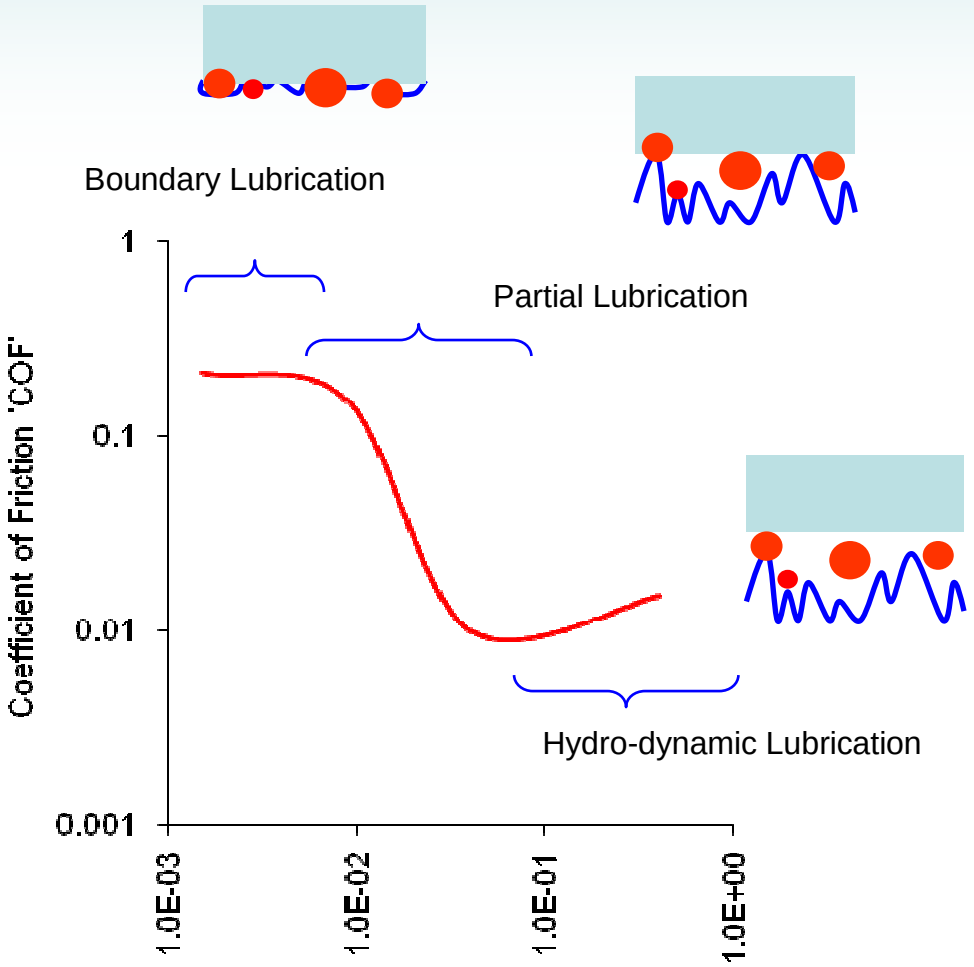
Method for Ultra Rapid Determination of the Lubrication Mechanism in CMP

Outline

- Background and Motivation
- Objectives
- Polishing Apparatus
- Methodology
- Case Studies
  - Copper CMP
  - Oxide CMP
- Summary

