aluminum Armour

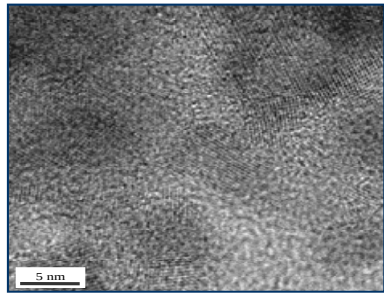






Current Advanced Materials Research Topics

- Mg alloy as Hydrogen storage absorber
- Composites Al-SiC and Al-Al_2O_3
- Polymer based composites for Fuel Cell Material
- Carbon-carbon composites
- Rapid-set cement geopolymer concrete
- Dye-Sensitized Solar Cell with Highly Organized Nanostructures of Oxide Semiconductors



- Natural fiber for Polymer Electrolyte Membrane Fuel Cell (PEMFC)
- Nanofluid synthesis through wet mechanical-chemical process
- Development of advanced polymers
- Battery Reseach (Hibah LPDP, Ministry of Finance)
- Al6061 reinforced Al_2O_3 for seamless pipe (PUPT, Ministry of Higher Education)
- Al356 (Al4C) reinforced Al_2O_3 / SiC for train brake shoe (MP3EI, Ministry of Higher Education)
- Biopolymers (PUPT, Ministry of Higher Education)
- Zinc Oxide nano rod for DSSC (PUPT, Ministry of Higher Education)
- CZT Sulfide for solar cells (PUPT, Ministry of Higher Education)
- Reserach Cluster of Renewable energy Univeristas Indonesia)

Current Mineral Processing, Corrosion and Material Selection Research Topics

- Reduction of Indonesia titanious iron sand to sponge iron
- Agglomerization of lateritic Indonesia Nickel Ore
- Charbothermic Reduction of lateritic Indonesia Nickel Ore
- Charbothermic Reaction and Direct Reduction of low cost of Indonesia lateritic Iron Ore
- Rare Metal Extraction from waste Tin (Sn) production
- Corrosion on steel-strengthened concrete
- Control of sea water corrosion by green inhibitor
- Corrosion study on Suramadu bridge




Research Facilities

- Chemical Metallurgy Laboratory
- Physical Metallurgy Laboratory
- Mechanical Metallurgy Laboratory
- Processing Metallurgy Laboratory
- Corrosion and Metal Protection Laboratory
- Metallographic and Heat-Surface Treatment Laboratory
- Non Destructive Test Laboratory
- Advanced Material Laboratory
- **Advanced Characterisation lab :**

Scanning Electron Microscope (SEM) coupled with EDX, FESEM, STA, BET, UV-Vis, X-Ray Diffraction, TEM

Chemical Composition: AAS, OES

Research Fund

1. Higher Education (Ministry of National Education Republic of Indonesia)
- Post Graduate Grants (Hibah Pasca)
- Competency Grants (Hibah Kompetensi)
- Competition Grant (Hibah Bersaing, MP3EI, RAPID, PUPT)
- Fundamental Grant
- Research community fund (Hibah Pengabdian Masyarakat)
- National and International Collaboration

2. University of Indonesia :
- Research Cluster Fund
- PUPT, Hibah Pasca
- International Collaboration

3. Ministry of Finance (LPDP)

4. Ministry of Research and Technology

5. International Funding
- Toray Foundation (Japan)
- KITECH-Korea

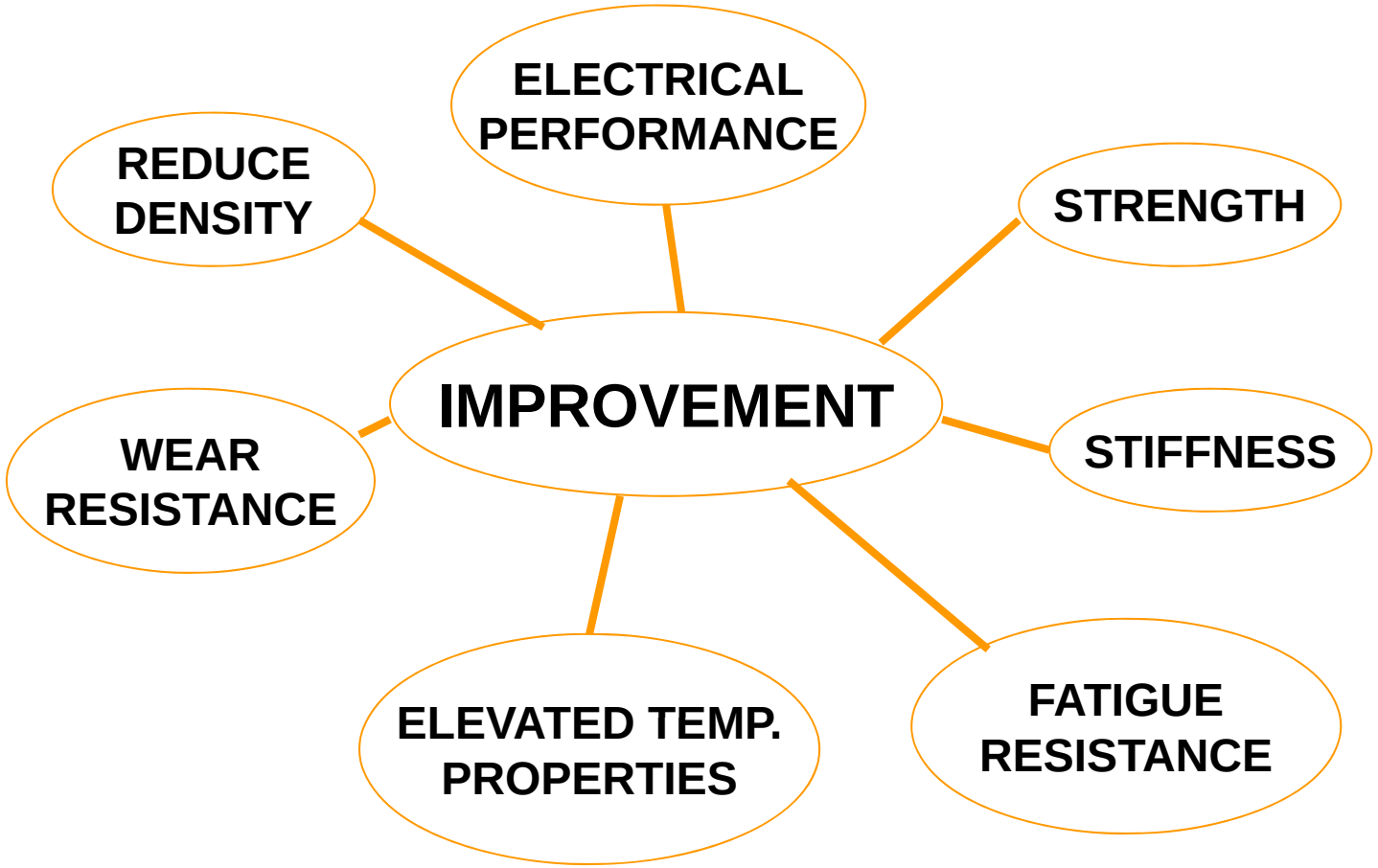
6. Others/Industries

Composites and its application in Aerospace

What is composites?

