
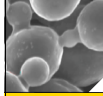


Effect of Surface Contaminants on the Sintering of Magnesium Powders

Paul Burke and Georges J. Kipouros


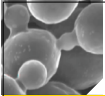
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4th Reactive Metals Workshop, MIT

Outline

- Introduction
- Background
- Surface Contaminants
- Mg Surface Contaminants
- Mg Sintering Strategies
- Summary
- Acknowledgments

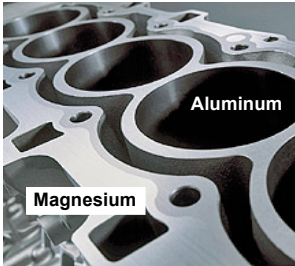
Introduction

Benefits of Magnesium

- High stiffness to weight ratio
- High damping capacity
- Recyclable


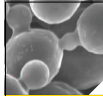
Issues with Magnesium

- Lack of developed alloys
- Difficult forming
- Corrosion



Aluminum

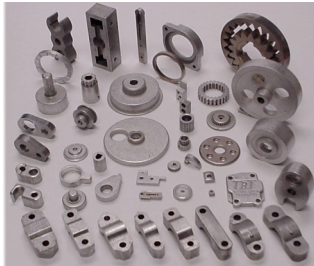

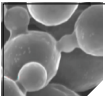
Magnesium

Introduction

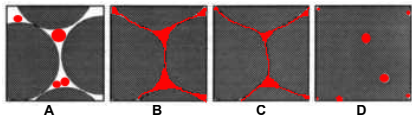
Powder Metallurgy

- Powder metal feedstock
- Near-net shape
- Essentially no chemical limitations
- Growth in ferrous and Al applications
- Mg P/M largely unexplored


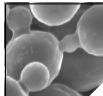




Sintering of Metal Powders

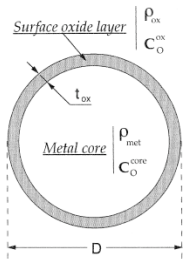
- Stages of sintering
 - » Point contact (A)
 - » Initial stage (B)
 - » Intermediate stage (C)
 - » Final stage (D)



A B C D

Surface Contaminants on Metal Powders



Surface oxide layer

t_{ox}

Metal core

ρ_{met}


ρ_{ox}

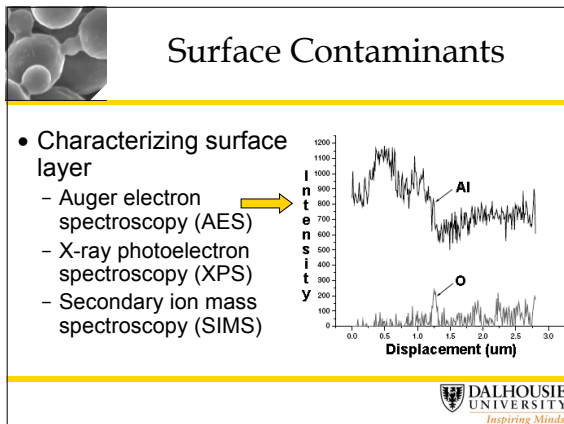
C_{O}^{core}

C_{O}^{ox}

D

- Metal core
- Surface layer
 - Oxide?
 - Hydroxide?
 - Thickness?





Surface Contaminants and Sintering

- Dealing with the surface layer
 - Thermo-chemical reduction
 - Dissolve layer into metal
 - Diffuse metal through layer
 - Break layer

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Surface Contaminants and Sintering

- Thermo-chemical reduction
 - Ellingham diagram
- Appropriate temperature, pressure and atmosphere
- Addition of more reactive metal

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Surface Contaminants and Sintering

- Dissolve layer into metal
 - Depends on oxygen solubility in metal
 - Sintering preceded by incubation period
 - Fe ~10 seconds
 - Al ~ 100 days + (Estimate)
 - Mg ~100 days + (Estimate)

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Surface Contaminants and Sintering

- Diffuse metal through layer
 - Depends on diffusion rates and layer thickness

	D_M $m^2 \text{ sec}^{-1}$	D_{Ox} $m^2 \text{ sec}^{-1}$
Cu	5.65×10^{-13}	6.65×10^{-12}
Al	1.84×10^{-12}	5.51×10^{-30}
Mg	3.01×10^{-12}	5.25×10^{-24}