Background

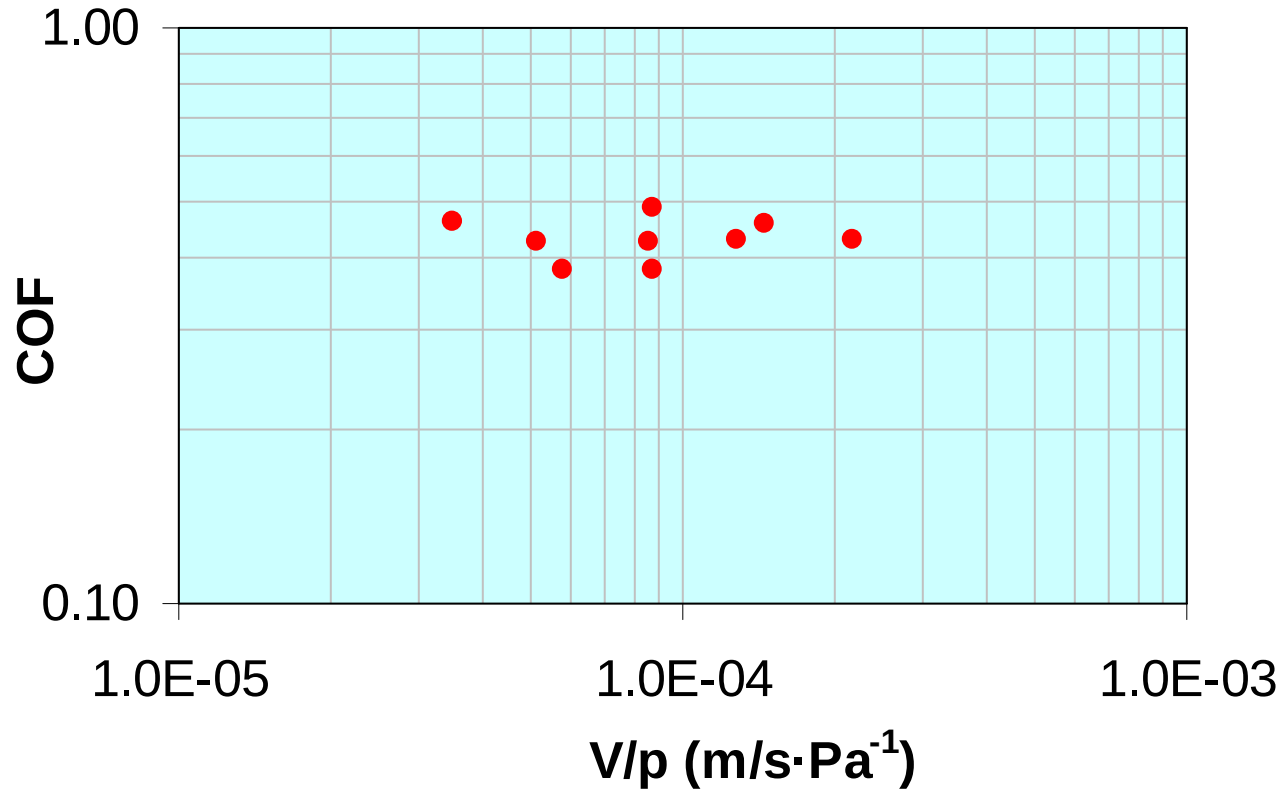
- As a first approximation, the Stribeck curve helps provide evidence of the extent of contact among wafer, pad and abrasive particles where three major lubrication modes can be distinguished.
- Additionally, it can help screen certain consumable sets by determining if and how they contact one another during CMP.
- It can help determine optimal polishing parameters as well as help avoid certain polishing conditions.



$$So = \frac{(u) \times (\mu)}{(P) \times (\delta_{eff})}$$

Motivation

- **Constructing 'Traditional' Stribeck curves requires polishing many wafers at various pressures and sliding velocities.**
- **This is quite costly and time consuming and may not provide the full picture.**

