A Comparison of the Thermal Stability Factors in Single Layer and Exchange-Coupled Longitudinal Media

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NSF (Grant No. ECS-008534) and made use of the NSF MRSEC Shared Facilities (Grant No. DMR-9809423)

Motivation

• Thermal stability problem: the straightforward solution of increasing the anisotropy energy is limited by the write field capabilities of currently available heads and is thought to limit the potential areal density of longitudinal media.

• Recently proposed\textsuperscript{1,2} antiferromagnetically exchange coupled multi-layers (synthetic ferrimagnetic media, SFM) are believed to extend the areal densities beyond the predicted superparamagnetic limit for single layer media (SLM).

Description of the Samples

Glass / NiP / Cr / CoCr / CoCrPtB / Ru / CoCrPtB / C

<table>
<thead>
<tr>
<th>Sample</th>
<th>$t_1$ (nm)</th>
<th>$t_2$ (nm)</th>
<th>$t_2-t_1$ (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL6</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SL8</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SL12</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF7</td>
<td>5</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>SF9</td>
<td>5</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>SF12</td>
<td>4</td>
<td>16</td>
<td>12</td>
</tr>
</tbody>
</table>

Major advantage: low $\text{Mrt}$!

$\text{Mr}_{\text{SFM}} = \text{Mrt}_2 - \text{Mrt}_1$

Ru layer: 0.7 nm
Typical Hysteresis Loop and Remanent Magnetization curve

- Hysteresis loops confirm antiferromagnetic coupling of the layers (arrows represent magnetization configuration)
- No difference in the shape of the remanent magnetization curve from that of a single-layer media.
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Mst, Mrt

- Mst_{SFM} data points laying below the Mst(t) line predicted from the SLM data suggest the saturation field is not strong enough to fully align the moments in both layers.
- Mrt_{SFM} values are above the SLM data. This suggests, the moments are not fully antiparallel at remanence.
- Linear growth of the Mst with thickness for SLM.

SLM: \( t = t_1 \),
SFM: \( t = t_1 + t_2 \) for Mst and \( t = t_2 - t_1 \) for Mrt.
Time-Dependent Remanent Coercivity
Measured: AGM

Sharrock’s formula 3:

\[ H_{CR} = H_0 \left( 1 - \left( \frac{kT}{KV} \ln \left( \frac{f_0 t}{\ln(2)} \right) \right)^{2/3} \right) \]

Intrinsic Switching Field ($H_0$)

- The increase in $H_0$ in the SLM samples with thickness is due to the change of the anisotropy energy density $K$.

- The values of $H_0$ for SFM do not change significantly with $t$ indicating that the structure of the top layer varies only slightly.

$H_0$ (Oe) vs. $t$ (nm)

SLM: $t = t_1$,
SFM: $t = t_1 + t_2$ for $M_{st}$ and $t = t_2 - t_1$ for $M_{rt}$.

4 A. Ajan, Fujitsu Laboratories, private communication

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• Small slope for SLM: Switching volume V increases with the decrease of t faster than K decreases.  

5 • Greater slope and a non-zero intercept for the SFM.

• At zero effective magnetic layer thickness the physical thicknesses of the component layers may be far from zero.

• The KV/kT of an SFM is determined primarily by the top layer properties!

Conclusions

• Time-dependent remanent coercivity data confirms that the $KV/kT$ of the synthetic ferrimagnetic media is determined primarily by the properties of the top layer.

• A significant improvement in thermal stability of the synthetic ferrimagnetic media with respect to that of a single layer media of the same effective magnetic layer thickness without serious increase in switching field is confirmed.