Production, processing and utilization of materials

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Outline

1. Overview of materials processing
2. Overview current work in GJK laboratory
3. Major findings of investigations
4. Research needs and future trends

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Overview of materials processing

I. Value added utilization of materials
II. Sustainability of processing
III. Extensive utilization of materials
IV. Development of new materials
V. Estimation of thermodynamic data

Example: magnesium, aluminum

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Value added utilization of materials

- Processing magnesium or aluminum for parts utilizes only 50-55 % of the metal/alloy. The remaining is returned as scrap for remelting.
- Ingot metallurgy limits chemistry of alloy development

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Sustainability of processing

- Maximum utilization of energy-intensive produced materials
- Recycling of reactive metals
- Replacement of environment harmful steps in processing of reactive metals
- Sustainability of knowledge of processing for reactive metals

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Extensive utilization of materials

- Extend the life of utilization of materials
- Re-examine the ways we produce and utilize magnesium

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Estimation of thermodynamic data

- First principles calculation the best way
- Evaluation of the existing estimation techniques
- Development of new estimation techniques
- Couple estimation with calculating curve – fitting softwares

Development of new materials

- For magnesium only 160 alloys were developed in the last 15 years
- Processing magnesium (HCP) remains a challenge

Aluminum has 1600 alloys to choose from for use

Overview current work in GJK laboratory

Magnesium processing and utilization
- Powder metallurgy of magnesium
- Coatings on magnesium

Aluminum powder processing techniques such as forging

Copper-nickel alloys
- Corrosion behaviour in sea water
- Development of improved Cu-Ni alloys

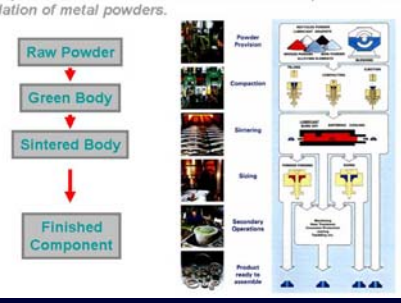
Electroless deposition in low temperature molten salts

Major findings of investigations

- Magnesium processing and utilization (Mr. Paul Burke will present the results)
- For aluminum research:
  1. Alloys were developed
  2. Chemistries altered
  3. Industry attracted
- P/M new processing powder forging consolidation

What is Powder Metallurgy?

Definition - *A process used to manufacture metallic components through the consolidation of metal powders.*

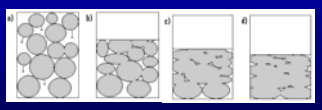


Powder consolidation projects

Manufacturing process

In Microscopic scale

Metal powder



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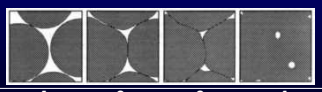


sintering

1. 2. 3. 4.

New research

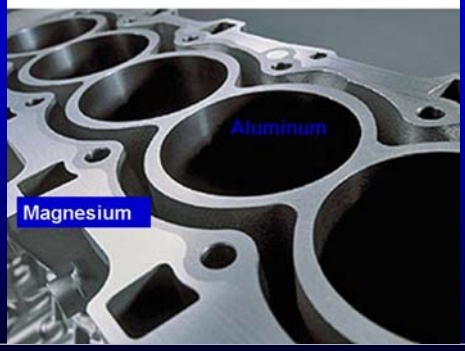
Semi-solid aluminum processing

1. Die-casting processing at the semi-solid state of aluminum alloys

2. Powder metallurgy – casting processing combination

Coatings on magnesium

BMW Composite Engine Block

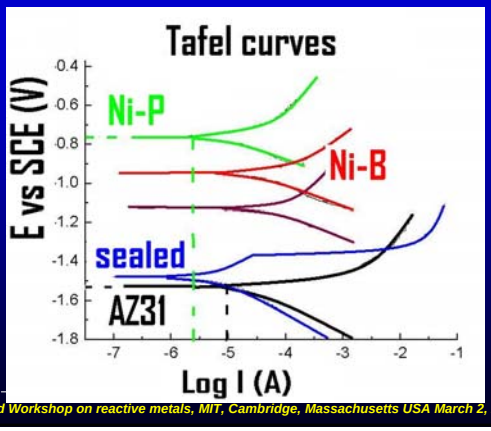


Poor corrosion properties

- Formation of conversion coating to avoid Mg/Ni couple
- Seal coating in silicate solution (1ST step)

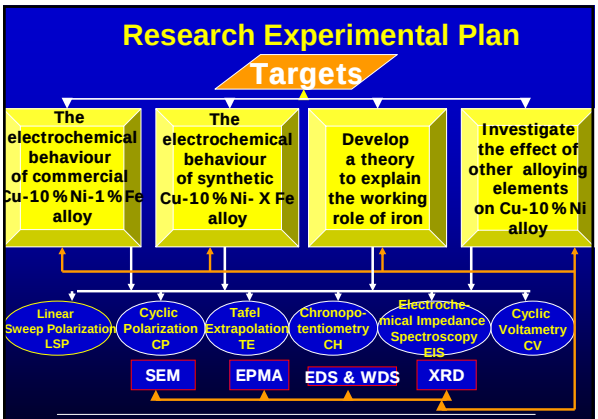
ELECTROLESS Ni-B PLATING

- Plate on sealed conversion coating (2 step process)
- Plate on sealed Ni – P coating (3 step process)



Extensive utilization of materials

Research Experimental Plan



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Methodology

- **Commercial Alloy**
- Sample preparation (C96200)

* Cutting * Polishing

* Characterization by SEM, EDS, WDS and EPMA

- Electrochemical measurements
- Characterization by SEM, EPMA,EDS, WDS & XRD

- **Synthetic Alloy**
- Sample preparation in induction furnace
- Sample homogenization/quenched by using tube furnace
- Perform measurements, characterization as per commercial alloy