- A Composite material is a material system composed of two or more **macro constituents** that differ in shape and chemical composition and which are insoluble in each other. The history of composite materials dates back to early 20th century. In 1940, fiber glass was first used to reinforce epoxy.
- Applications:
  - Aerospace industry
  - Sporting Goods Industry
  - Automotive Industry
  - Home Appliance Industry

WHY COMPOSITES ?



Composites

Material	Characteristics
Fibers	
Glass	High strength, low stiffness, high density; lowest cost; E (calcium aluminoborosilicate) and S (magnesia-aluminosilicate) types commonly used.
Graphite	Available as high-modulus or high-strength; low cost; less dense than glass.
Boron	High strength and stiffness; highest density; highest cost; has tungsten filament at its center.
Aramids (Kevlar)	Highest strength-to-weight ratio of all fibers; high cost.
Other fibers	Nylon, silicon carbide, silicon nitride, aluminum oxide, boron carbide, boron nitride, tantalum carbide, steel, tungsten, molybdenum.
Matrix materials	
Thermosets	Epoxy and polyester, with the former most commonly used; others are phenolics, fluorocarbons, polyethersulfone, silicon, and polyimides.
Thermoplastics	Polyetheretherketone; tougher than thermosets but lower resistance to temperature.
Metals	Aluminum, aluminum-lithium, magnesium, and titanium; fibers are graphite, aluminum oxide, silicon carbide, and boron.
Ceramics	Silicon carbide, silicon nitride, aluminum oxide, and mullite; fibers are various ceramics.

Alternative matrix materials

Metal (MMCs)

Fibre: boron; Borsic; carbon (graphite); SiC; alumina (Al_2O_3)

Matrix: aluminium; magnesium; titanium; copper

Fibres improve high temp creep; thermal expansion. Strength, stiffness

Polymer (PMCs)

thermoplastic

Tough; high melt viscosity; 'recyclable'

thermoset

Brittle; low viscosity before cure; not recyclable

Ceramic (CMCs)

Fibre: SiC; alumina; SiN

Matrix: SiC; alumina; glass-ceramic; SiN

Fibres improve toughness

The matrix material largely determines the processing method…

Composites – Metal Matrix

The metal matrix composites offer higher modulus of elasticity, ductility, and resistance to elevated temperature than polymer matrix composites. But, they are heavier and more difficult to process.

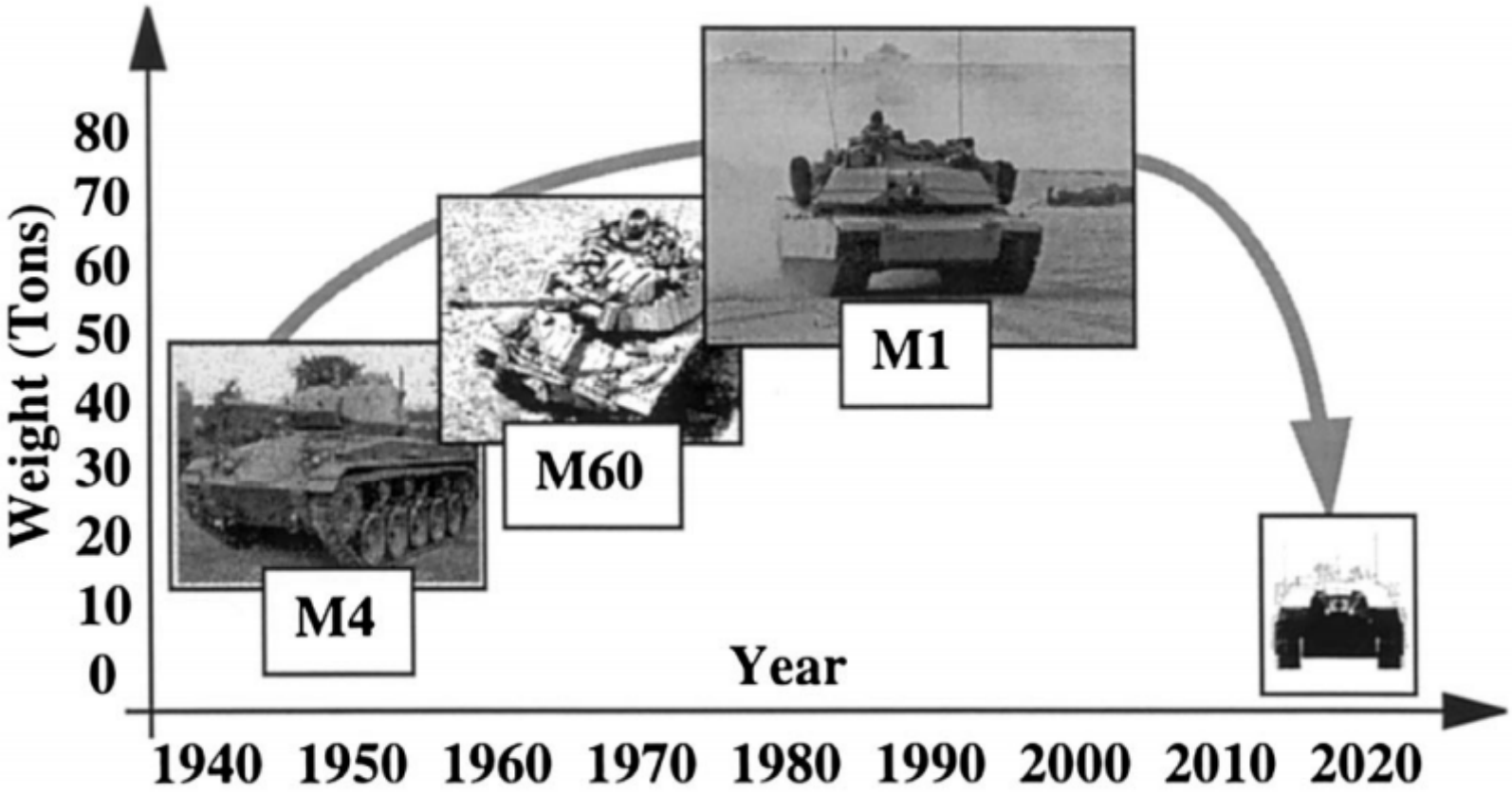
Fiber	Matrix	Applications
Graphite	Aluminum	Satellite, missile, and helicopter structures
	Magnesium	Space and satellite structures
	Lead	Storage-battery plates
	Copper	Electrical contacts and bearings
Boron	Aluminum	Compressor blades and structural supports
	Magnesium	Antenna structures
	Titanium	Jet-engine fan blades
Alumina	Aluminum	Superconductor restraints in fission power reactors
	Lead	Storage-battery plates
	Magnesium	Helicopter transmission structures
Silicon carbide	Aluminum, titanium	High-temperature structures
	Superalloy (cobalt-base)	High-temperature engine components
Molybdenum, tungsten	Superalloy	High-temperature engine components

