P-01

Plasma anisotropic deposition of copper in trenches of nm scale

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Filling of materials in trenches and holes of nm scale is important for fabrication of three dimensional nano-structures such as ULSI interconnects, quantum dots and wires, micro-electrochemical systems, and system in package. Recently, we have realized anisotropic deposition of Cu, for which Cu is filled preferentially from the bottom of trenches without being deposited on their sidewall as shown in Fig. 1. Anisotropic deposition is realized by using a hydrogen assisted plasma chemical vapor deposition reactor in which a capacitively-coupled main discharge and an inductive-coupled discharge for an H atom source are sustained as shown in Fig. 2 [1, 2]. This reactor provides independent control of densities of Cu-containing radicals and H atoms. The anisotropic deposition is useful for fabricating nano-scale interconnects, because it has two interesting features. One is the fact that the narrower the width of a trench is, the faster the deposition rate on its bottom becomes. The other is the self-limiting deposition, that is, the deposition in trench stops automatically just after filling it completely. Such type of deposition has a potential to overcome common problems associated with conformal filling: namely, small crystal grain size below half of the trench width, and formation of a seam with residual impurities of relatively high concentration. Ion irradiation on the surface of interest is the key to realizing the anisotropic deposition, since the deposition rate on the bottom surface of trenches increases with the flux and kinetic energy of ions impinging on the surface. In the presentation, we will show the features of anisotropic deposition and discuss the deposition mechanism. Moreover, we will show anisotropic deposition of other materials, which suggests wide applicability of the deposition method.

[1] K. Takenaka, M. Shiratani, M. Takeshita, M. Kita, K. Koga, and Y. Watanabe, Pure Appl. Chem. **77**, 391 (2005).
[2] K. Takenaka, M. Kita, T. Kinoshita, K. Koga, M. Shiratani, and Y. Watanabe, J. Vac. Sci. Technol. A**22**, 1903 (2004).

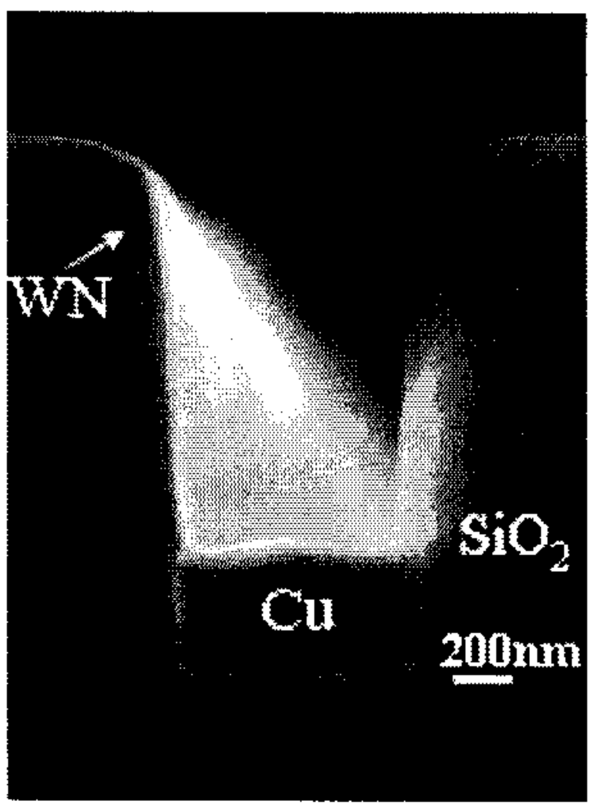

Fig. 1. Cross sectional SEM image of Cu deposited in a trench using anisotropic CVD.

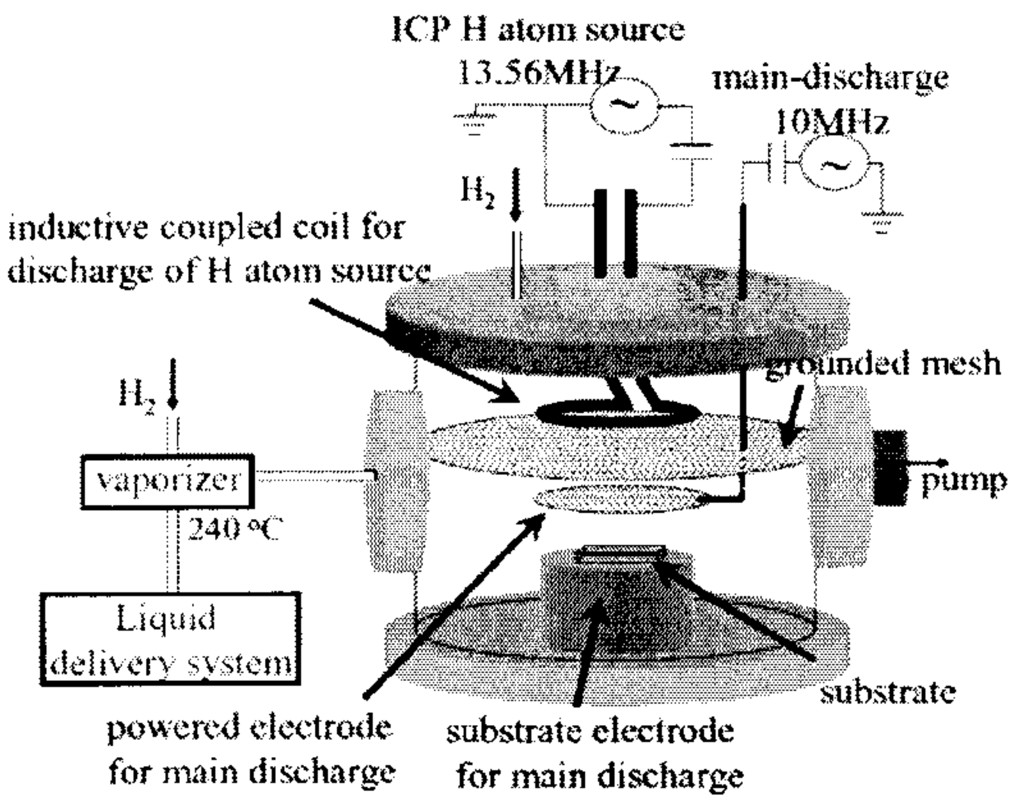

Fig. 2. H-Assisted Plasma CVD reactor.