ALUMINUM FOIL AS CATHODIC PROTECTOR TO PREVENT SILVER MIRRORING

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INTRODUCTION

Silver mirroring is one of the major problem we face in every photographic collection, a new method has been developed using commercial aluminum foil as a cathodic protector to prevent it, the new method has the advantage of being (cheap-available) so it can be applied in every archive or museum with no need of too much fund.

SILVER MIRRORING

Silver mirroring starts with an Oxidation of the silver particles by an oxidizer usually (H₂O₂), in presence of moisture the silver will oxidized into silver ions (Ag⁺), the silver ions then Diffusion inside the emulsion layer to up, then the silver ions will Reaction with the hydrogen sulphide (H₂S) forming (Ag₂S) which is silver mirroring, then in keep contacting with the (H₂S) it will Grow in size not in number is called the (ODRG) model.

CATHODIC PROTECTION (SACRIFICIAL ANODE)

Simply sacrificing by less value metal to protect the metal we want to protect by providing by electrons instead of the ones it lost due to the RED-OX reactions.
THE IDEA

We all agree about the following facts:

1- the first step in silver mirroring is the oxidation of silver metallic (Ag) and turn it into unstable silver ions (Ag+).

2- silver mirroring also occurs on the top surface of the emulsion layer.

3- silver (Ag) can oxidise aluminium (Al), in electron terms silver can take electrons from aluminium.

4- aluminium can be used as a sacrificial anode to silver.

5- we can sputter a thin film of the aluminium to any material.

So simply if we add a very thin film of aluminium foil on the top surface of the emulsion layer using sputtering technique the silver ions witch diffuse to the emulsion surface will hit the aluminium layer acting as a oxidizing agent and oxidize the aluminium resulting in reducing the silver ions(Ag+) back into silver metallic (Ag).

![Showing the normal silver mirroring steps the ODRG model](image1)

![Showing the result of using a thin film of Al which will help reduce the silver ions Ag+ into silver metallic Ag again before forming the Ag2S](image2)
**RESULTS**

The table shows the results of using a *q 150r es magnetron sputtering machine* with both profiles.

<table>
<thead>
<tr>
<th>Profile name</th>
<th>Fitted material</th>
<th>current</th>
<th>Sputtering time</th>
<th>Chamber pressuer</th>
<th>Aluminum existance</th>
<th>Color change</th>
</tr>
</thead>
<tbody>
<tr>
<td>QT-TIMED GOLD</td>
<td>GOLD</td>
<td>40 MA</td>
<td>90 SEC</td>
<td>$7 \times 10^{-2}$</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>QT-TIMED GOLD</td>
<td>GOLD</td>
<td>40 MA</td>
<td>100 SEC</td>
<td>$7 \times 10^{-2}$</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>QT-TIMED GOLD</td>
<td>GOLD</td>
<td>40 MA</td>
<td>120 SEC</td>
<td>$7 \times 10^{-2}$</td>
<td>NO</td>
<td>YES</td>
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<tr>
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<td>GOLD</td>
<td>40 MA</td>
<td>180 SEC</td>
<td>$7 \times 10^{-2}$</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>QT-TIMED GOLD</td>
<td>GOLD</td>
<td>40 MA</td>
<td>200 SEC</td>
<td>$7 \times 10^{-2}$</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>QT-TIMED GOLD</td>
<td>GOLD</td>
<td>40 MA</td>
<td>300 SEC</td>
<td>$7 \times 10^{-2}$</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>HENDY</td>
<td>ALUMINIUM</td>
<td>80 MA</td>
<td>90 SEC</td>
<td>$1 \times 10^{-1}$</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>HENDY</td>
<td>ALUMINIUM</td>
<td>80 MA</td>
<td>300 SEC</td>
<td>$1 \times 10^{-1}$</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

**The results using SEM-EDX**

Showing failer to add the AL layer

Showing success to add the AL layer

**Conclusion**

using aluminum foil is applicable theoretically to prevent silver mirrirong for silver based photographic materials by sputtering it using a sputtering machine or using a piece of aluminum foil and just add it on the top surface of the photographic material.

**reccomendation**

Further experimentaions is highly reccomended to make sure this method is working practicaly and has no bad effects on the long term.