Copper metallization is rapidly being introduced as a replacement for aluminum. It is well known that the microstructure of both sputtered and electrodeposited copper can change with time: even at room temperature, remarkable grain growth or recrystallization has been reported [1-4]. In deposition processes that are used to fabricate thin solid films, there is a very sensitive and complex dependence of film microstructure on growth condition [5]. Growth generates a rough surface in many cases [6,7]. Scaling analysis provides a quantitative method of surface characterization, [8,9] that has increased the understanding of dominant growth processes during both vapor deposition and electrodeposition [10, 11]. Although the assumptions in the theoretical model are usually not strictly satisfied by real surfaces, nevertheless scaling analysis provides valuable insight into the growth mechanisms [1, 8]. In this paper, scaling analysis is implemented for understanding the changes over time associated with spontaneous recrystallization in electrodeposited copper films.

An AFM image of the surface of a typical copper film electrodeposited on a polished gold substrate is shown in Fig 1. The image (a) was obtained 13960 s after deposition whereas image (b) was obtained 14850 s after deposition, i.e. 890 s after the scan of image (a). The two images show essentially the same area. Although no changes were apparent in real time imaging of this film during the previous 13960 s, the grain structure of the film can be seen to change markedly over this 890 s period.

The scaling analysis derived from these AFM images is shown in Fig. 2. in which (a) and (b) show the curves corresponding to the images in Fig. 1a and Fig. 1b respectively. Fig. 2a shows a knee at a characteristics length $L_c = 300$ nm where the rms roughness levels off. The corresponding knee in Fig. 2b occurs at a much shorter characteristic length ($L_c = 183$ nm). Thus the value of the characteristic length $L_c$ decreases significantly during recrystallization. The roughness in curve (b) is also significantly greater than in (a), particularly below the knee at $L_c$.

Scaling analysis was carried out on images obtained for a variety of deposition conditions on gold and on copper on Si/TaNi/Cu. The detailed results will be discussed.

REFERENCES