SURFACE STRUCTURING BY ELECTROCHEMICAL TECHNIQUES

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Abstract

Electrochemical processes are used to create a uniform colour and special surface properties of the plated objects. The development of different techniques for the surface structuring using resist films opens also a field of possible applications of such techniques for new design in jewellery production. The presentation gives an overview of the use of photo resist films and other structuring techniques in combination with electrochemical processes for the deposition of precious metals for jewellery applications.

Keywords

Electrodeposition, surface structuring, surface properties, gold layers and structures, photo resist, LIGA-technique, microstructures,

Introduction

In the field of jewelry production electrochemical processes are widely used e.g. to create a uniform surface color and brightness or to improve the properties of the surface by using special hard coatings or dispersion layers to increase the wear resistant of the plated parts. Furthermore electrochemical processes are used for the production of jewelry by using galvanoforming techniques.

In the case of the application of electrochemical processes for the deposition of final layers, relatively thin coatings in the range from 0.1 to 20 µm are used, whereas for the galvanoforming thick layers up to 300 µm where applied. The big advantage of the application of galvanoforming techniques is that also complicated shaped jewelry with a special surface structure can be produced easily nearly without limitations in design.

An other possibility of using electrochemical processes in jewelry production is the surface structuring. An overview about the possible application of such techniques is given in the following.

Surface structuring

For new jewelry design also new production techniques are necessary. A combination of different surface colors or surface structures are widely used in jewelry design. So in many cases a bright area is applied beside a dull or a structured part of the surface, to achieve special design effects. These dull or structured parts often becoming bright or loosing their special surface structures after a relatively short time of wearing the jewelry.

Apart from the mechanical methods or laser techniques to product structured surfaces also chemical and electrochemical processes can be used. With mechanical technique only very low aspect ratios – aspect ratios means the relation between the height and the width of the structures - can be achieved, limited by the dimension of the used tools. Other possibilities for the surface structuring are electrochemical techniques.

Electrochemical and electroplating processes are widely used in the different fields of technology for structuring surfaces. The most common applications are the production of printed circuits boards and the production of micromechanical components. For micromechanical components different types of structuring methods are applied according to the wide range of demands concerning the precision of the geometry.

The principle of all the structuring methods in combination with electroplating processes is the same.

The surface of the substrate to be structured has to be covered with a resist film first. This resist film can be deposited on the surface by different techniques in dependence of the type of the used resist and also of the thickness of the applied resist structure. In principle two different types of resists are used the dry and the liquid resists. Dry film resists are laminated onto the surfaces while liquid resists can be deposited by dipping the surfaces into the resist solution, by spraying, spinning or with an electrophoretic process.

After designing the surface structure these pattern have to be transferred into a special mask witch can be used for the exposure of the resist.

These masks can be achieved by printing techniques or by the use of photolithography. Ultraviolet light is used normally for the exposure of the resists. Strongly parallel X-rays, so-called syncrotron radiation, are used for the exposure of the resists for special applications. After exposure the exposed or nonexposed areas can be dissolved in a chemical process. It depends if a positive or negative working resist is used.

For a very high structure heights with a high aspect ratio the LIGA-technique is used. LIGA is an abbreviation for lithography in combination with galvanoforming.

The steps of the production of LIGA-microstructures are shown in principle in the following FIG.1:

