CONFOCAL SPECTROMICROSCOPY
OF
AMORPHOUS AND NANOCRYSTALLINE
TUNGSTEN OXIDE FILMS

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State-of-the-Art

• “Blu-ray” disks, having capacity of more than 25 GB per recording layer, use a 405 nm laser, focussed through a high numerical aperture (NA=0.8-1.0) objective lens to a spot size of about 300 nm.

• The most frequently used rewritable phase change recording materials, belong to the group of semiconductor chalcogenides.
  For example: ternary GeSbTe and quaternary AgInSbTe alloys.

• Other materials - tungsten oxides:
  - a reversible photoredox reaction under two-wavelength laser excitation of tungsten oxide in air
  - heat treatment of WO₃/metal thin-film bilayered structures
  - rewritable electrically selective multi-layered optical recording disk, based on the electrochromic behaviour of WO₃
  - write-once optical recording was demonstrated in WO₂ film
Present work goal

• To demonstrate the possible use of WO$_3$ & AWO$_4$ thin films for write-once phase change optical recording.

• To propose the multilayer AWO$_4$ phase-change media structure based on Raman scattering detection of the highest frequency stretching W-O mode.
3D scanning confocal microscope with spectrometer "Nanofinder-S"
produced by SOLAR TII, Ltd.

Simultaneous / Multifunctional Analysis:
- Optical and Confocal Microscopy
- Raman Spectroscopy
- Luminescence Spectroscopy
- 0D, 1D, 2D & 3D High-speed Imaging and Spectroscopy
"Nanofinder-S" modular optical layout

He-Cd 441.6 nm 50 mW
Commercial Compact Disk Imaging in Confocal Mode

CD-ROM

CD-R

CD-RW

Track pitch = 1.6 µm

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Images size: 20×24 µm
Thin Film Preparation by DC Magnetron co-Sputtering

Metallic targets:
- W (99.95%)
- Ni (99.0%)
- Zn (99.9%)

Substrates: Si, glass

Sputter gas: Ar (80%) + O₂ (20%)
Total gas pressure: 6.7 Pa
Discharge power: 100 W
Crystalline Structure of WO$_3$

\[ \text{WO}_3 : [\text{WO}_6] \]

Well known electrochromic material based on valence change of tungsten ions: \( W^{6+} \) (transparent) \( \rightarrow \) \( W^{5+} \) (blue)
Crystalline Structure of $\text{AWO}_4$

$\text{(A} = \text{Ni, Zn)}$

$\text{AWO}_4 : [\text{AO}_6] \& [\text{WO}_6]$

Tungstates are known as scintillators and Raman shifters.
Optical Recording in t.f.-WO$_3$

Confocal images:

(a) 15 mW

(b) 25 mW

(c) 50 mW

O-W-O stretching modes

O-W-O & W=O stretching modes

Optical Recording in t.f.-NiWO$_4$

Confocal images:
- 15 mW
- 25 mW
- 50 mW

Raman shift (cm$^{-1}$)

O-W-O stretching modes

Optical Recording in t.f.-ZnWO$_4$

- O-W-O stretching modes
- W-O-W bending modes

Raman Intensity (a.u.) vs. Raman shift (cm$^{-1}$)

- Si
- ZnWO$_4$

- 700°C
- 50 mW
Possible Mechanisms of Optical Recording in Tungsten Oxides

\[ W^{6+}O_{3-x} & AW^{6+}O_{4-x} \ (A = \text{Ni, Zn}) \]

Formation of metastable color centers \( W^{6+} \rightarrow W^{(6-y)+} \)
- short term life time in air

Change in reflectivity (10-20%)

Crystallization to \( WO_3 / AWO_4 \)
- long term life time
- good thermal stability

Change in phase & reflectivity

Multilayer phase-change media structure based on Raman scattering detection
**Multilayer write-once phase-change media structure based on Raman scattering detection**

1,..., n

Sequential Writing

Parallel Reading

AWO₄ band gap ~ 3.0-3.8 eV
Thank you!

For more information look at the Internet:
http://www.cfi.lu.lv/exafs

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