TABLE 1.11

Typical Mechanical Properties of Metal Matrix Composites

Property	Units	SiC/ aluminum	Graphite/ aluminum	Steel	Aluminum
System of units: USCS					
Specific gravity	—	2.6	2.2	7.8	2.6
Young's modulus	Msi	17	18	30	10
Ultimate tensile strength	ksi	175	65	94	34
Coefficient of thermal expansion	μin./in./°F	6.9	10	6.5	12.8
System of units: SI					
Specific gravity	—	2.6	2.2	7.8	2.6
Young's modulus	GPa	117.2	124.1	206.8	68.95
Ultimate tensile strength	MPa	1206	448.2	648.1	234.40
Coefficient of thermal expansion	μm/m/°C	12.4	18	11.7	23

Background



Reduce weight of *armor materials for* military tank

Background :
Research Sienas

1. High specific stregth
2. High specific modulus
3. High fatigue strength
4. High temperature resistance

Roket Fins-168 LAPAN Steel S45C (courtecy LAPAN)

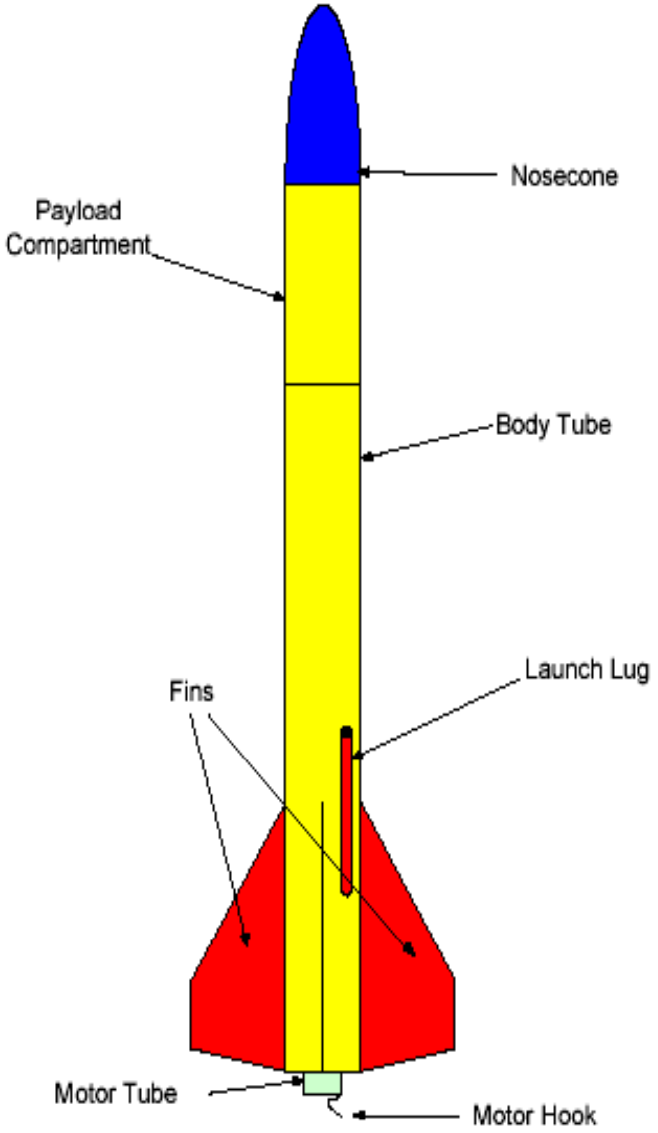
Composites

Body Tube Rocket-RX.420 LAPAN, Steel S45C

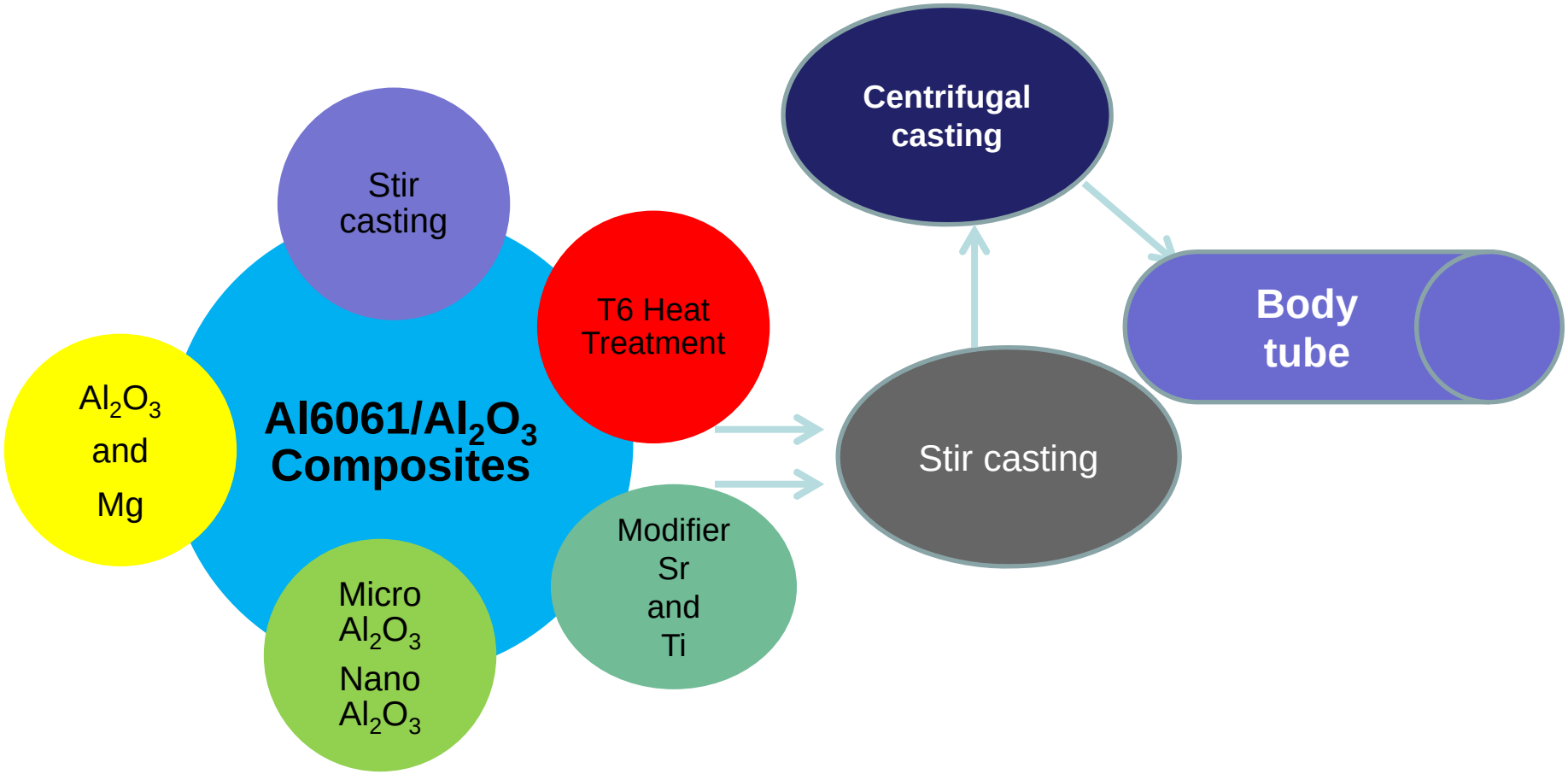
Rocket Principles

- High pressure/temperature/velocity exhaust gases provided through combustion and expansion through nozzle of suitable fuel and oxidiser mixture.