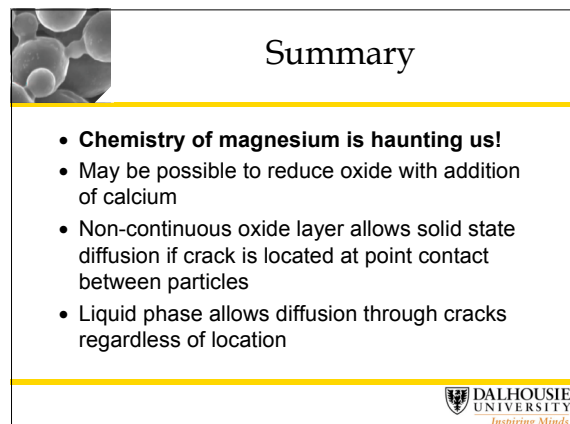
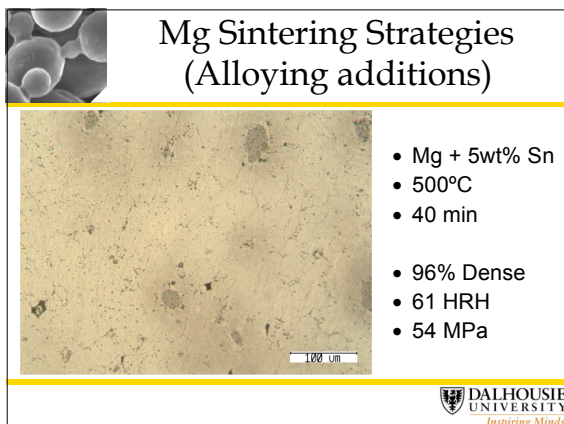
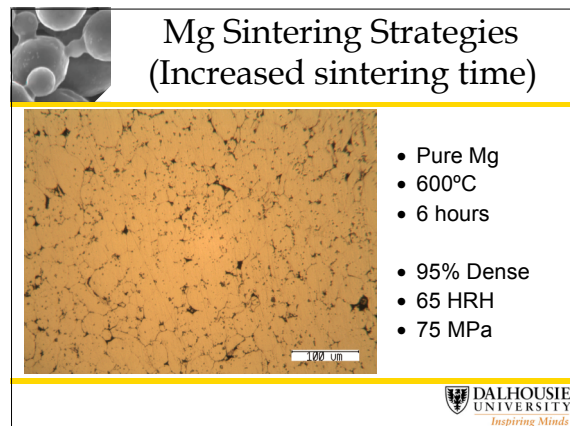
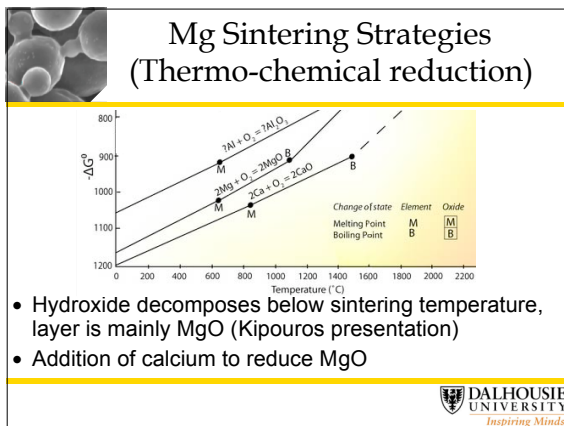
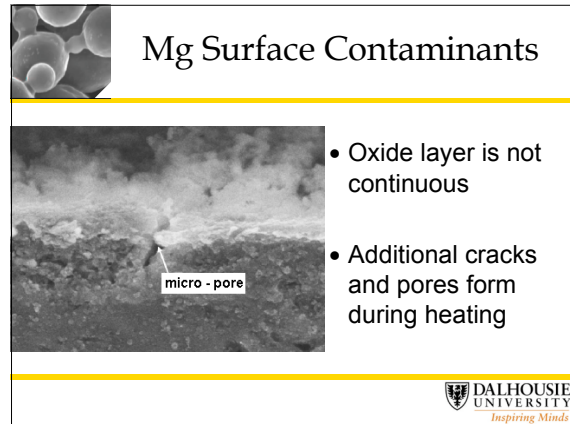
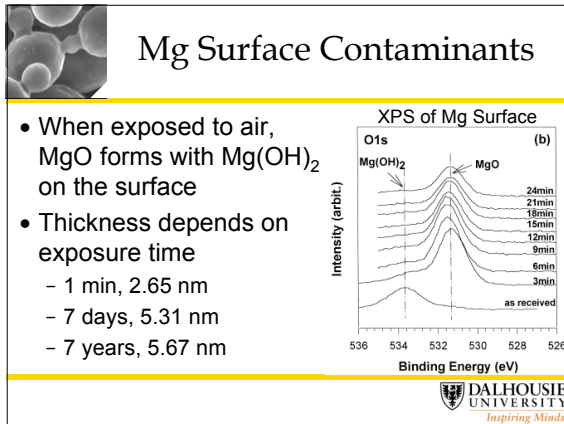
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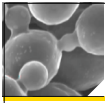
Surface Contaminants and Sintering

- Break layer
 - Create short-circuit pathway for diffusion through cracks in layer
 - Accomplished mechanically or chemically

The diagram shows a cross-section of powder particles. Arrows indicate the direction of diffusion through cracks in the surface layer. Labels include 'Powder Particle' and 'Crack in Surface Layer'.

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Acknowledgments

- Natural Sciences and Engineering Research Council (NSERC) of Canada
- Minerals Engineering Centre (MEC)