Method for Reduction of Silver Biocide Plating on Metal Surfaces

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Silver ions in aqueous solutions (0.05 to 1 ppm) are used for microbial control in water systems. The silver ions remain in solution when stored in plastic containers, but the concentration rapidly decreases to non-biocidal levels when stored in metal containers. The silver deposits onto the surface and is reduced to non-biocidal silver metal when it contacts less noble metal surfaces, including stainless steel, titanium, and nickel-based alloys.

Five methods of treatment of contact metal surfaces to deter silver deposition and reduction are proposed:

1. High-temperature oxidation of the metal surface;
2. High-concentration silver solution pre-treatment;
3. Silver plating;
4. Teflon coat by vapor deposition (titanium only); and
5. A combination of methods (1) and (2), which proved to be the best method for the nickel-based alloy application.

The mechanism associated with surface treatments (1), (2), and (5) is thought to be the development of a less active oxide layer that deters ionic silver deposition. Mechanism (3) is an attempt to develop an equilibrium ionic silver concentration via dissolution of metallic silver. Mechanism (4) provides a non-reactive barrier to deter ionic silver plating.

Development testing has shown that ionic silver in aqueous solution was maintained at essentially the same level of addition (0.4 ppm) for up to 15 months with method (5) (a combination of methods (1) and (2)), before the test was discontinued for nickel-based alloys. Method (1) resulted in the maintenance of a biocidal level (approximately 0.05 ppm) for up to 10 months before that test was discontinued for nickel-based alloys. Methods (1) and (2) used separately were able to maintain ionic silver in aqueous solution at essentially the same level of addition (0.4 ppm) for up to 10 months before the test was discontinued for stainless steel alloys. Method (3) was only utilized for titanium alloys, and was successful at maintaining ionic silver in aqueous solution at essentially the same level of addition (0.4 ppm) for up to 10 months before the test was discontinued for simple flat geometries, but not for geometries that are difficult to Teflon coat.

This work was done by John Steele, Timothy Nalette, and Durwood Beringer of Hamilton Sundstrand for Lockheed Martin under contract with Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457(f)} to Hamilton Sundstrand. Inquiries concerning licenses for its commercial development should be addressed to:

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Silicon Micromachined Microlens Array for THz Antennas

There is strong demand for a multi-pixel heterodyne detector array for Earth observation, astrophysics, future planetary, and ground applications.

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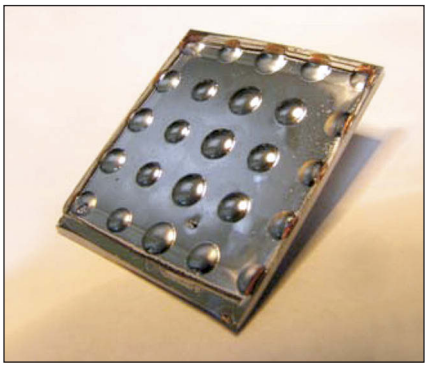
A 5×5 silicon microlens array was developed using a silicon micromachining technique for a silicon-based THz antenna array. The feature of the silicon micromachining technique enables one to microfabricate an unlimited number of microlens arrays at one time with good uniformity on a silicon wafer. This technique will resolve one of the key issues in building a THz camera, which is to integrate antennas in a detector array. The conventional approach of building single-pixel receivers and stacking them to form a multi-pixel receiver is not suited at THz because a single-pixel receiver already has difficulty fitting into mass, volume, and power budgets, especially in space applications.



Photograph of Silicon Microlens Array Antenna. The reason why there are different sizes of silicon microlenses is that each column has a different diameter of microlens on the mask plate. The microlens diameter of each column is very uniform.

In this proposed technique, one has controllability on both diameter and curvature of a silicon microlens. First of all, the diameter of microlens depends on how thick photoresist one could coat and pattern. So far, the diameter of a 6-mm photoresist microlens with 400 μm in height has been successfully microfabricated. Based on current researchers' experiences, a diameter larger than 1-cm photoresist microlens array would be feasible.

In order to control the curvature of the microlens, the following process variables could be used:

1. Amount of photoresist: It determines the curvature of the photoresist microlens. Since the photoresist lens is

transferred onto the silicon substrate, it will directly control the curvature of the silicon microlens.

2. Etching selectivity between photoresist and silicon: The photoresist microlens is formed by thermal reflow. In order to transfer the exact photoresist curvature onto silicon, there needs to be etching selectivity of 1:1 between silicon and photoresist. However, by varying the etching selectivity, one could control the curvature of the silicon microlens.

The figure shows the microfabricated silicon microlens 5×5 array. The diameter of the microlens located in the center is about 2.5 mm. The measured 3-D profile of the microlens surface has a smooth curvature. The measured height of the silicon microlens is about 280 μm. In this case, the original height of the photoresist was 210 μm. The change was due to the etching selectivity of 1.33 between photoresist and silicon. The measured surface roughness of the silicon microlens shows the peak-to-peak surface roughness of less than 0.5 μm, which is adequate in THz frequency. For example, the surface roughness should be less than 7 μm at 600 GHz range. The SEM (scanning electron microscope) image of the microlens confirms the smooth surface. The beam pattern at 550 GHz shows good directivity.

This work was done by Choonsup Lee, Goutam Chattopadhyay, Imran Mehdi, John J. Gill, and Cecile D. Jung-Kubiak of Caltech; and Nuria Llombart of the Universidad Complutense de Madrid, Spain, for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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