- A rocket carries both the *fuel* and *oxidiser* onboard the vehicle whereas an *air-breather* engine takes in its oxygen supply from the atmosphere.



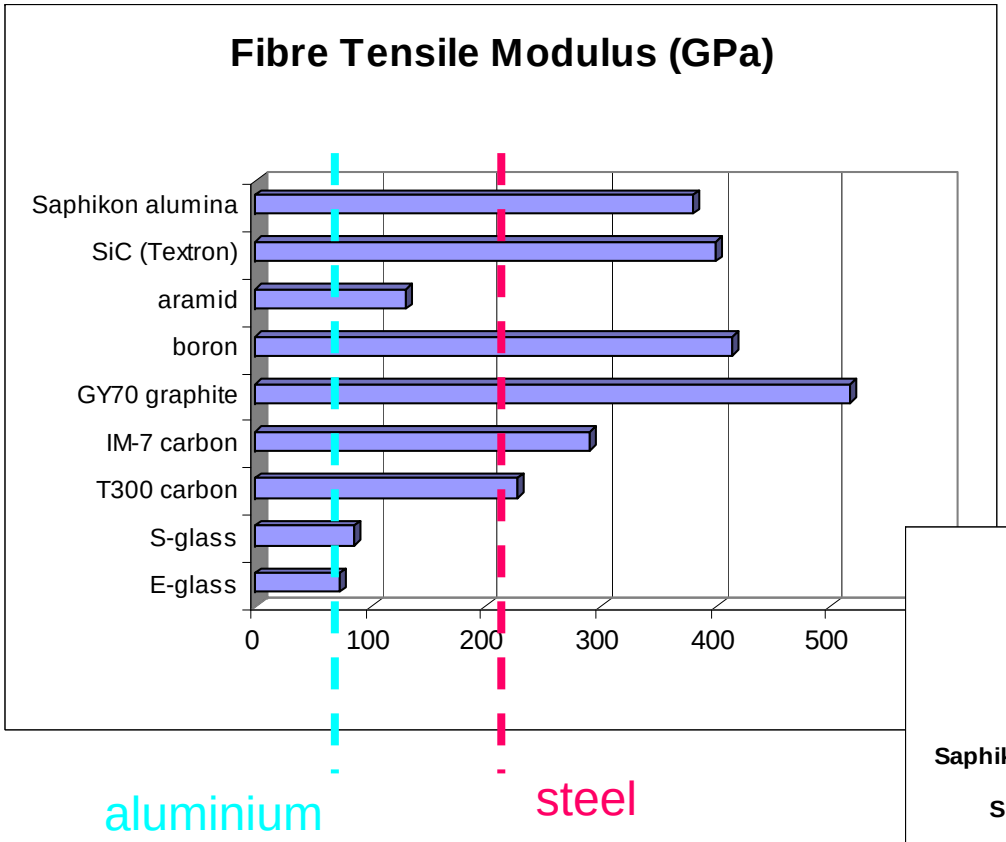
Objective

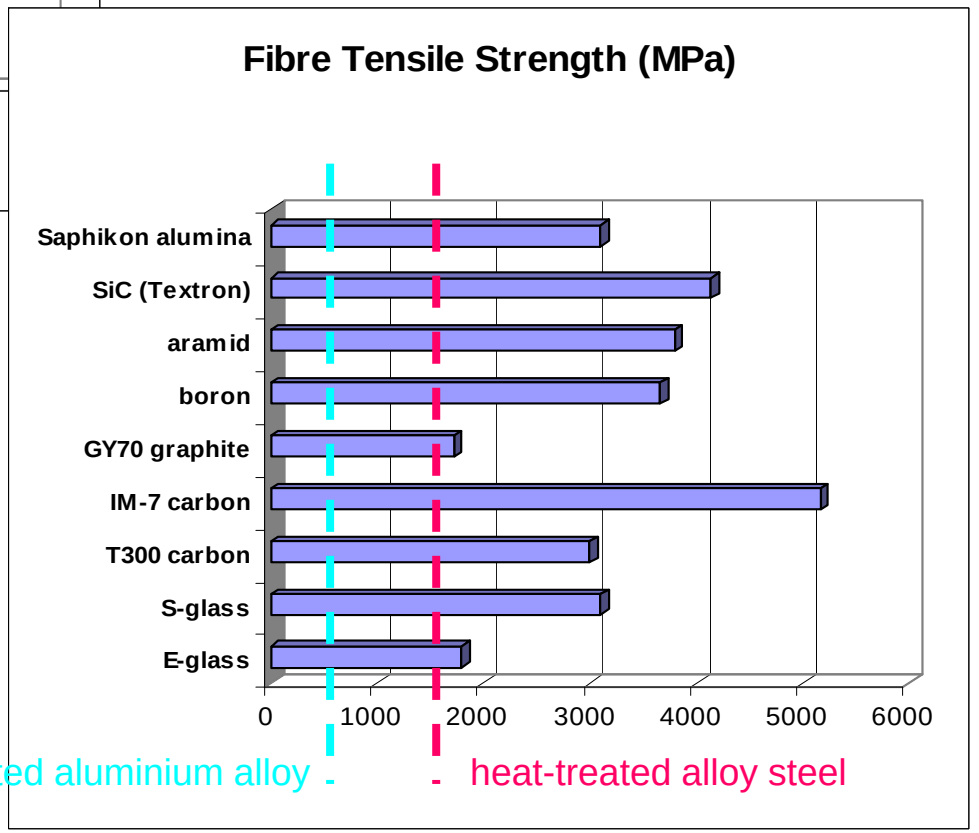

Stir casting
T6 Heat Treatment
Al_2O_3 and Mg
Al6061/Al_2O_3 Composites
Micro Al_2O_3 Nano Al_2O_3
Modifier Sr and Ti
Centrifugal casting
Stir casting
Body tube

Our Research (UI-LAPAN)

