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Controls of Crystallinity and Surface Roughness of Cu film in Partially Ionized Beam Deposition

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Changes of crystallinity and surface roughness have been discussed in terms of an average energy of depositing particles in the partially ionized beam(PIB) deposition. Degree of crystallinity $R=I(111)/I(100)$ was varied from 6 to 37 and average Root Mean Square(R_{ms}), σ , of surface roughness was changed from 37 Å to 210 Å when acceleration voltage(V_a) and ionization potential(I_p) are adjusted. Ion beam current density was measured to calculate the average depositing energy in the deposition process, and the energy was varied in a range 0 to 100 eV at fixed ionization potentials $I_p=400$ V and 450 V. The total ion beam current density in the PIB consists of a residual gas ion beam current density and an ionized Cu beam current density, and it is suggested that energy delivery media in the PIB are not only ionized Cu beam but also residual gas ion beam. The residual gas ion beam is highly contributed to the total ion beam current density at $I_p = 400$ V, but a portion of the ionized residual gas beam current is similar to a portion of the ionized Cu ion beam current in the contribution to total energy in the deposition at $I_p= 450$ V in the PIB source. The optimum average energy in the Cu film formation which can produce $R=37$ and $\sigma= 37$ Å was 60 eV which be generated by PIB source at $V_a= 3$ kV and $I_p=400$ V. The degree of crystallinity was closely related with the average depositing energy, and change of σ which is a function of ion flux and particles energy was dependent on the degree of crystallinity.