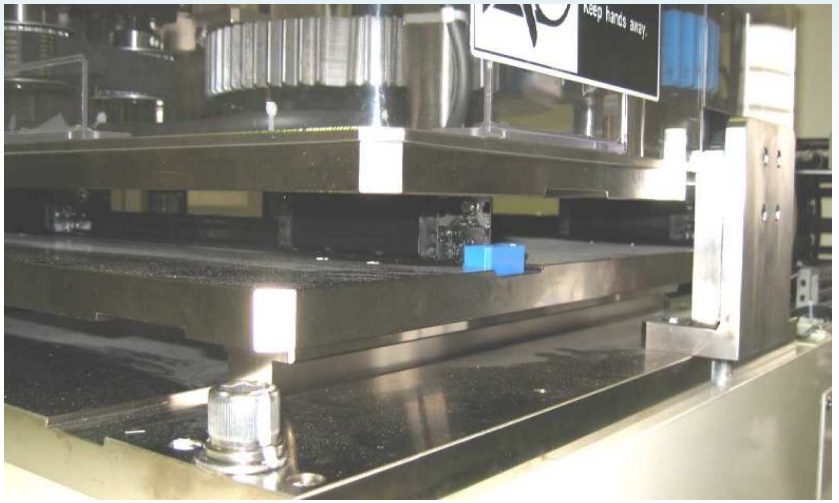


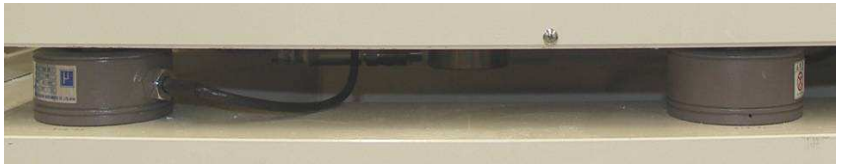
Objectives

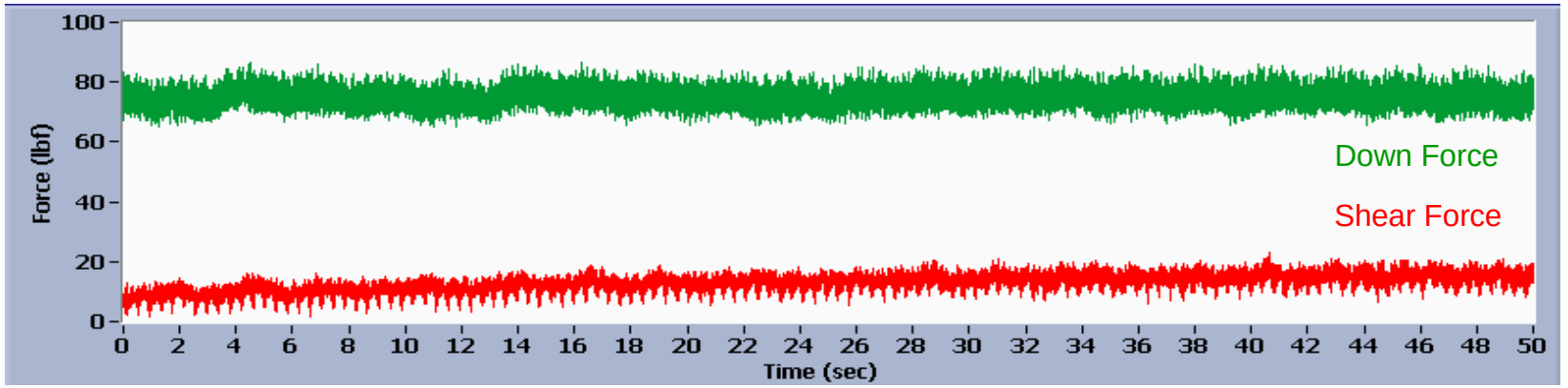
- **Introduce a new method for obtaining the Stribeck curve corresponding to a set of consumables in CMP by only performing one wafer polishing experiment.**

- **Review and discuss several Stribeck curves resulting from polishing various substrates (i.e. blanket copper and silicon dioxide wafers using different types of polishing pads and slurries).**