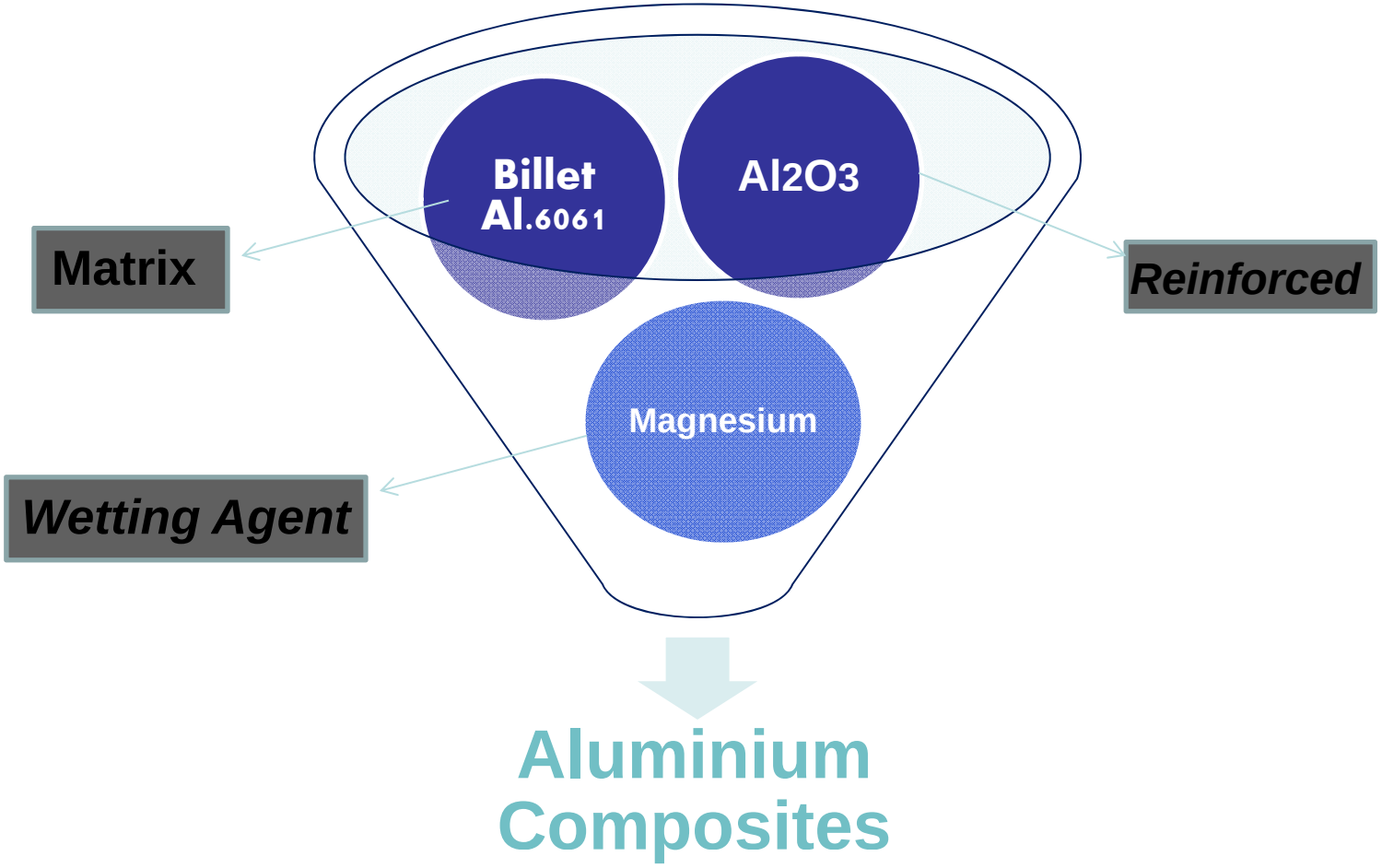
Development of lighter body tube (casing) rocket with high strength and high temperature of Al6061/Al_2O_3

(*Sienas Funding (2011-2014) Lilis Mariani as a Team Leader)*


Fibre Tensile Modulus (GPa)
Saphikon alumina
SiC (Textron)
aramid
boron
GY70 graphite
IM-7 carbon
T300 carbon
S-glass
E-glass
0
100
200
300
400
500
aluminium
steel


Fibre Tensile Strength (MPa)
Saphikon alumina
SiC (Textron)
aramid
boron
GY70 graphite
IM-7 carbon
T300 carbon
S-glass
E-glass
0
1000
2000
3000
4000
5000
6000
heat-treated aluminium alloy
heat-treated alloy steel

Metal Matrix Composites



Stir Casting Process

Preheat Alumina dan cetakan 500^{0}C

Stirr & Degassing

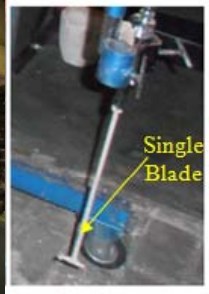
Stir casting

Degassing

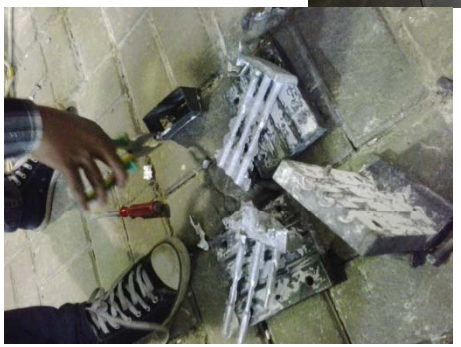
Penambahan Al_2O_3 & Mg

Pouring

Molten Al

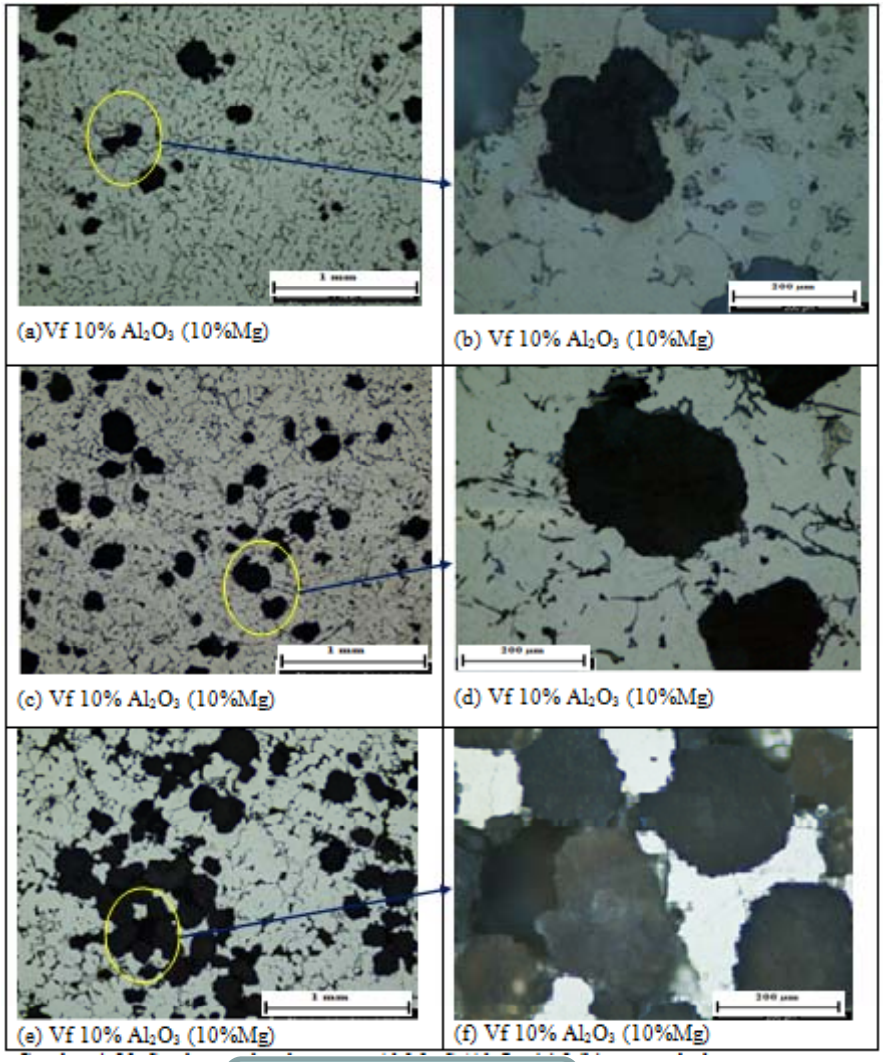


Single blade stirerr



Tensile Test sample

Microstructure of Al composites reinforced with 65µm Al_2O_3



(a)Vf 10% Al_2O_3 (10%Mg)

