論 文 の 内 容 の 要 旨

論文題目　Study of Cu/Cu Low Temperature Direct Bonding Using Formic Acid Treatment
（ギ酸処理による銅−銅の低温直接接合に関する研究）

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This thesis developed a new Cu/Cu low temperature direct bonding technology using formic acid treatment with Pt catalyst. A bonding equipment was fabricated for the realization of this bonding technology. Cu film samples, Cu electrodes samples were bonded successfully at 200°C or below 200°C in N_2 or Ar atmosphere using formic acid treatment without/with Pt catalyst.

First, effects of formic acid treatment on Cu film surface morphology were investigated using AFM. Through several different Cu film samples were treated and analyzed, it is found that surface roughness of all samples is hardly changed after treatment. However, the effect of formic acid on surface morphology is different for different samples. For smooth sample such as CMP-Cu film, some grooves formed at Cu grain boundary after treatment. On the contrary, for the rough surface sample such as EB-Cu film, surface morphology is hardly changed with formic acid treatment. It indicates that the effect of formic acid treatment on Cu surface morphology depends on surface roughness. Using different treatment without Pt catalyst and with Pt catalyst, almost same results were obtained from surface AFM analysis.

In addition, XPS analysis results proved that, Cu surface oxide could be reduced at 200°C using formic acid treatment without/with Pt catalyst. For the treatment without Pt catalyst, surface reduction is more effective with higher temperature or longer time treatment. Using the treatment with heated Pt catalyst, the reduction is more effective compared to the treatment without Pt catalyst.

Bonding qualities with different treatment processes were evaluated through bonding strength, electrical performance and bonding interface observation. Cu electrodes sample were bonded for the bonding quality evaluation. Without Pt catalyst, the bonding strength and contact resistance are 19.5MPa and 0.28mΩ, respectively. Using the treatment with heated Pt catalyst, bonding strength is higher as 40MPa, and the contact resistance is lower as 0.17mΩ. Bonding interface is composed of Cu fine grains, which is observed by TEM. Therefore, using formic acid treatment with Pt as catalyst, higher quality bonding can be achieved for Cu/Cu low temperature direct bonding.