A micellar approach to magnetic ultra-high density data storage media

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Motivation

Dekker Encyclopedia of Nanoscience and Nanotechnology

bit size

- 2000: 400nm x 50nm
- 2004: 400nm x 50nm
- 2006: 400nm x 50nm
- 2008: 400nm x 4x4nm
- 2010: 400nm x 4x4nm
- 2012: 400nm x 4x4nm

Dekker Encyclopedia of Nanoscience and Nanotechnology
Data storage media based on nanoparticles

Monodisperse FePt Nanoparticles and Ferromagnetic FePt Nanocrystal Superlattices

Shouheng Sun, C. B. Murray, Dieter Weller, Liesl Folks, Andreas Moser

FePt nanoparticles (4nm)

50nm


Excellent approach, initiated many studies ...
Problems - I

as-prepared
- chem. disordered A1
- superparamagnetic

annealed (600°C)
- chem. ordered L1₀
- hysteresis at RT

BUT...
XAS at Fe-L edge

iron oxide

JACS 124, 2884 (2002)

Nano Lett. 1, 443 (2001)
Preparation of clean FePt nanoparticles (in situ)

O-plasma (RF / 100W / 0.01mbar)

H-plasma (RF / 100W / 0.01mbar)
Chemical analysis (XPS, XAS)

Problems - III

XMCD

dipolar coupling !
- difficult to change particle size ($\approx 4\text{nm}$)

- difficult to control composition ('by chance')

**How to do better?**

*Increase distance!* *(but not too much...)*
The micellar approach

PS-b-P2VP + toluene → + H₂PtCl₆, FeCl₃

(PolymerSource, Inc)

dipping

O(H)-Plasma
RF, 100W, 0.01mbar
Variation of size (1-10nm) & distance (15-150nm)

TEM: Au dots


SEM: Au dots
The micellar approach: FePt alloys

- No phase separation
- No core/shell structures or other inhomogeneities

The micellar approach

after plasma treatments

SEM

size: \( \approx 4 \text{ nm} \)

distance: \( \approx 25 \text{ nm} \)

= 1 Tbit / inch\(^2\)
The micellar approach

Magnetization curves (XMCD, RT):

As prepared state (after H-plasma):
Chemically disordered A1 phase

Annealing to 650°C (90min):
Chemically ordered L1₀ phase
The micellar approach

Magnetization curves (XMCD, RT):

1. step: 650°C (90min)

2. step: 700°C (30min)

\[ B_c, \text{bulk} \approx 1 \text{T} \]
The micellar approach

FePt nanoparticles (4nm)

before

annealing

after

no agglomeration!
TEM after annealing to 700°C (30min)
To be improved: quality of the array

> 1 Tbit/inch²

use templates (conventional lithography)

APL 81, 3658 (2002)
From random orientation to epitaxy...

Z. Zhang, U. Kaiser
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(unpublished)
Micellar particles are better!