APD – 800 ® Polisher & Tribometer

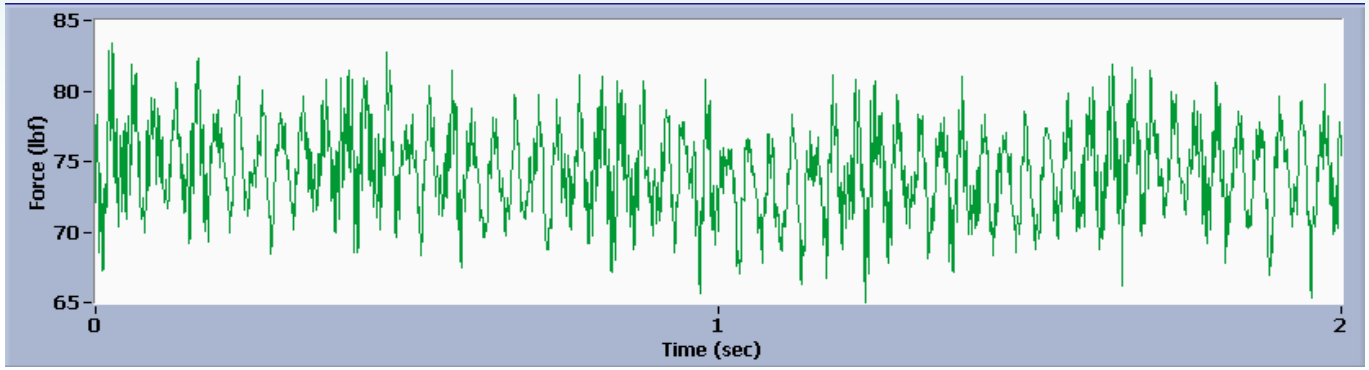




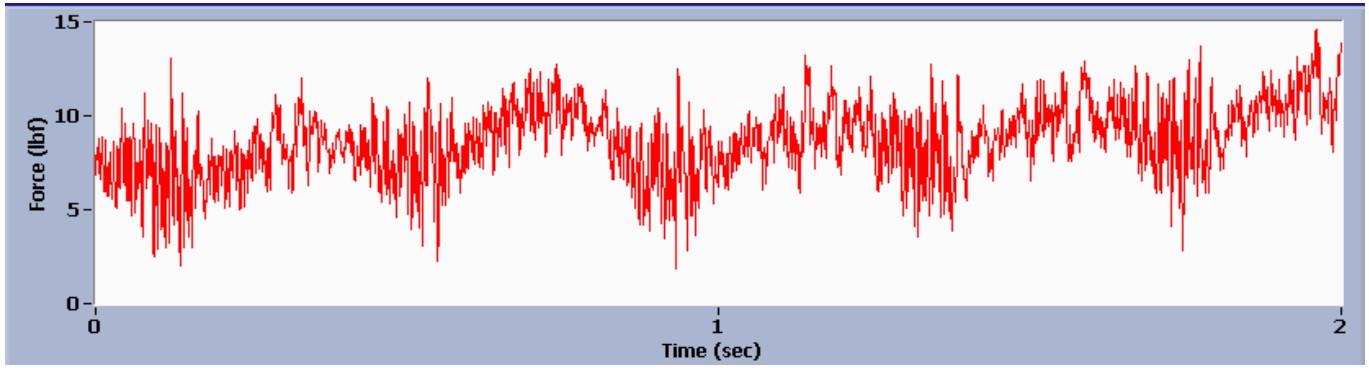