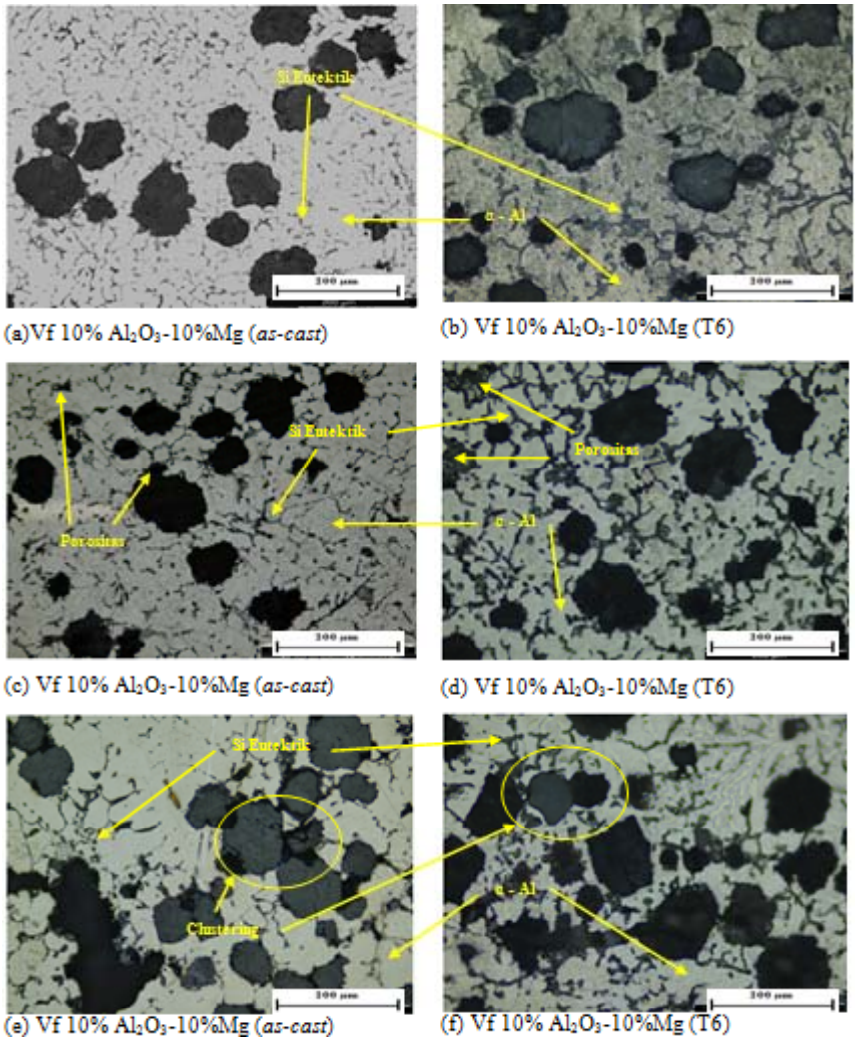
(b) Vf 10% Al_2O_3 (10%Mg)

(c) Vf 10% Al_2O_3 (10%Mg)

(d) Vf 10% Al_2O_3 (10%Mg)

(e) Vf 10% Al_2O_3 (10%Mg)

(f) Vf 10% Al_2O_3 (10%Mg)



(a)Vf 10% Al_2O_3-10%Mg (*as-cast*)

(b) Vf 10% Al_2O_3-10%Mg (T6)

(c) Vf 10% Al_2O_3-10%Mg (*as-cast*)

(d) Vf 10% Al_2O_3-10%Mg (T6)

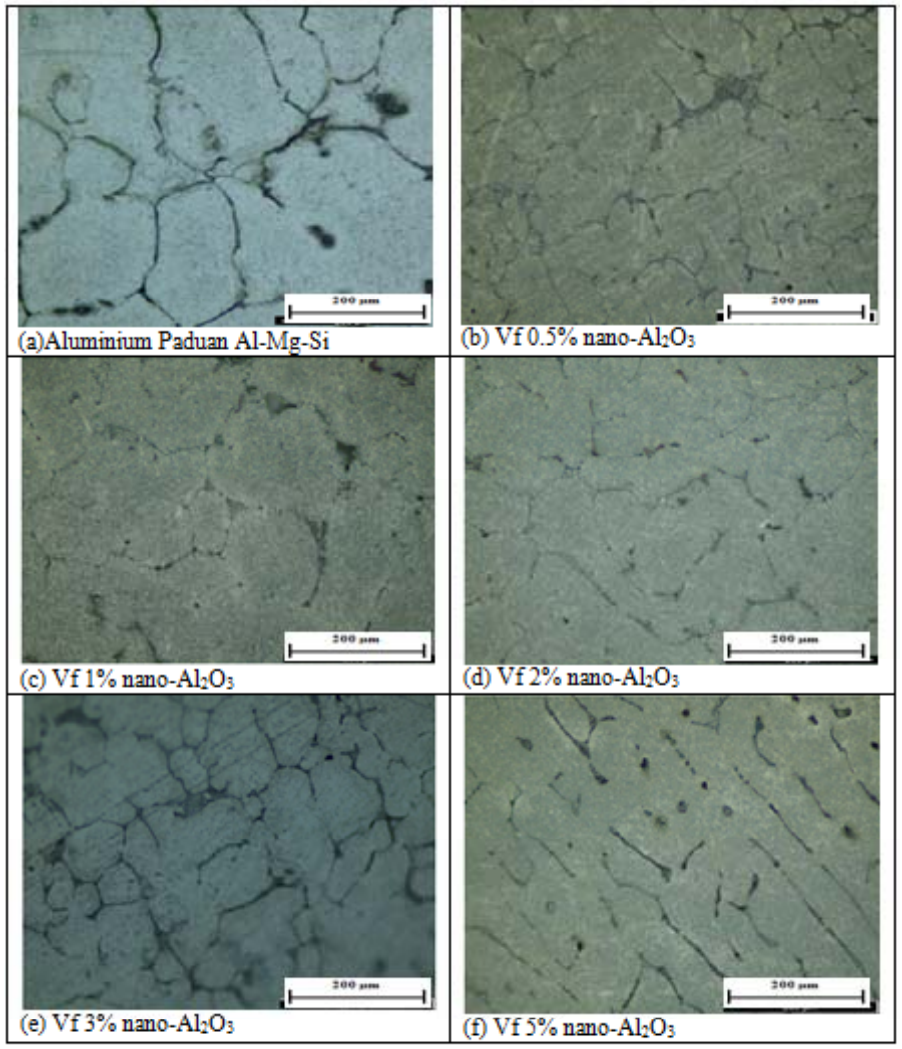
(e) Vf 10% Al_2O_3-10%Mg (*as-cast*)