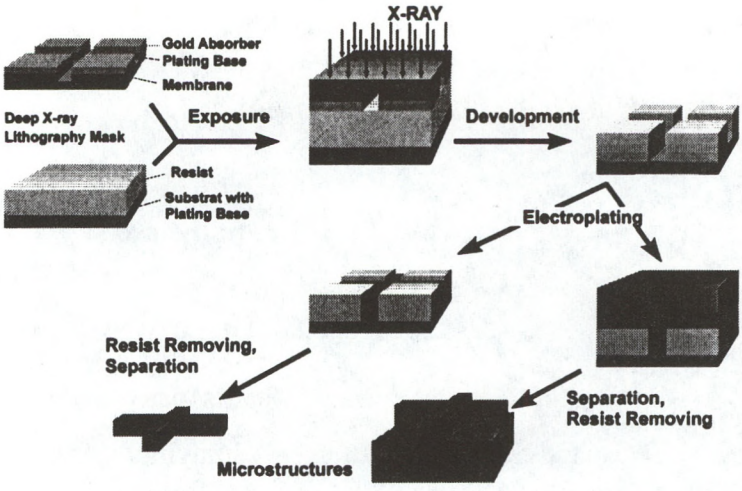

Figure 1: Production steps of LIGA-microstructures

With the LIGA-technique structures in a micrometer range with a height of some hundred micrometers can be produced. This is only possible with the application of X-Ray exposure with high energy. For X-Ray exposure special structured masks of materials with a high absorption coefficient are necessary. As absorber materials gold, platinum or tungsten can be applied. Also these masks can be produced by electroplating processes.

The following FIG. 2 and FIG. 3 shows an overview and in detail how precise the microstructures of gold can be produced by the use of electrochemical techniques.

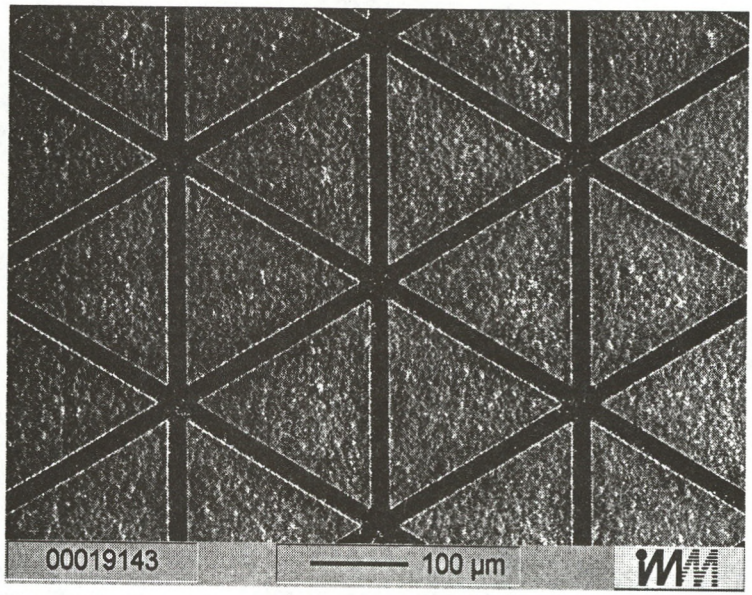

Figure 2: Overview of a gold-structure

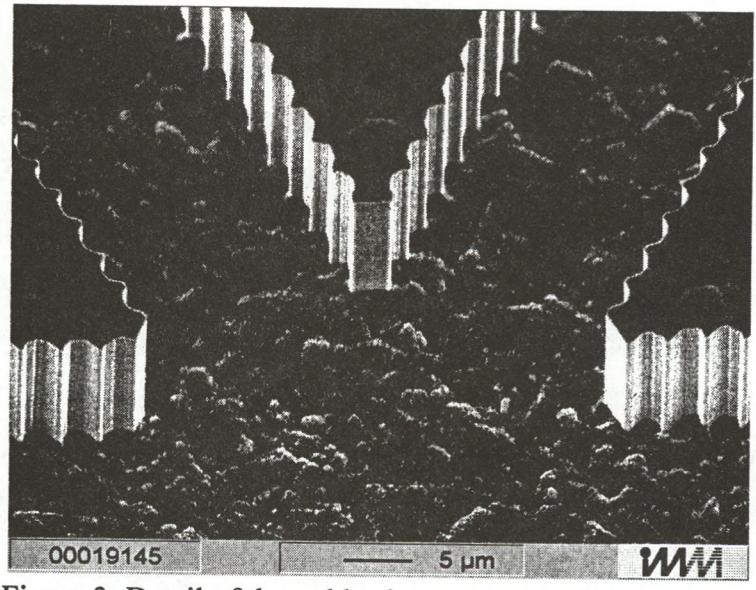

Figure 3: Detail of the gold-microstructur in Fig.2

For decorative applications a structuring of surfaces with such a high precision, as it is possible with the LIGA-technique is not necessary. By using normal ultraviolet sensitive resists with printed masks, highly accurate structures in the range of ten to hundred micrometers can be achieved easily. These possibilities are demonstrated with the electrodeposition of test structures. The results are described below.