Real-Time Monitoring of Process Fluctuation

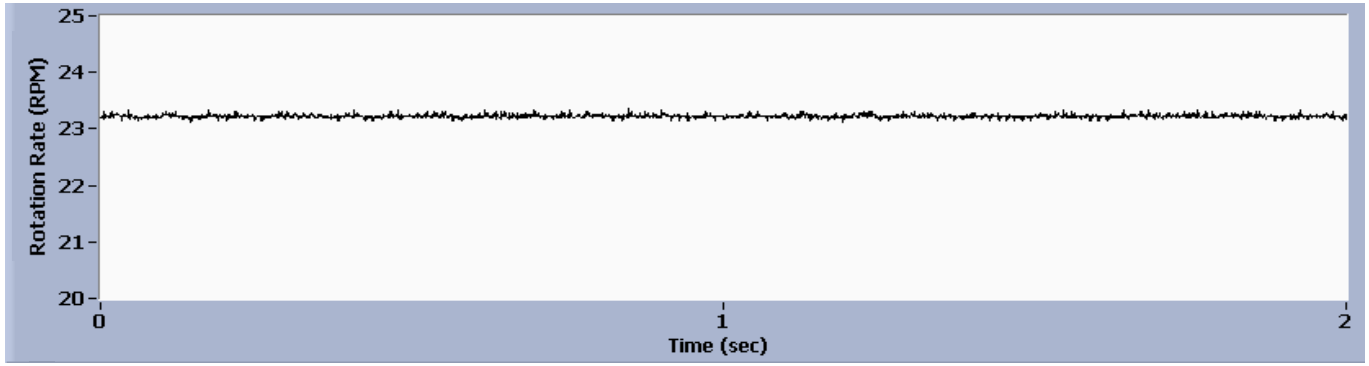
Down Force



Shear Force

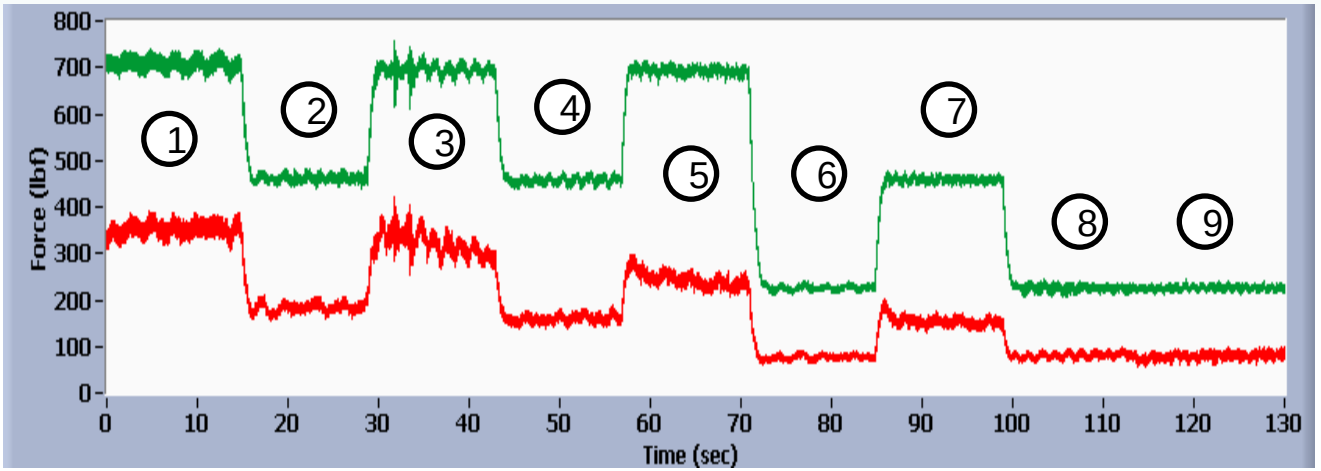


