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Ruthenium (Ru^{44})

Properties

Ruthenium is a hard white metal with an atomic mass of 101.07. Ruthenium has a density of 12.45 g/cm^3, a high melting point of 2607 ^{o}C, a relatively low electrical resistivity of 7.1µOhm cm, a thermal conductivity of 117 W/(m-K) and a Brinell hardness of 2160 MPa.

Like the other metals of the platinum group, ruthenium is inert to most other chemicals. Ruthenium dissolves in fused alkalis to give ruthenates (RuO^{2-}) is not attacked by acids but is attacked by halogens at high temperatures. Ruthenium is a polyvalent metal with −4, −2, 0, +1, +2, **+3**, **+4**, +5, +6, +7, +8 oxidation states. Standard electrode potential of Ru is +0.45V. Rhenium is a rare earth element in the Earth's crust with an estimated average concentration of 100 parts per trillion (ppt).

Plating Solutions

Rhenium can be electroplated from aqueous electrolytes, containing in g/l:

a) Example #1. Ruthenium – 3, hydrochloric acid – 37 at temperature of 20 – 25 ^{o}C and current density of 400 - 500 mA/cm^2 with current efficiency of ~2%.
b) Example #2. Ruthenium – 6, sulfuric acid – 175 at temperature of 60 – 65 ^{o}C and current density of 20 - 25 mA/cm^2 with current efficiency of ~17%.
c) Example #3. Ruthenium, trichloronitrosyl-(Cl_3NORu) – 10, sulfuric acid – 10 at temperature of 65 – 70 ^{o}C and current density of 10 - 15 mA/cm^2 with current efficiency of ~15%.
d) Example #4. $Ru(OH)Cl_3$ – 10, sulfamic acid – 40 at current density of 15 mA/cm^2 with current efficiency of ~20%.
e) Example #5. Ruthenium, trichloronitrosyl-(Cl_3NORu) – 15, EDTA Tetrasodium salt – 60, KOH – 140 – 200 at 15 – 60 ^{o}C and current density of 5 – 20 mA/cm^2 with current efficiency of 10 – 40%

Applications

Most ruthenium produced is used in wear-resistant electrical contacts and thick-film resistors. A minor application for ruthenium is in platinum alloys and as a chemistry catalysts. Novel application of ruthenium are as the capping layer for extreme ultraviolet photomasks and barrier/seed layer for copper interconnects in IC fabrication. Copper can be directly electroplated onto ruthenium,[1] in contrast to tantalum nitride. Copper also adheres poorly to TaN, but well to Ru. By depositing a layer of ruthenium on the TaN barrier layer, copper adhesion would be improved and deposition of a copper seed layer would not be necessary.

References:

1. Moffat, T. P.; Walker, M.; Chen, P. J.; Bonevich, J. E.; Egelhoff, W. F.; Richter, L.; Witt, C.; Aaltonen, T.; Ritala, M. (2006). Journal of the Electrochemical Society. **153** (1): C37–C50.

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