SUBSTRATE PLANARIZATION STUDIES ON IBAD SUBSTRATES

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To achieve high critical currents in 2nd generation superconductors deposited on metallic substrates, substrate average roughness and texture of the buffer layer are key factors. This study is about planarization of IBAD substrates using an inductively coupled RF discharge operating at 13.56MHz. A pancake coil antenna was used to construct the inductively coupled discharge system. Exposure to an Ar plasma for varying Ar pressures and time 15 min to 1 hr created linearized substrates. Surface roughness was measured using AFM as well as surface profilometer. Unpolished Inconel substrates have been studied under varying RF plasma conditions, such as pressure, RF power, and etch time to determine effects on substrate roughness. AFM and KLA- TENCOR SP measured average surface roughness (Ra) of the planarized samples. The best Ra found on plasma etched substrate is 4nm under 240 mTorr pressure and 100 W RF power and 30 min time from AFM analysis. The Ra values for Inconel substrates vary between 35-51 nm under varying conditions. Our initial results suggest that there is a decreasing tendency in Ra with the increase of Ar pressure.
Substrate Planarization Studies on IBAD Substrates

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ABSTRACT

To achieve high critical currents in second generation superconductors deposited on metallic substrates, substrate average roughness and texture of the buffer layer are key factors. This study is about Planarization of ion beam assisted deposition (IBAD) substrates using an inductively coupled radio frequency (RF) discharge operating at 13.56 MHz. The inductively coupled discharge system was constructed using a pancake coil antenna. Linearized substrates were created by exposure to an Ar plasma for varying Ar pressures (8 m Torr - 1 Torr) and time 15 minutes to 1 hr. Surface roughness was measured using atomic force microscopy (AFM) as well surface profilometer. Unpolished Inconel substrates have been studied under varying RF plasma conditions, such as pressure (8 m Torr to 1 Torr), RF power (50 Watts to 200 Watts) and etch time (15 to 60 minutes) to determine the effects on substrate roughness. Average surface roughness (Ra) of the planarized samples was measured using AFM and KLA-TENCOR surface profilometer (SP). The best Ra observed on plasma etched substrate is 4 nm under 240 m Torr pressure and 100 watts RF power and 30 minutes time from AFM analysis. The Ra values for Inconel substrates vary between 35-51 nm under varying conditions. Our initial results suggest that there is a decreasing tendency in Ra with the increase of Ar pressure.

INTRODUCTION

For the deposition of oxide buffer layers using ion beam assisted deposition (IBAD), the substrate smoothness is important for obtaining good texture of the buffer layers. However, there are no systematic studies reported on the substrate planarization. So in this paper we report a systematic investigation of substrate planarization using RF plasma under varying plasma conditions.

EXPERIMENTAL

An inductively coupled discharge system was constructed using a pancake coil antenna. Cross sectional view of the experimental set up is shown in Figure 1. The chamber is pumped using a Turbo pump prior to the etching. Plasma was created by ionizing ultra pure Ar gas at 13.56 MHz RF power (max. 200 Watts) in the chamber to treat the substrates. Linearized substrates were created by exposure to the plasma at different Ar
Figure 1 Cross sectional view of the experimental set up

pressures (8 mTorr – 1 Torr) and time (15 minutes to 1hr). We have also investigated the
effect of magnetron plasma on the planarization at very low Ar pressures. Substrates were
placed on the top of a circular magnetron. Ra of the sample, before plasma treatment and
after plasma treatment determined using AFM as well as a SP.

RESULTS AND DISCUSSION

AFM surface analytical studies (10µm x10µm area over 30 positions) suggest that Ra is
not affected from 30 to 120 mTorr pressure. However, a sudden increase in the Ra has
been observed at 240 mTorr Ar pressure. The best fit for this graph is a Polynomial fit as
shown in the Figure 2. The surface morphology of a planarized substrate at 30mTorr Ar
pressure for 30 minutes with 100W RF power is shown in Figure 3. However, the Ra data
(50µm x50µm) obtained from SP analysis shown in Figure 4 suggests that the trends are
towards lower surface roughness with the increase of Ar pressure. Figure 5 suggests that
there is no significant effect of RF power with time on the average Ra. However, a
decreasing tendency in Ra with the increase in Ar pressure has been observed. More
studies are in progress to explain the effects of Ar pressure or RF power or time of
planarization on the substrate average roughness.

Table 1. Summary of AFM analysis for certain conditions of substrate planarization

<table>
<thead>
<tr>
<th>Pressure mTorr</th>
<th>Power Watts</th>
<th>Time in mts</th>
<th>Ra (nm)</th>
<th>Mean</th>
<th>Median</th>
<th>Std Deviation</th>
<th>Variance</th>
<th>Best Ra (nm)</th>
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<tbody>
<tr>
<td>0</td>
<td>*</td>
<td>*</td>
<td>9.1</td>
<td>8.7</td>
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<td>2.71</td>
<td>7.4</td>
<td>5.9</td>
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<td>30</td>
<td>9.6</td>
<td>8.9</td>
<td>8</td>
<td>3.41</td>
<td>11.7</td>
<td>4.1</td>
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<tr>
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<td>100</td>
<td>30</td>
<td>8.1</td>
<td>7.5</td>
<td>6.8</td>
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</tr>
<tr>
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<td>100</td>
<td>30</td>
<td>8.6</td>
<td>8.2</td>
<td>8.04</td>
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<td>6.76</td>
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</tr>
<tr>
<td>240</td>
<td>100</td>
<td>30</td>
<td>15.2</td>
<td>15.2</td>
<td>8.6</td>
<td>10.1</td>
<td>101</td>
<td>5.1</td>
</tr>
</tbody>
</table>

* Unpolished substrate
Figure 2. Affect of Ar Pressure on $Ra$ of planarized Inconel (AFM analysis).

Figure 3. Typical surface morphology of the planarized Inconel substrate (SP micrograph).

Figure 4. Affect of Ar partial pressure on $Ra$ (from SP data analysis).

Figure 5. Affect of RF power on $Ra$ (from SP data analysis).

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