

# Effect of Pad Hardness on Planarization Efficiency of Selected Features in Cu CMP

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## Abstract

The planarization efficiency of Cu bulk polishing was determined for four pads with Shore D hardness ranging from 59 to 23. Three groups of features were monitored to determine planarization for dishing, protrusion, and erosion. The results show that planarization efficiency was influenced strongly by pad hardness and that pad was the key factor in delivering planarization. Above Shore D 47, pad hardness had a small effect on planarization efficiency. Below Shore D 47, planarization efficiency decreased dramatically with decreasing pad hardness. Improvement in planarization efficiency by slurry formulation was smaller compared to the effect of pad hardness in most cases but might be significant for some features on a pad of medium hardness.

## Introduction

Planarity of wafer surface as measured by residual step height continues to be the key deliverable in chemical and mechanical planarization (CMP) for Cu bulk removal. A hard pad is typically used to achieve good planarization efficiency but it can be a concern for mechanical defects. In contrast, a softer pad can be used to reduce mechanical defects but planarization efficiency is usually compromised. In this study, four pads of same design were used to determine the effect of pad hardness on planarization efficiency in Cu bulk polishing.

## Method

### Pads:

- Four pads were provided by NEXPLANAR. They were manufactured using the same materials and had the same groove pattern and thickness. Therefore, pad hardness was the only major variable.

Table 1. NexPlanar pads used in this study

Pad #1	Shore D 59	Hard pad
Pad #2	Shore D 47	
Pad #3	Shore D 34	
Pad #4	Shore D 23	Soft pad

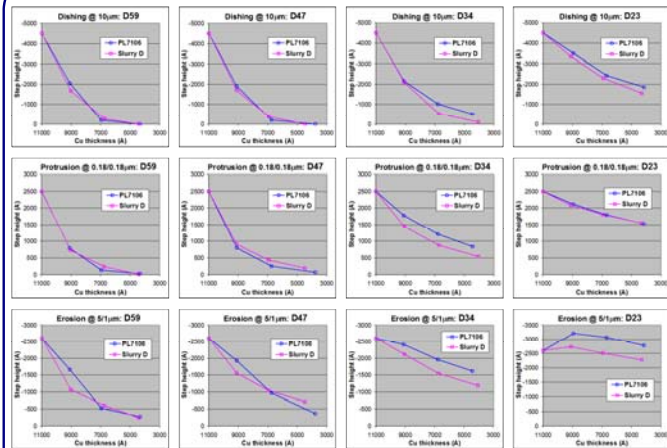
### Slurries:

- Two Fujimi slurries were used: (1) PL7106 (i.e. PLANERLITE 7106) – a commercial slurry for Cu bulk CMP; (2) Slurry D – a developmental slurry for improved planarization efficiency of Cu protrusion [1].

### Polishing and measurement:

- Polisher: IPEC Westech 372M
- Pad conditioners: 3M A165 for D59/D47/D34 pads, A3700 for D23 pad
- Polishing conditions: pressure 1.5psi, speed 85/80rpm, slurry 200mL/min
- Patterned wafers: commercial, 200 mm, Cu TEOS, 854 mask

## Improvement by slurry formulation



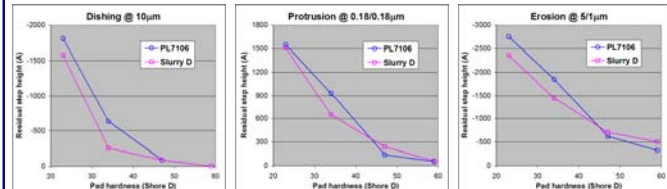
On D59 and D47 pads, dishing at 10 µm and protrusion at 0.18/0.18 µm was reduced to zero or near zero by using PL7106, little or no improvement was obtained by using Slurry D.

On softest D23 pad, the improvement was small and far from enough to help reduce step heights to an acceptable level.

On D34 pad, the improvement was noticeable and could be significant for some features.

- For example, by changing from PL7106 to Slurry D, the residual dishing was reduced from 200 Å to -0 Å at 5 µm line and from 635 Å to 250 Å at 10 µm line (a 60% reduction).

## Effect of pad vs. improvement by slurry



Note: residual step height @ 5000Å Cu remained/6000Å Cu removed.

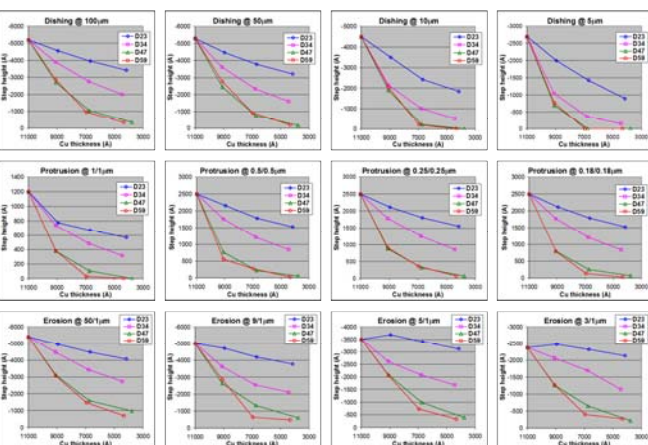
### Effect of pad hardness:

- Above D47: weak effect, small benefit by using a harder pad.
- Below D47: strong effect, planarization efficiency decreased dramatically when using a softer pad.

### Effect of slurry:

- The improvement in planarization efficiency by slurry formulation was smaller than the effect of pad hardness. Thus, pad hardness was the key factor that determined the planarization efficiency.

## Effect of pad hardness



D59 to D47: planarization efficiency decreased only slightly – weak effect  
D47 to D23: planarization efficiency decreased dramatically – strong effect

**Dishing** in isolated lines decreased with decreasing line width.

- Zero dishing was obtained at 5 and 10 µm lines on D59 and D47 pads but not on softer D34 and D23 pads.
- The 50 and 100 µm lines did not reach zero dishing on any pad.

**Erosion** in the arrays was more difficult to planarize (width of ~1250 µm).

**Protrusion** was reduced to <100 Å on D59 and D47 pads, but not on softer D34 and D23 pads.

## Summary

For the pads with hardness in the range of Shore D 59 to 23, the effect of pad hardness on planarization efficiency is weak when pad hardness is above Shore D 47 but strong when it is below Shore D 47.

Improvement in planarization efficiency by slurry formulation is smaller compared to the effect of pad hardness but can be significant for some features on a pad of medium hardness (Shore D 34).

Pad hardness is the key factor in delivering planarization in Cu bulk polishing.

## Acknowledgement and Reference

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[1] J. Lin, C. A. Poutasse, "Planarization efficiency of copper protrusion", *Proceedings ICPT 2012*, Grenoble, Oct. 15-17, 2012, pp. 61-66.