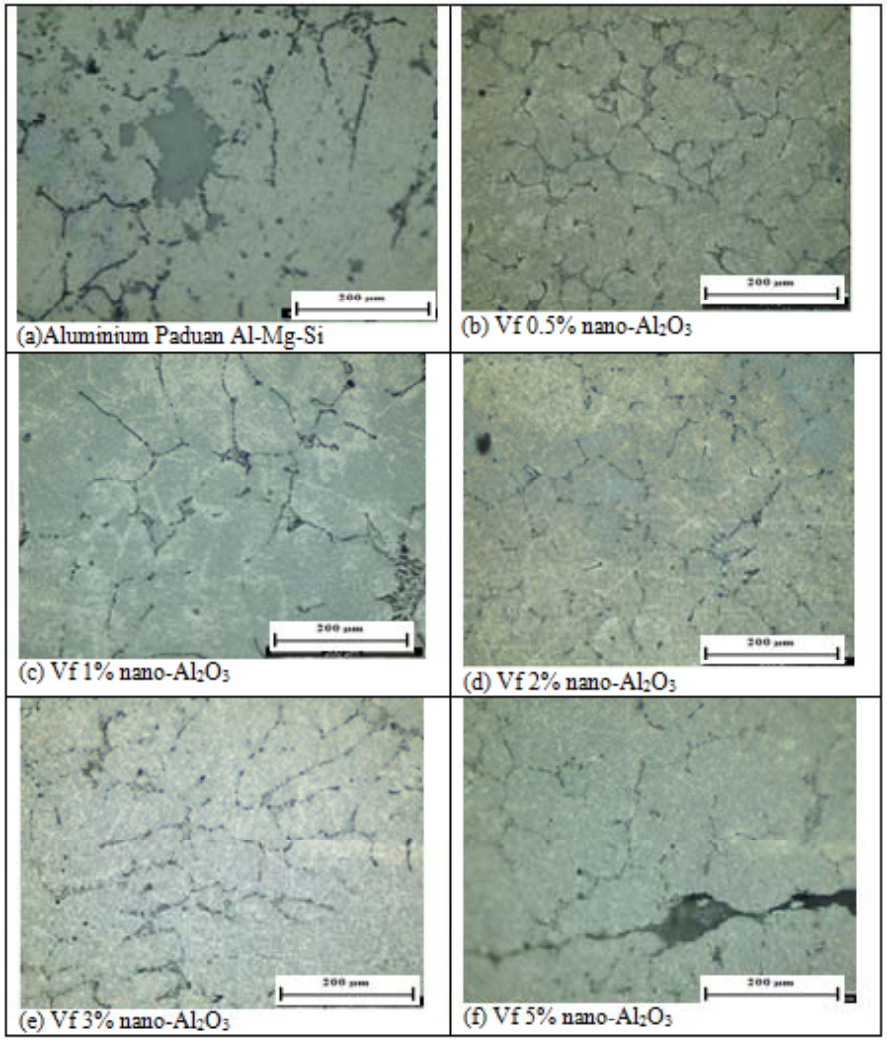
(f) Vf 10% Al_2O_3-10%Mg (T6)

as-cast

T6

Microstructure of Al composites reinforced with 80nm Al_2O_3

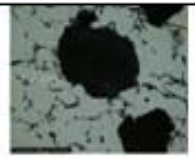
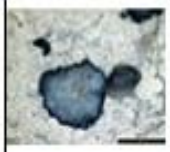
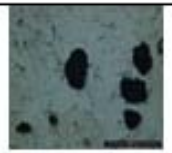
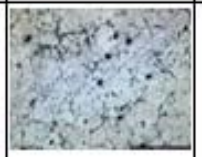
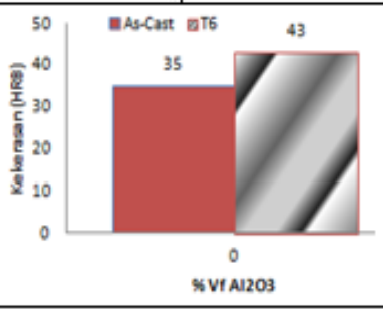
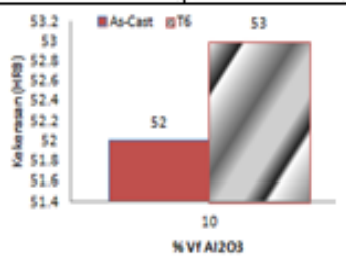
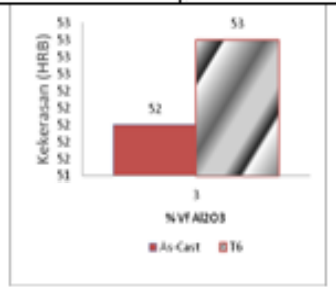
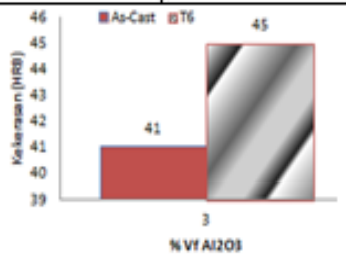
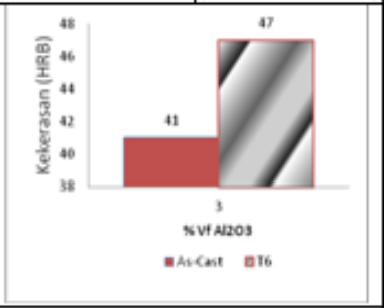
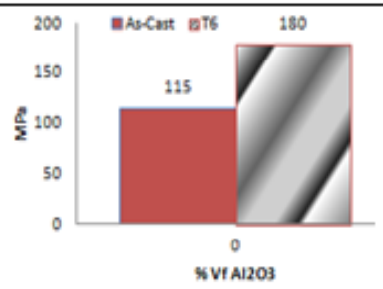
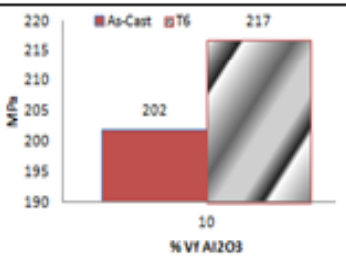
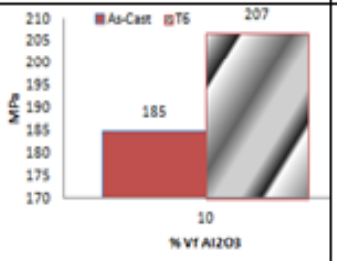
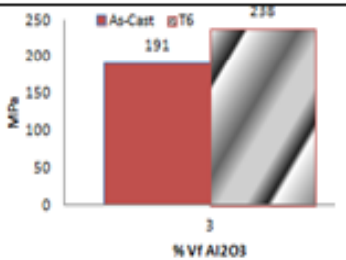
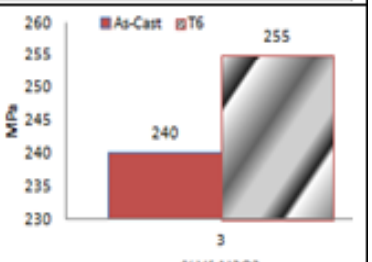
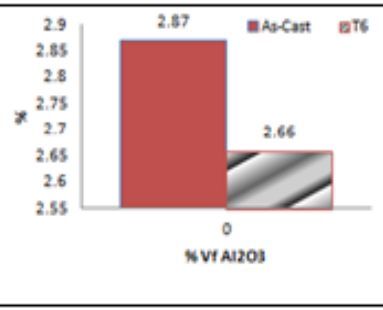
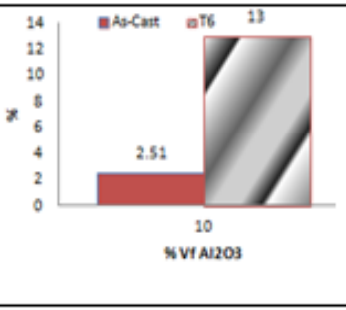
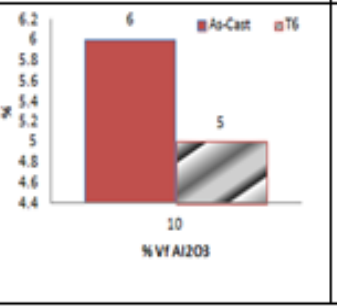
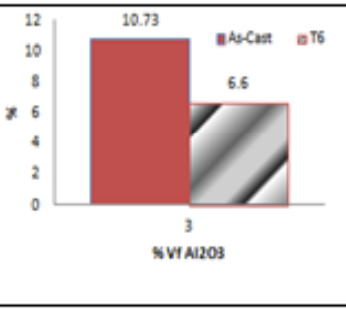
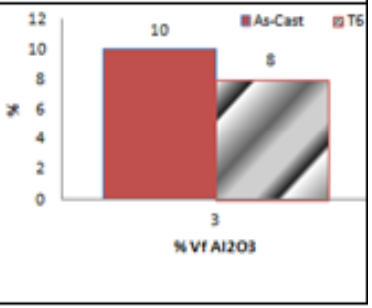