Electrodeposition of test structures

Electrolytes to be used for the surface structuring have to meet different requirements. One of the most important points is the compatibility to the used resist system. Most of the resists are not stable under alkaline conditions, so it is necessary to keep the pH-value in the range under 7. To achieve a uniform thickness distribution of the layers in the electroplated structures a good throughing power of the electrolyte is needed. Furthermore a high deposition rate and the possibility to get a high thickness of the structures is important for the application of this technique.

To keep the surface structure for a long time the layers must have the following properties:

- high wear resistant
- high hardness
- low internal stresses
- good adhesion to the substrate

For the deposition of the test structures a commercial fine gold electrolyte (DEGUSSA AURUNA 556 ®) has been used. The process parameters of the electrolyte are shown in TAB.1.

gold content in the layer	99.9%
pH-value	6
gold content in the electrolyte	8 g/l
temperature	50 °C
current density	0.8 A/dm^2
current efficiency	90%
deposition rates	0,5 µm/min
hardness of the layer	250 $HV_{0.025}$
maximum layer thickness	>200 µm

Table 1: Process parameters of the used electrolyte

Using this electrolyte the possibility of a structuring of surfaces by electrochemical techniques was been investigated. In the following FIG. 4-7 it is shown how uniform the resist structures can be filled with metal in the electrochemical process. FIG. 4 shows an overview of the plated structure whereas in FIG.5-7 the structures can be seen in a higher magnification.

