Method for Metallization Stripping of Gold Interconnected Semiconductors Using an Aqueous Potassium Iodide Solution

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Thin films in microcircuits can vary from as little a few hundred angstroms, in the case of dielectrics such as silicon nitride and silicon dioxide, to several microns in the case of interconnects. However, most metallization systems used as interconnects and in active structures are generally in the order of 0.5 µm to 4 µm. Gold has a number of desirable properties such as high electrical conductivity, the ability to be easily electroplated, low residual stress after deposition, corrosion resistance etc., Gold is commonly found in microelectronic devices, particularly in high frequency applications like cellular telephony, fiber-optic amplifiers and other high frequency analog applications. An aqueous potassium iodide solution offers a fast and relatively safe method for the removal of thin gold films.

MATERIALS AND METHODS

Most microcircuit technologies are a composite of materials used in substrates such as Si, GaAs, InGaAsP, AlGaAs, InP, SiGe etc. and a series of metallization systems that are used to electrically connect the active and passive circuit elements to each other and the external world. In most cases, many of these metal systems are used simultaneously and in very close proximity, often less than 1 µm from each other. For example, gold is used principally as an interconnect but in the same device there will be base metals beneath it and surrounding it such as Ti, W, Pt etc. and metal alloys such as NiCr, which is used to form passive electrical elements, e.g. resistors.

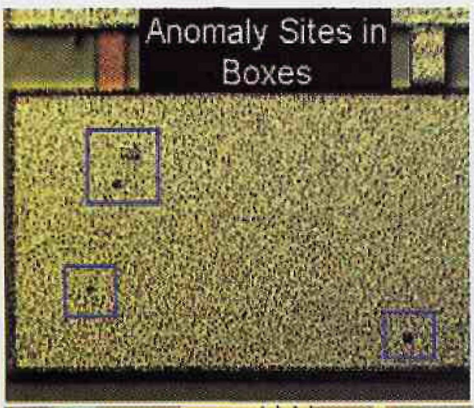
Potassium iodide, unlike chlorine chemistry or other etchants like aqua regia [HCl-Nitric Acid], is far less "corrosive" to the other metal films residing on the same substrate. It is also much less of a safety hazard in the laboratory. KI [CAS #7681-11-0] has a negligible effect, if any in terms of erosion, on nitrides and oxide films used as dielectrics and passivation systems. It can be used at room temperature and is easily washed from sample surfaces using acetone, 2-Propanol or a mild surfactant.

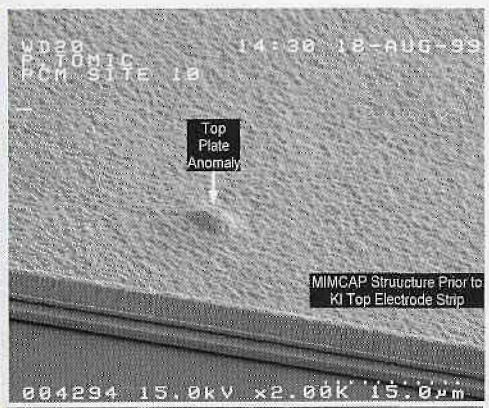
EXAMPLE IN MICROELECTRONICS

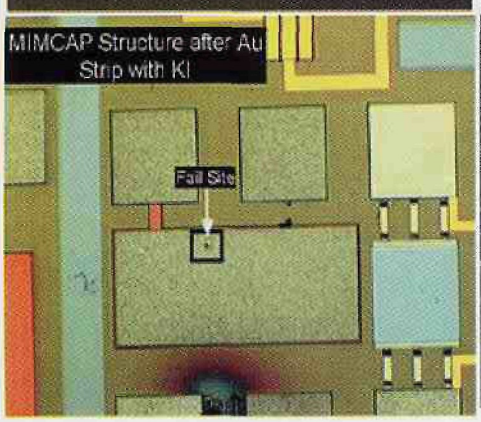
A structure commonly used in microcircuit devices is a MIMCAP [Metal-Insulator-Metal-Capacitor]. This structure is in effect a "sandwich" of a dielectric material between two metal films. In the case presented here, a top electrode made of Au and an underlying base metal were fabricated. Within this structure an anomaly exists that must be revealed without significant alteration of the surrounding circuit structures or the anomaly itself. Figure 1 (upper left) is an optical photomicrograph of the MIMCAP structure with possible fail sites indicated. The structure is 40 µm x 120 µm in size. The structure in Fig.1 has not been stripped of its' top Au surface at this juncture. Figure 2 (upper right) is an SEM image of the MIMCAP structure and its corresponding top plate anomaly. The sample was rotated and tilted in the SEM.

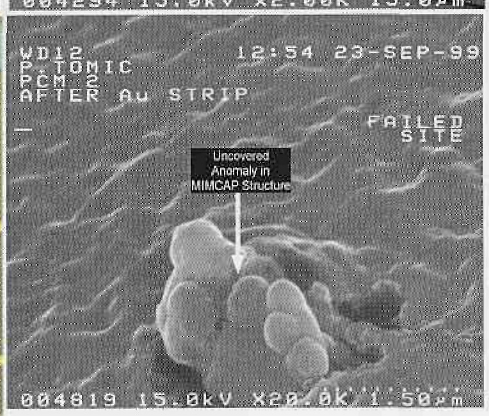
A commercially available aqueous solution of potassium iodide [> 65% H_2O] was used to dissolve the upper Au electrode in approxiametly 10 minutes at room temperature with light periodic agitation. The specimen was submerged in a covered 100-ml glass beaker at room temperature. The top electrode is approximately 4 µm thick. Figure 3 (lower left) is an optical photo of the structure after the KI removal of the top electrode. It can be seen that the substrate and adjacent structures that are in proximity to the MIMCAP are unaffected.

Figure 4 (lower right) is a SEM secondary electron image of the anomaly uncovered by the KI chemical stripping procedure. It can be seen that relatively little coincident damage occurred to the anomaly itself. Because of the ability to preserve the anomaly, further analysis using EDX was able to identify the anomaly as a fragment of base metal composed of Ti and W.









Aqueous potassium iodide does have some caveats. It does not readily attack other metals such as Cu, Ti, Pt, W and dielectric materials such as SiO2 or Si3N4. However, it does etch Si and GaAs [gallium arsenide] semiconductor substrates at a relatively high rate. In the final analysis, KI chemical stripping advantages out-weigh its disadvantages. ■

References:

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Potassium iodide is available from Acton Technologies under the trade name of "GE-6" for Gold Etch. It is incompatible with organic solvents or reducing agents. The MSDS should be read and understood for compatibility with other materials and safety precautions.

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