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Copper thin films deposited on polymers by RF-IPVD. Correlations between film properties and discharge parameters.

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Ionised physical vapour deposition (IPVD) was initially developed to improve the ionisation degree of vapour sputtered from DC magnetron process [1,2]. We used this technique to deposit thin copper layers on 3D polymer substrates. The reactor developed for this study includes a 5 cm diameter circular balanced DC magnetron as neutral copper vapour source. A secondary plasma (ICP), is generated with a one loop internal coil powered by a 350 W RF generator. For this process, the pressure range (2 to 13 Pa) is higher than for typical magnetron sputtering devices. Increasing the pressure leads to improve the thickness uniformity all over the 3D substrates, but a deterioration of films resistivity is observed. Nevertheless, the copper layers resistivity can directly be controlled by the RF-power. We made several investigations to understand what links experimental discharge parameters to film resistivity. First of all, substrate surface temperature was measured using thermal indicating labels. Then, XRD analysis was performed on copper layers to determine their crystalline structures and the grain sizes. Results show a linear dependence between surface temperature and RF Power. Furthermore, the grain size also seems to increase linearly with the surface temperature. Finally, film resistivity shows a logarithmic decay when mean grain size increases, according to Matthiesen's rule. In addition to surface analysis, Langmuir probe measurements (n_e, n_i, T_e, V_p, V_f and eedf) and optical emission spectroscopy diagnostics (Ar, Cu) have been performed on the plasma phase. Results are still not well understood concerning plasma particles which mainly contribute to the film quality. The development of a collisional radiative model of this IPVD discharge could emphasize the main species contributing to matter and energy transfer to the substrate surface (ions, electrons, radiations, metastables ...) [3].

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