The scaling required to reach faster chip performances in electronic devices has pushed the dimensions of copper interconnect (Cl) lines to the nanometer domain. This constant downscaling of Cls implies a change in their microstructure. A change in the grain boundary type distribution and local texture will strongly influence the resistivity and the mechanical reliability of downscaled Cls. A different texture can imply different mechanical properties and a different local distribution of stresses. It is, therefore, necessary to map the texture evolution with the size of Cls.

Unfortunately, Cls that reach lateral sizes of less than 100 nm, with Cu grains smaller than 50 nm, cannot be characterized by conventional techniques like EBSD and XRD, because they do not have enough spatial resolution.

For reliable texture quantification, it is important to acquire extensive and reliable data sets to have statistically meaningful results and at the same time have a high spatial resolution. ASTAR with a parallel nano-sized beam, coupled with a small precession angle, has the appropriate spatial resolution (1 nm) and the reliable pattern indexing which reduces the 180° ambiguities by sampling reflections from higher order zones (HOLZ). In addition, ASTAR is able to acquire data and index patterns rapidly, which makes it possible to acquire statistically relevant information.

ASTAR orientation maps reveal the evolution of texture as the Cl are scaled from Cls from 1.8 µm to 70 nm. In large Cls the Cu grains have a strong <111> fiber texture normal to the trenches (Fig. 1). In the smallest Cls, a <110> texture is observed, normal to the trench while (111) planes are now parallel to the trench sidewalls (Fig. 1). The microstructure also changes from a bamboo-like structure in large Cls into a polygranular structure in small Cls, where a polygranular microstructure is a microstructure in which there are continuous grain boundary paths along the length of the interconnect. In the 70 nm Cls grain size is not uniform and clusters of small grains are formed at the bottom of the trenches. Such clusters of small grains adversely affect the reliability of Cls. In addition, a decrease in the fraction of coherent twin boundaries was observed with decreasing line widths (Fig. 2). Twin boundaries play an important role in the resistivity performance of Cls. These results are crucial to optimize the process of Cl fabrication and to understand how to improve their mechanical and electrical properties.

**Experimental Data**
TEM type: Jeol 2010 F
Map resolution: 1 nm
Scanned area: 2 x 2 µm

**Crystal Structure**
Cu: Cubic, Fm3m
a = 3.610 Å

**figure 1**
ASTAR orientation maps of Cls along with texture plots. (A) shows the map from 1.8µm wide line.
(C) plot shows the distribution of crystal directions normal to the trench. Similar plots for the 70 nm wide lines are shown in (B) & (D) figures. Note the change in texture between the two line widths.

**figure 2**
Fraction of twin boundaries as a function of line widths. Note the decreasing twin boundary fraction as the line width decreases. Approximately 8000 boundaries extracted from orientation maps was used for this purpose.