



University of Groningen

Stability of magnesium based nanoparticles for hydrogen storage

Krishnan, Gopi

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version Publisher's PDF, also known as Version of record

Publication date: 2011

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):

Krishnan, G. (2011). Stability of magnesium based nanoparticles for hydrogen storage. s.n.

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: https://www.rug.nl/library/open-access/self-archiving-pure/taverneamendment.

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): http://www.rug.nl/research/portal. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

Download date: 11-12-2022

RIJKSUNIVERSITEIT GRONINGEN

Stability of Magnesium Based Nanoparticles For Hydrogen Storage

Proefschrift

ter verkrijging van het doctoraat in de Wiskunde en Natuurwetenschappen aan de Rijksuniversiteit Groningen op gezag van de Rector Magnificus, dr. F. Zwarts, in het openbaar te verdedigen op maandag 21 februari 2011 om14.45 uur

door

Gopi Krishnan

geboren op 17 augustus 1981 te Assam, India Promotores: Prof. dr. ir. B. J. Kooi

Prof. dr. J. Th. M. De Hosson

Copromotor: Dr. G. Palasantzas

Beoordelingscommissie: Prof. dr. B. Dam

Prof. dr. ir. P.R. Onck Prof. dr. K.U. Loos

STABILITY OF MAGNESIUM BASED NANOPARTICLES FOR HYDROGEN STORAGE

Gopi Krishnan

For my family

ISBN (Book): 978-90-367-4787-5 ISBN (Digital): 978-90-367-4786-8

Zernike Institute PhD thesis series 2011-10 ISSN 1570-1530

Print: Groningen University Press 2011

Cover: The front page image is a high resolution TEM micrograph of magnesium nanoparticle with a crystalline MgO oxide shell around the Mg Core.

Cover design courtesy: Lalitha Nanduri



The PhD Project was carried out in the Zernike Institute for Advanced Materials according to the requirements of the Graduate School of Science (Faculty of Mathematics and Natural Sciences, University of Groningen).

CONTENTS

Thesis Outline	VII
Chapter 1	1
Introduction	
1.1. Hydrogen as a fuel	2
1.2. Metal hydrides	5
1.3. Magnesium nanostructures	8
1.4. Kirkendall effect and Kirkendall void	9
1.5. Nanoscale Kirkendall Effect.	12
Chapter 2	19
Experimental Procedures	
2.1. Nanoparticle from gas phase synthesis	19
2.2. Nanoparticle synthesis based on sputtering	21
2.3. NC200-UHV nanocluster source	22
2.4. Transmission electron microscopy	27
2.5. High-resolution transmission electron microscopy	35
2.6. TEM analysis of the specimen	42
Chapter 3	47
Thermal stability of gas phase Magnesium nanoparticles for hydrogen Storage	
3.1. Introduction	47
3.2. Experimental procedure	48
3.3. Results and discussions	49
3.4. Conclusions	60

Chapter 4	65
Improved thermal stability of gas phase Mg nanoparticles for hydrogen storage	
4.1. Introduction	65
4.2. Experimental procedure	66
4.3. Results and discussions	67
4.4. Conclusions	72
Chapter 5	75
Influence of Ti on the formation and stability of gas-phase Mg nanoparticles	
5.1. Introduction	75
5.2. Experimental procedures	76
5.3. Results and discussion	76
5.4. Conclusions	82
Chapter 6	85
Hollow MgO nanoshell: formation and stability	
6.1. Introduction	85
6.2. Experimental procedures	86
6.3. Results and discussion	87
6.4. Conclusions	94
Summary	97
Samenvatting	99
List of publications	101
Acknowledgements	103