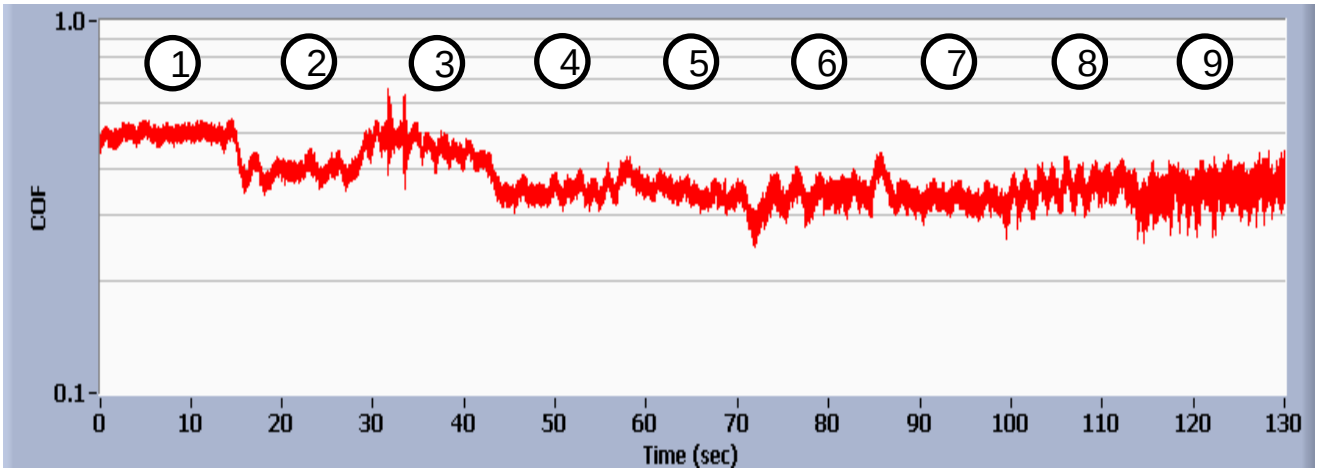
Pad/Wafer Rotation Rate



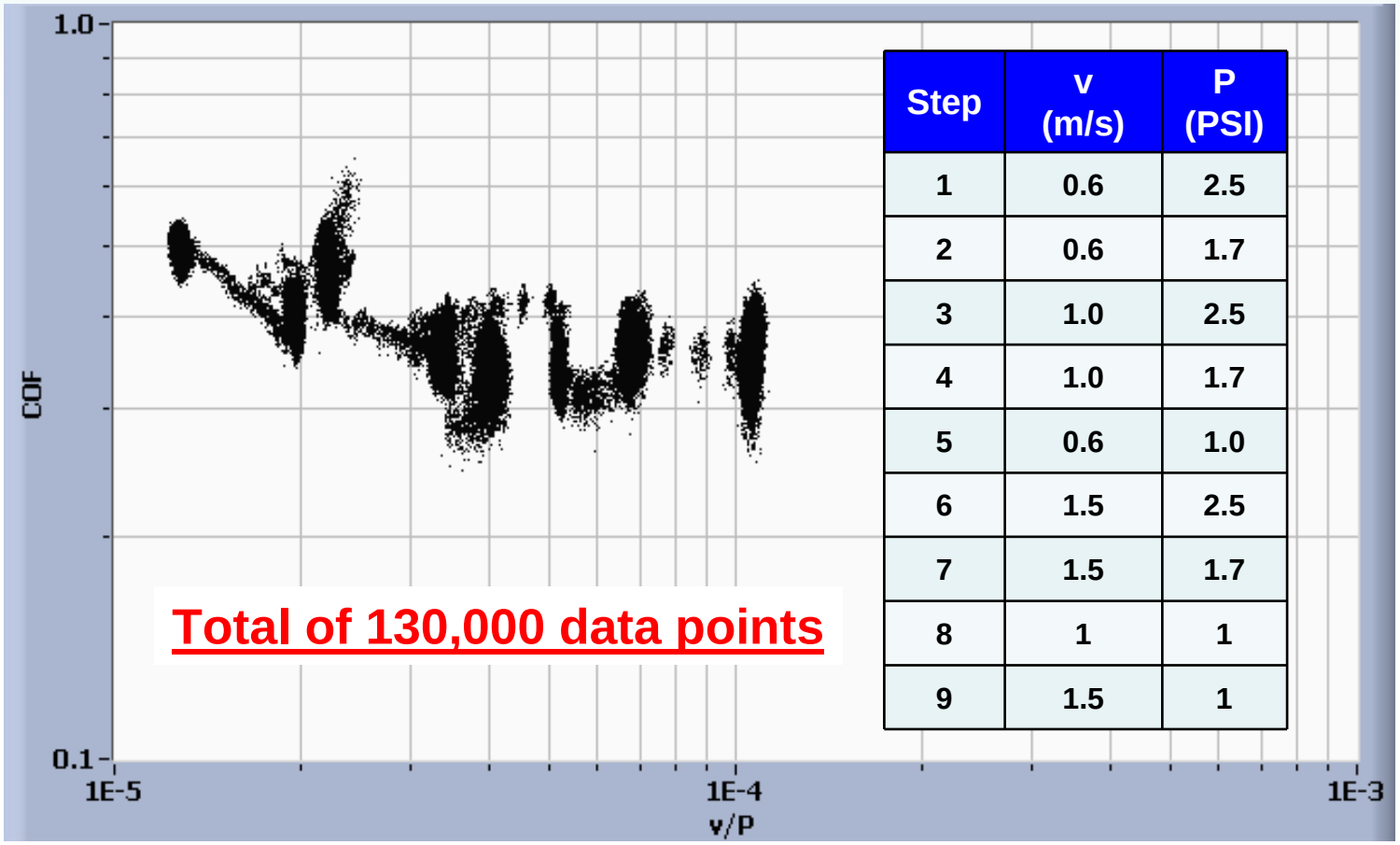
Example of Shear Force, Down Force and COF