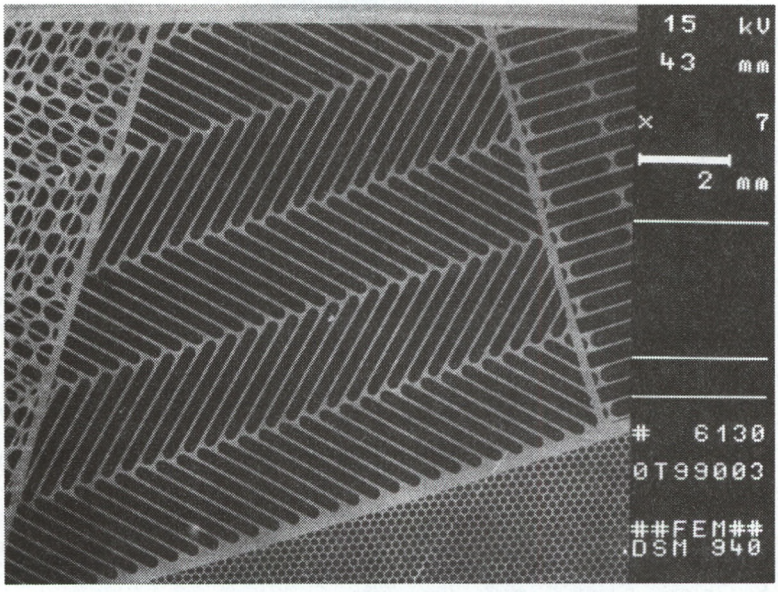

Figure 4: Overview of an Au-structure

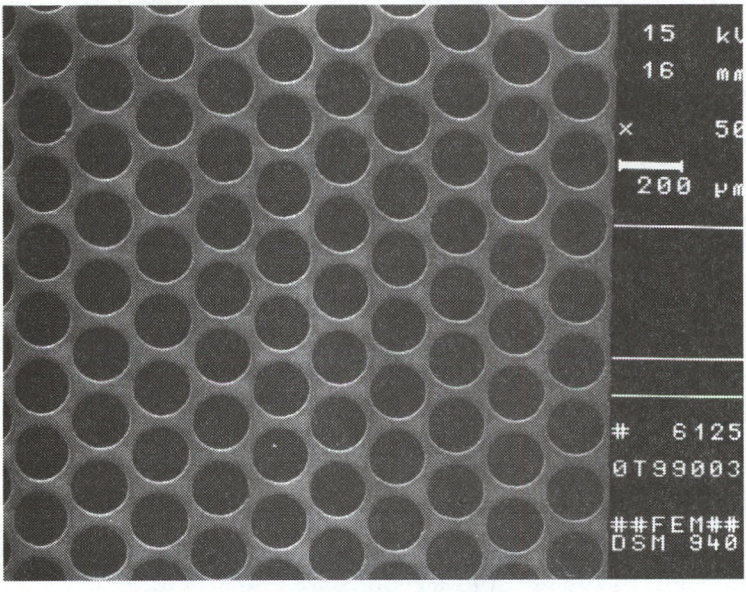

Figure 5: Detail of Fig. 4, gold-structure

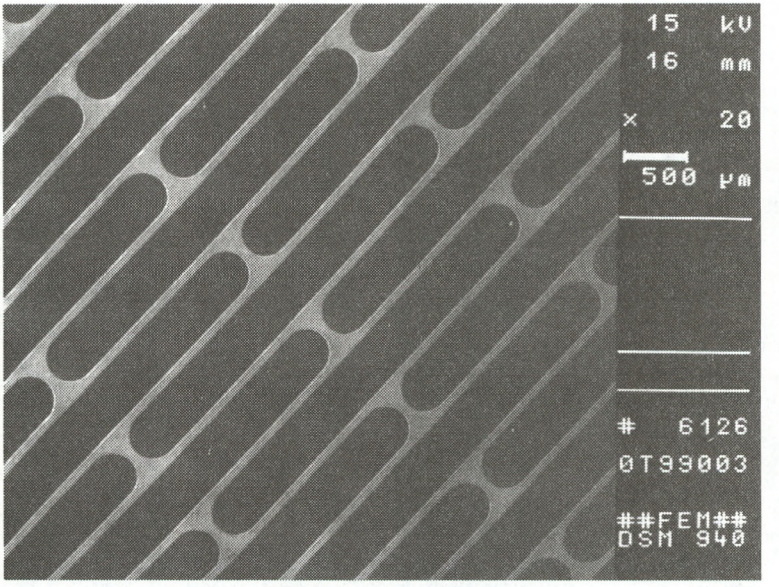

Figure 6: Detail of Fig. 4, gold-structure

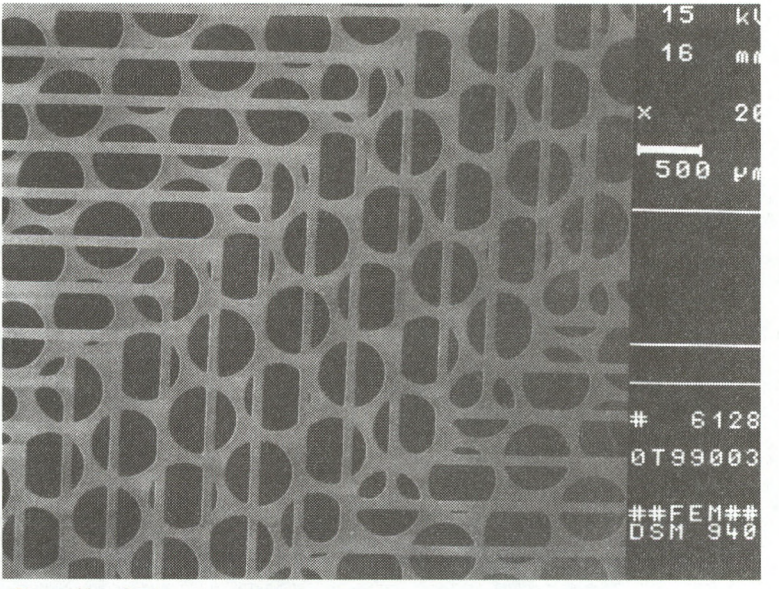

Figure 7: Detail of Fig. 4, gold-structure

Conclusion

With electrochemical processes it is possible to handle a deposition process in atomic dimensions. Therefore this processes can be used for structuring of surfaces in combination with resist techniques. The type of the used resist film and the exposure techniques can influence the dimensions and the aspect ratio of the surface structures direct. For very small dimensions of the surface structures a flat or only slightly bent substrate is necessary. The surface structuring for decorative application with a resolution of about 100 µm is also possible on more complicated shaped substrates or the structured parts can be soldered onto the jewelry surfaces.

The use of surface structuring techniques opens new possibilities in the field of jewelry design.

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