

University of Groningen

Manipulation and control of the growth of magnetic iron nitride films

Grachev, Sergey Yu.

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:
2003

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Grachev, S. Y. (2003). Manipulation and control of the growth of magnetic iron nitride films Groningen: s.n.

Copyright

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).

Take-down policy

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.

RIJKSUNIVERSITEIT GRONINGEN

**Manipulation and control of the growth of
magnetic iron nitride films**

Proefschrift

ter verkrijging van het doctoraat in de
Wiskunde en Natuurwetenschappen
aan de Rijksuniversiteit Groningen
op gezag van de
Rector Magnificus, Prof. dr. F.Zwarts,
in het openbaar te verdedigen op
vrijdag 4 juli 2003
om 14:15 uur

door

Sergey Yu. Grachev

Geboren op 1 december 1972

te Chișinău

Promotor: Prof. dr. D.O. Boerma

Beoordelingcommissie:
Prof. dr. T. Hibma
Prof. dr. L. Niesen
Prof. dr. ir. B. Poelsema

Front cover: the Snake and the Charmer from an Indian puppet show

MSC Ph.D.-thesis series 2003-05
ISSN 1570-1530



Contents

1. Introduction	5
2. Experimental methods and setups	11
2.1 Introduction	11
2.2 The setups	11
2.2.1 The setup at the Groningen University	11
2.2.2 The setup at the Universidad Autonoma de Madrid	12
2.3 Substrate and sample preparation	12
2.4 Auger electron spectroscopy	13
2.5 X-ray diffraction	14
2.6 Low-energy electron diffraction	15
2.7 Rutherford backscattering spectroscopy and channeling	16
2.8 Low-energy ion scattering spectroscopy	17
2.9 Conversion electron Mössbauer spectroscopy	19
2.10 Atomic force microscopy	20
2.11 Scanning tunneling microscopy	21
2.12 References	22
3. Atomic N-assisted MBE growth of Fe₄N with different sources of nitrogen	23
3.1 Introduction	23
3.2 An overview of Fe-N phases	23
3.3 MBE growth of Fe in ammonia background pressure	25
3.4 MBE in the presence of a gas flow through a hot iron nozzle	26
3.5 MBE in the presence of a flow from a RF plasma source	26
3.6 Conclusions	31
3.7 References	31
4. A radio-frequency plasma source of N atoms	33
4.1 Introduction	33
4.2 Design of the RF-source	34
4.3 Gas flux calculations by Monte-Carlo simulations	34
4.4 Optical spectroscopy	36
4.5 Conclusions	37
4.6 References	38
5. Mechanism of growth of Fe₄N on MgO(100)	39
5.1 Introduction	39
5.2 Sticking coefficient of N atoms to iron	39
5.3 Growth of mixed α -Fe and γ' -Fe ₄ N samples	41

Contents

5.4 Possible role of hydrogen	44
5.5 Channeling study of a sample grown on a cleaved MgO(100)	46
5.6 Conclusions	48
5.7 References	49
6. A preparatory study: N and Fe on Cu(100)	51
6.1 Introduction	51
6.2 The test sample: Fe ₄ N on MgO(100)	51
6.3 Adsorption and diffusion of N on Cu(100)	52
6.4 Intermixing of Fe on Cu(100)	55
6.5 Conclusions	60
6.6 References	60
7. On the growth mechanism of Fe₄N on Cu(100)	63
7.1 Introduction	63
7.2 The early stages of growth	64
7.3 Summary and discussion	74
7.4 References	77
8. Low energy ion scattering study of Fe₄N on Cu(100)	79
8.1 Introduction	79
8.2 The c(2x2) and p4g(2x2) reconstructed surfaces of Fe ₄ N	80
8.3 Conclusions	85
8.4 References	86
9. Summary and outlook	87
Samenvatting	91
List of publications	97
Acknowledgments	99

to my dearest friends