Step	v (m/s)	P (PSI)
1	0.6	2.5
2	0.6	1.7
3	1.0	2.5
4	1.0	1.7
5	0.6	1.0
6	1.5	2.5
7	1.5	1.7
8	1	1
9	1.5	1





Example of Stribeck Curve from Polishing a Wafer



Step	v (m/s)	P (PSI)
1	0.6	2.5
2	0.6	1.7
3	1.0	2.5
4	1.0	1.7
5	0.6	1.0
6	1.5	2.5
7	1.5	1.7
8	1	1
9	1.5	1

Case Studies re: Copper CMP

Traditional vs. ‘New’ Stribeck Curves

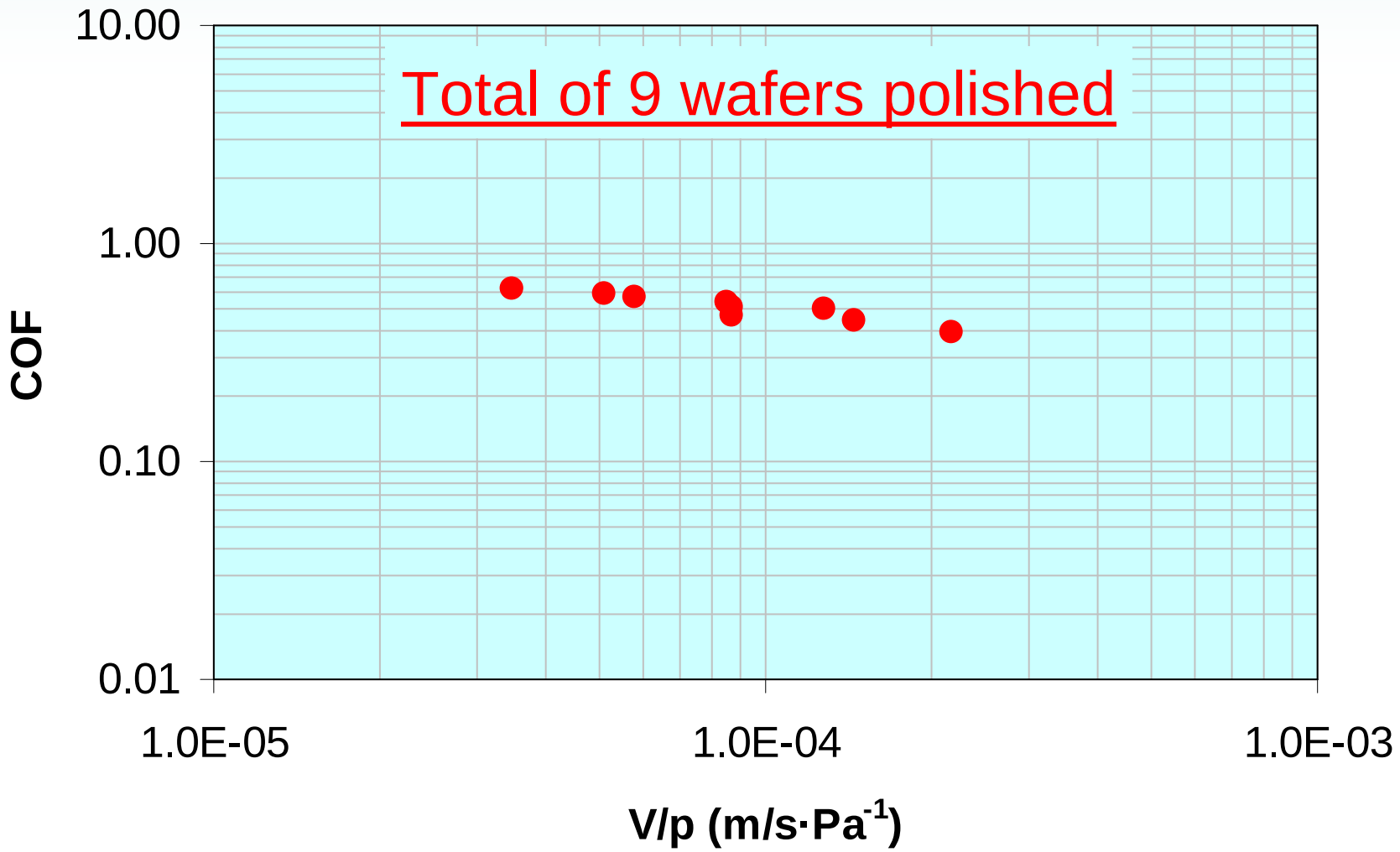
Experimental Conditions

Copper CMP

- Wafers = 300-mm blanket copper wafers
- Wafer pressure = 1.0, 1.7 and 2.5 PSI
- Sliding velocity = 0.6, 1.0 and 1.5 m/s
- Slurry flow rate = 300 cc/min
- Slurry = CMC EP-C600Y-75, HCC HS-2H635 and Fujimi PL-7103
- Pad = CMC D100, DOW IC1000 K-groove and Dow IC1000 M-groove Groove
- Conditioner = 3M A165
- Conditioning force = 6 lb_f
- Conditioning = In-situ at 95 RPM & 10 per minute sweep frequency
- Polishing time = 130 seconds

