Gold plated brass annealing trials and annealed C101 copper residual resistivity ratio.

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The present note summarizes the result of several heat treatments preformed on gold plated brass and bare C101 copper. The tests were made in order to study the behavior of plated devices under heat treatment as well as to find a suitable temperature to anneal them.

A) Gold plated brass annealed at 300C in nitrogen atmosphere

A gold plated (PurAGold-125, 300μin) brass block was cut in half in order to have two pieces with identical characteristics. One half was annealed for 3 hours at 300C in a nitrogen atmosphere. The other half was use as a control sample.

![Fig.1a. Gold plated brass annealed (right) at 300C and control sample (left). Plated surfaces.](image)

The annealed sample does not show appreciable change in color on the gold plated surfaces. This suggests that no significant diffusion between the substrate and the plating has occurred, nor strong interaction between the surface and the atmosphere. As shown in Fig.1.a.
On the other hand the naked brass sides (where the block was cut and filed) show an appreciable change in color, the annealed piece being darker than the un-annealed one. An examination under the microscope showed that the change in color is superficial given that after scratching the surface the original color was easily found.

**B) Gold plated brass annealed at 500C in nitrogen atmosphere**

As in the 300C test, a gold plated brass block was cut in half. The test showed that at a temperature of **500C during 3 hours** the gold plating is heavily damaged, falling off, and changing it color all around the piece. The annealed sample shows a darker color and oxidized-like appearance.
C) C101 copper annealed at 700C and 300C in nitrogen atmosphere. DC residual resistivity ratio (RRR) measurements.

Two C101 copper bars were annealed for **3 hours at 700C and 3 hours at 300C**. Both samples show a darker color and oxidized-like appearance after the annealed being more extensive in the bar treated at 700C as shown in fig. 3a.

![Fig.3a. C101 copper annealed at 700C (below) and control sample (above).](image1)

![Fig.3b. C101 copper annealed at 300C (below) and control sample (above).](image2)

The DC residual resistivity ratio (RRR), the ratio between the resistivity at room temperature and 4.2K, was measured in the 3 samples using a 4 wire micro-ohm meter.

The results are show in the following table

<table>
<thead>
<tr>
<th>Sample</th>
<th>Residual resistivity ratio (RRR)</th>
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<tbody>
<tr>
<td>Control Sample (un-annealed C101)</td>
<td><strong>106 +/- 4</strong></td>
</tr>
<tr>
<td>700C for 3 hours</td>
<td><strong>468 +/- 50</strong></td>
</tr>
<tr>
<td>300C for 3 hours</td>
<td><strong>276 +/- 40</strong></td>
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</table>
D) Bare copper at 220°C in nitrogen atmosphere and vacuum

In order to understand the change of color and oxidized-like behavior of the samples due to the thermal treatment an additional heat treatment was performed in nitrogen and vacuum.

Three pieces of C101 copper were used for control, vacuum annealing and nitrogen atmosphere annealing respectively.
The annealing under nitrogen and vacuum was performed at **220°C for 1 hour**.

The Fig. 4.a and 4.b shows the C101 samples after the thermal treatment and the control sample.

![Fig.4a. C101 copper annealed at: 220°C in nitrogen (below) and control sample (above).](image)

![Fig.4b. C101 copper annealed at: 220°C in vacuum (below) and control sample (above).](image)

The sample annealed in nitrogen atmosphere shows a darker color than the control piece. No appreciable change in color was noticed in the copper piece annealed under vacuum.
Conclusions

The nitrogen atmosphere appears not to be completely inert on contact with bare brass or copper at temperatures above 220°C.

The nitrogen atmosphere and a temperature of 300°C appeared suitable for annealing gold plated devices with brass substrates.

Thermal treatment of gold plated brass in a nitrogen atmosphere above 500°C yields extensive damage to the plating and the substrate surfaces.

The Annealing of C101 copper at temperatures above 300°C for 3 hours produces a considerable increase in electrical conductivity at cryogenic temperatures. The residual resistivity ratio (RRR) after a 300°C/3 hours annealing was 2.6 times the RRR of the un-annealed copper. The RRR after a 700°C/3 hours annealing was 4.4 times the RRR of the un-annealed piece.