

wafer with a native oxide surface (obtained from Monsanto). After 15 minutes immersion in the electroless copper plating bath only a few small, randomly distributed patches of metal were present on the wafer surface.

### EXAMPLE 3

An n-type silicon wafer with a native oxide surface (obtained from Monsanto) was silanized using the procedure described in Example 1. The wafer was then placed in an argon atmosphere and irradiated for 10 minutes with ultraviolet light from a Mercury/Argon lamp (Oriol Co., Stamford Conn.) that was spaced at a distance of 3 cm from the wafer. The intensity of the radiation, as measured with a Mamir UV dosimeter at 254 nm was 4.3 mw/cm<sup>2</sup> at 3 cm from the irradiated surface of the wafer. After being immersed for 15 minutes in the copper plating bath employed in Example 1, no copper plate was present on the wafer.

### EXAMPLE 4

An n-type silicon wafer with a native oxide surface (obtained from Monsanto) was cleaned by standard techniques and was then silanized using the procedure described in Example 1. After the residual solvent had been driven off the wafer was allowed to cool to room temperature. A low resolution metal mask was placed upon the silanized surface to block the light in selected regions. The wafer was then flood irradiated for 10 minutes by ultra violet (UV) light from a mercury/argon (Hg/Ar) lamp (Oriol Co, Stamford, Conn.) while the wafer was situated in an inert gaseous atmosphere of argon. The intensity of the UV radiation, as measured with a Mamir UV dosimeter, was 4.3 m V/cm<sup>2</sup> at 3 cm from the surface of the wafer and the measured wavelength of that UV radiation was 254 nm. After exposure to the UV radiation, the wafer surface was immersed in the XD2408 palladium chloride/tin chloride colloidal activator (MacDermid & Co.) for five minutes. The wafer was then thoroughly rinsed with water. Only the regions of the surface that had not been irradiated were hydrophobic. That result indicated that the olefinic silane interacted strongly with the Pd/Sn colloid. Subsequent immersion of the wafer into the Metex 9027 Cu bath for five minutes, as in Example 1, produced a thin copper plate that reproduced the features of the masked regions.

### EXAMPLE 5

An n-type silicon wafer with a native oxide surface (obtained from Monsanto) was silanized using the Example 1 procedure except that a 2% (V/V) solution of the ODMC silane in toluene was used. The silanized wafer was irradiated for 15 minutes through a photolithograph mask having an electron beam defined chrome film on a quartz blank. Prior to silanization of the wafer, a Pd/Sn colloidal activator had been prepared from Cataposit 44 concentrate and solid Cataprep 404, as directed by the manufacturer (Shipley Company, Newton, Mass.). An electroless copper plating bath had also been prepared from 328A and 328Q stock solutions as prescribed by the Shipley Company which manufactured those stock solutions.

After irradiation, using the photolithography procedure, the wafer was covered by the Shipley colloid for five minutes. After a thorough rinse with distilled water, the wafer was immersed in the copper plating bath for two and one half minutes. After rinsing the wafer, the wafer surface was inspected by bright field reflection microscopy.

That inspection showed that the pattern of the mask had been reproduced in copper on the wafer. The thickness of the copper film, measured with a Sloan Dektak profilometer, was 20 nm. The conductivity of the film was 5000 mho/cm as measured with a two-point probe apparatus.

The copper patterned wafer was placed in a Plasmatherm Model 54 reactive ion etch system (Plasmatherm Co., Crescent, N.J.) and exposed to CF<sub>4</sub><sup>+</sup> plasma for five minutes. Under the prevailing conditions, the etch rate of silicon was 0.1 microns/min, giving a total etch of 0.5 microns. Examination of the wafer with a Nikon Optiphot M differential interference contrast Nomarski microscope revealed that the wafer had been etched to a depth of 0.5 microns everywhere except beneath the copper plating. Lines five microns in width with five micron spacing between adjacent lines (the resolution of the edges was about 1 micron), as well as other patterns, had been reproduced on the silicon wafer as raised regions above the etched surface, i.e. as plateau regions. It was evident that the copper pattern had served as a high resolution, positive resist layer. Examination of the etched wafer by X-ray fluorescence line scan in a ISI Scanning Electron Microscope equipped with a Kevex energy-dispersive, X-ray spectrometer, showed that copper was still present in the raised areas and proved that the copper plate had survived five minutes in the ion plasma.

### EXAMPLE 6

A copper patterned n-type silicon wafer was produced using the Example 5 procedure. However, a different photolithograph chrome on quartz mask having sub-micron features was employed for patterning. Before subjecting the copper patterned silicon wafer to the CF<sub>4</sub><sup>+</sup> plasma etch, a microscopic examination of the wafer revealed excellent reproduction of the mask pattern in copper on the surface of the wafer. After plasma etching the wafer for five minutes, the wafer was removed from the etching apparatus and was then examined with an electron microscope. The resistance of the copper plate to the plasma etch was apparent in the metallized regions where copper of approximately 40 nm thickness remained in the raised regions. Among the features reproduced on the wafer were lines about one centimeter long and less than 2 microns wide, lines 4 microns long and about a half micron in width, and a square cavity (i.e. a "trough") about five microns on a side.

### EXAMPLE 7

The procedure of Example 4 was repeated using a p-type silicon wafer (obtained from Monsanto). As in Example 4, a thin copper plate was formed on the wafer that reproduced the features of the masked regions. No appreciable difference was discerned between the plate on the p-type wafer and the plate on the n-type wafer.

### EXAMPLE 8

The procedure of Example 1 was repeated using a 1% solution of 5-hexenyldimethylchlorosilane (HDMC; Petrarch Co., Bristol, Pa.) in toluene. The wafer was irradiated and then plated with copper as in example 5. There was no apparent difference between the metal pattern produced on the HDMC-treated surface and the ODMC-treated surface.