as-cast

T6

Al6061/Al_2O_3 Metal Matrix Composites

Aluminium Paduan Al-Mg-Si		Al-Mg-Si /Al_2O_3 (10% Al_2O_3-10%Mg)		Al-Mg-Si/Al_2O_3 (Sr & Ti) (10% Al_2O_3-10%Mg)		Al-Mg-Si/nano Al_2O_3 (3% Al_2O_3-3%Mg)		Al-Mg-Si/nano Al_2O_3 (Sr & Ti)(3% Al_2O_3-3%Mg)	
As-Cast	T6	As-Cast	T6	As-Cast	T6	As-Cast	T6	As-Cast	T6
									
									
									
									

Tube Prototype

Preheat Alumina 500^{0}C → Preheat Cetakan Tabung → Pengecoran aduk

Centrifugal Casting

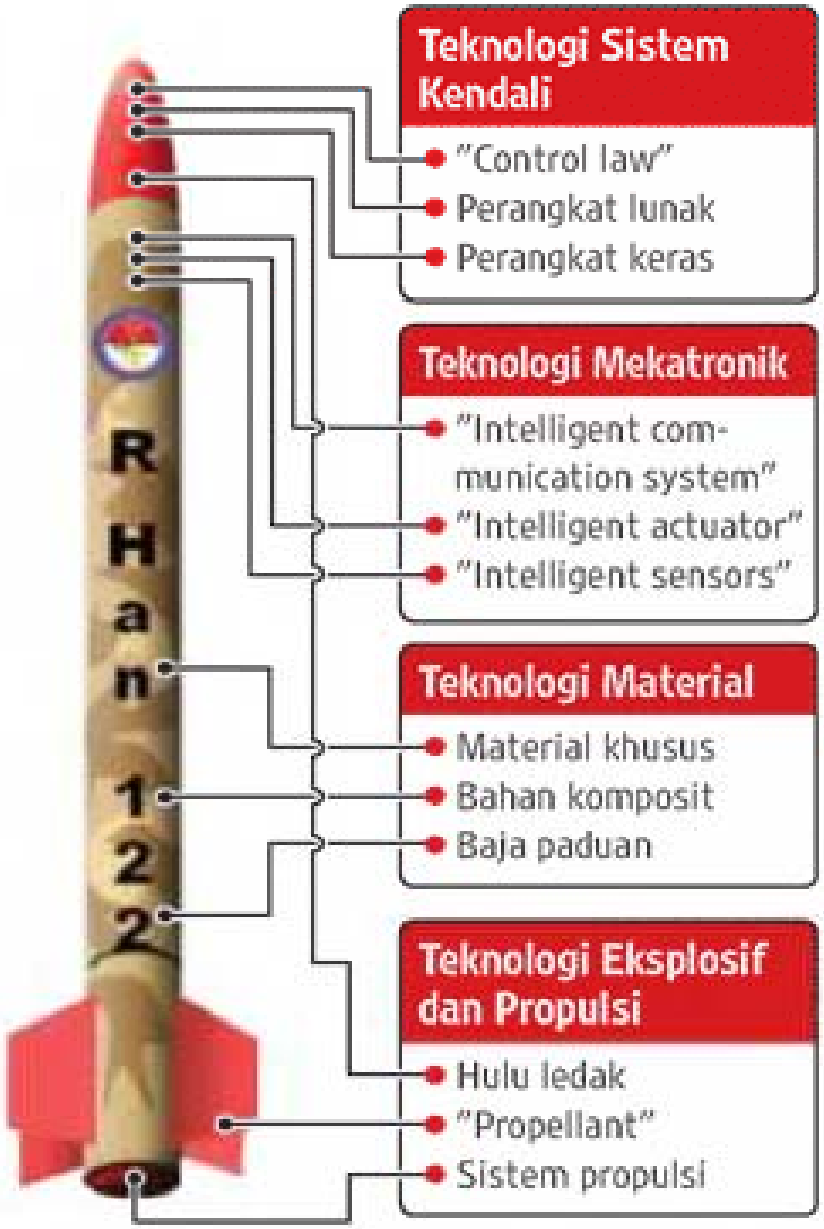
Prototipe tabung

Pembongkaran Cetakan

Putaran 300 rpm

Penuangan Cairan

ROKET R-HAN 122



Cortesy : Pindad

Conclussions

Increasing Vf Al_2O_3 and Mg generated higher tensile strength, stiffness and hardness but reduced the elongation of composites, the optimum composition of this composites found at 10Vf% for micro Al_2O_3 with 10 wt% Mg and 3 Vf% for nano Al_2O_3 with 3 wt% Mg

Tube composites can be made by centrifugal casting but the strengthis still need to improve by extrusion technique.


Thank you very
much for your
kind attention