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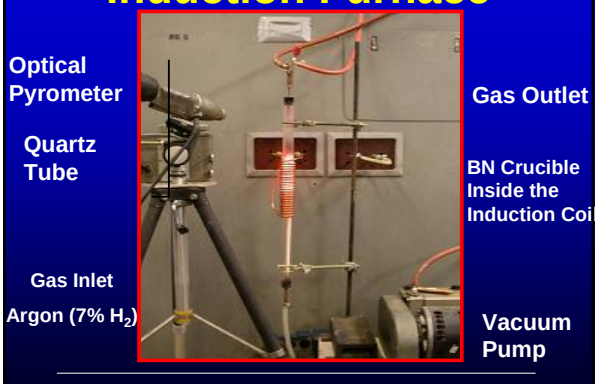
Induction Furnace



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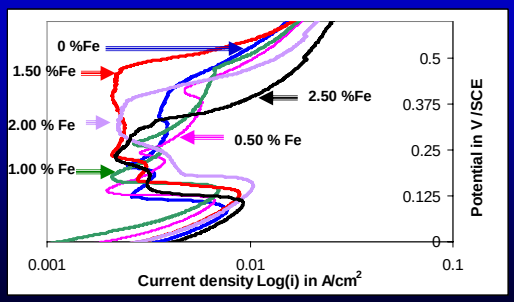
Linear Sweep Polarization of Synthetic Alloys with Different Iron Content in sea water



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Estimation of thermodynamic data

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TABLE 1

Dehydration reactions

	Reaction	Scheme			Reference		
1	$NdCl_3 \cdot 6H_2O \rightarrow NdCl_3 \cdot 5H_2O + H_2O$	I			9		
2	$NdCl_3 \cdot 6H_2O \rightarrow NdCl_3 \cdot 4H_2O + 2H_2O$		II			15	
3	$NdCl_3 \cdot 6H_2O \rightarrow NdCl_3 \cdot 3H_2O + 3H_2O$			III			12, 13
4	$NdCl_3 \cdot 5H_2O \rightarrow NdCl_3 \cdot 4H_2O + H_2O$	I			9		
5	$NdCl_3 \cdot 4H_2O \rightarrow NdCl_3 \cdot 3H_2O + H_2O$		II			15	
6	$NdCl_3 \cdot 4H_2O \rightarrow NdCl_3 \cdot H_2O + 3H_2O$	I			9		
7	$NdCl_3 \cdot 3H_2O \rightarrow NdCl_3 \cdot 2H_2O + H_2O$		II	III		15	12, 13
8	$NdCl_3 \cdot 2H_2O \rightarrow NdCl_3 \cdot H_2O + H_2O$		II	III		15	12, 13
9	$NdCl_3 \cdot H_2O \rightarrow NdCl_3 + H_2O$	I	II	III	9	15	12, 13

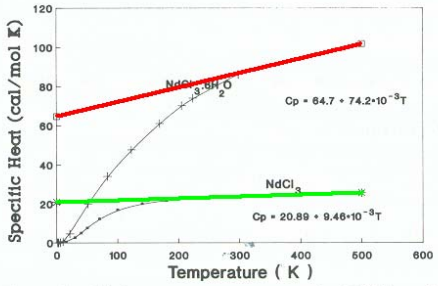
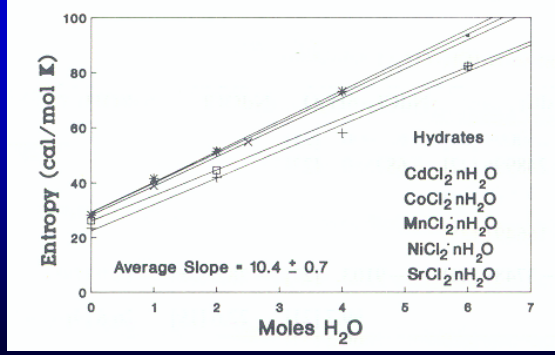
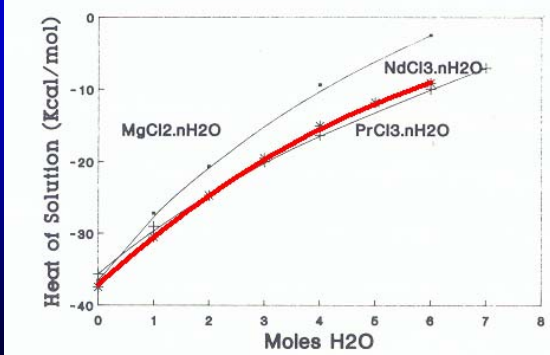
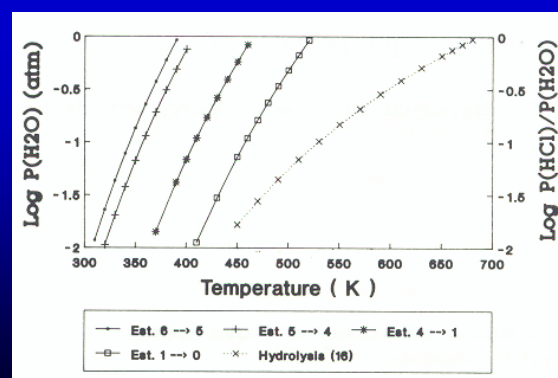


Fig. 1. Specific heat versus temperature for $NdCl_3$ and $NdCl_3 \cdot 6H_2O$.







Conclusions

- Production, processing and utilization of materials requires **sustainable** knowledge and **estimation** of data
- Also required is **combining processing** in a new way

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