CPP-GMR with Various Metallization Schemes

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This project was funded by grant NSF ECCS-529369 & shared equipment from NSF-MRSEC.

Introduction
In order to achieve high recording densities, recording head dimensions such as shield-to-shield spacing, track width and track thickness are scaled down, leading to requiring a corresponding scaling of sensor dimensions. For current-in-plane (CIP) sensors, the sensor length decreases results in decreasing resistance and magnetoresistance. The signal-to-noise ratio (SNR) also decreases with sensor length because of increasing edge effects. Vertical structures include current-perpendicular-to-the-plane (CPP) and tunneling magnetoresistance (TMR) sensors. TMR sensors have extremely large values of MR, but their intrinsically higher resistance indicates increasing difficulties with further scaling, making CPP-GMR sensors the preferred choice for > 10 Tb/in².

Successful fabrication and characterization of CPP-GMR stacks fabricated using a novel stepwise planarization scheme are presented here. Two different mask designs were used, one featuring nanopillars centered on micropillars (Design 2) and one featuring only nanopillars centered between crossed top and bottom leads Design 1. We present MR results from a variety of switching schemes, using synthetic antiferromagnet (SAF) pinning with and without a Ta seed layer, hard magnet (CoPt) pseudo spin valves (PSV) and CoFe PSV.

CPE GMR Fabrication – stepwise planarization

Metallization Schemes
Four different spin valves were used in the CPP-GMR devices:
1. SAF – Ta5/Cu80/CoFe3/Ru0.8/CoFe5/Cu10/CoFe4/Ru5
2. SAF Seed Layer – Ta3/Cu80/Ta2/CoFe3/Ru0.8/CoFe5/Cu10/CoFe4/Ru5
3. CoFe PSV – Ta3/Cu80/CoFe10/Cu10/CoFe2.5/Ru5

Design 1

Design 2

E-beam Resist Ellipse Size vs Dose

Two mask designs were employed to give different contact geometries

- Devices have a ~120/60nm elliptical nanopillar
- The nanopillars were patterned using e-beam lithography, varying the dose from 400-480µC/cm²
- The nanopillar contains the caping layer, free layer, and part of the spacer layer for each spin valve

Summary of PPMS Results

Devices from each type of spin valve were tested for MR at 300K and 10K using PPMS system

<table>
<thead>
<tr>
<th>Spin</th>
<th>Mask</th>
<th>300K (MR)</th>
<th>300K (R)</th>
<th>10K (MR)</th>
<th>10K (R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAF</td>
<td>2</td>
<td>0.67%</td>
<td>0.14</td>
<td>1.58%</td>
<td>0.06</td>
</tr>
<tr>
<td>SAF</td>
<td>1</td>
<td>0.60%</td>
<td>1.28</td>
<td>0.73%</td>
<td>1.05</td>
</tr>
<tr>
<td>SAF with</td>
<td>1</td>
<td>2.60%</td>
<td>0.02</td>
<td>2.65%</td>
<td>0.03</td>
</tr>
<tr>
<td>SAF with</td>
<td>1</td>
<td>0.40%</td>
<td>0.28</td>
<td>0.51%</td>
<td>0.28</td>
</tr>
<tr>
<td>CoFe PSV</td>
<td>1</td>
<td>0.23%</td>
<td>0.36</td>
<td>0.82%</td>
<td>0.15</td>
</tr>
<tr>
<td>CoFe PSV</td>
<td>1</td>
<td>0.63%</td>
<td>1.30</td>
<td>1.05%</td>
<td>0.97</td>
</tr>
<tr>
<td>CoPt PSV</td>
<td>1</td>
<td>0.48%</td>
<td>0.47</td>
<td>1.29%</td>
<td>0.36</td>
</tr>
<tr>
<td>CoPt PSV</td>
<td>1</td>
<td>0.59%</td>
<td>0.58</td>
<td>1.36%</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Conclusions

CPE GMR devices were successfully fabricated using stepwise planarization with four different metallization schemes and two sets of mask designs. We believe this fabrication scheme is simple and robust, and may be used to compare various switching schemes and contact geometries.