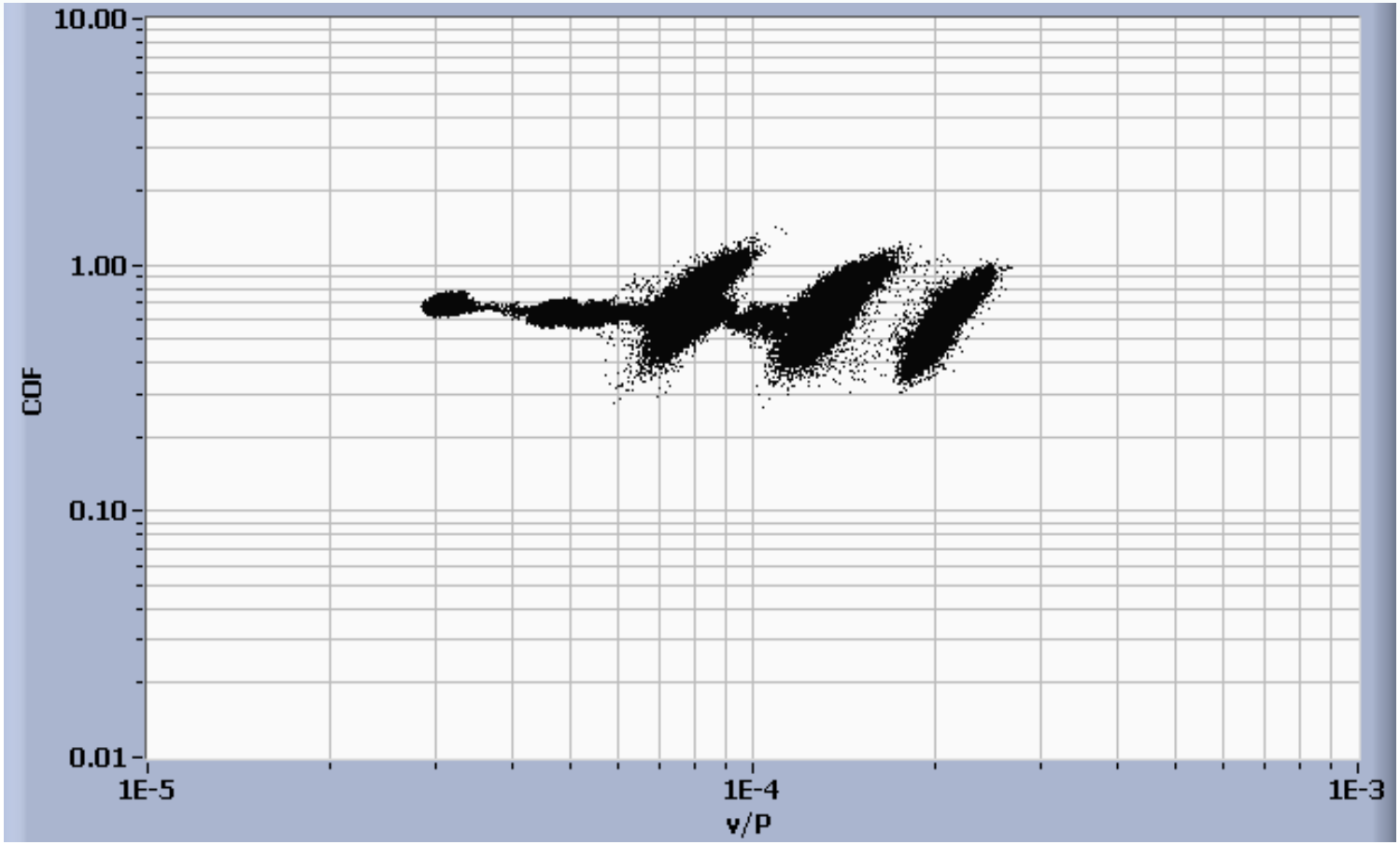
‘Traditional’ Stribeck Curve

D100 – Copper – CMC EP-C600Y-75



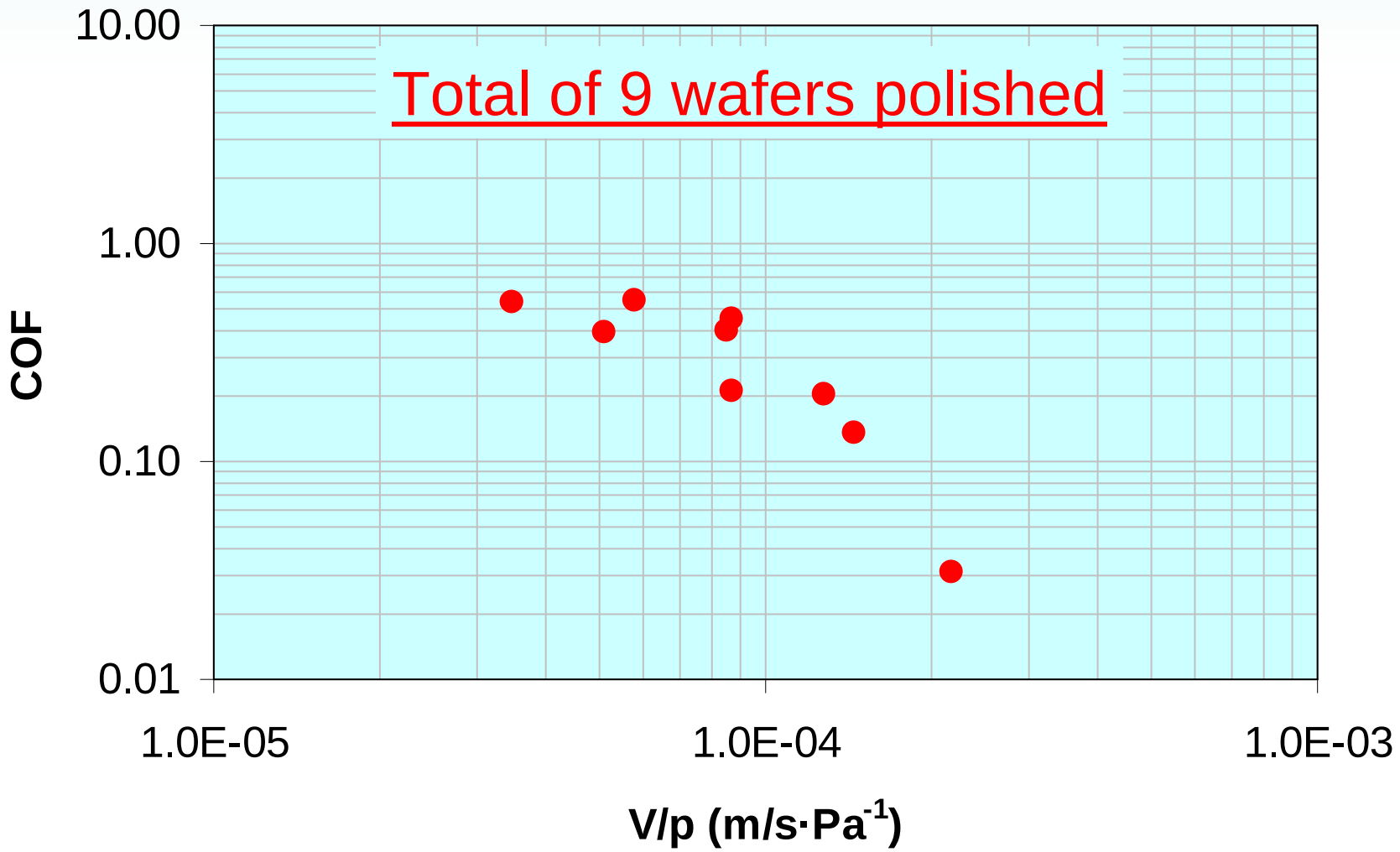
‘New’ Stribeck Curve

D100 – Copper – CMC EP-C600Y-75



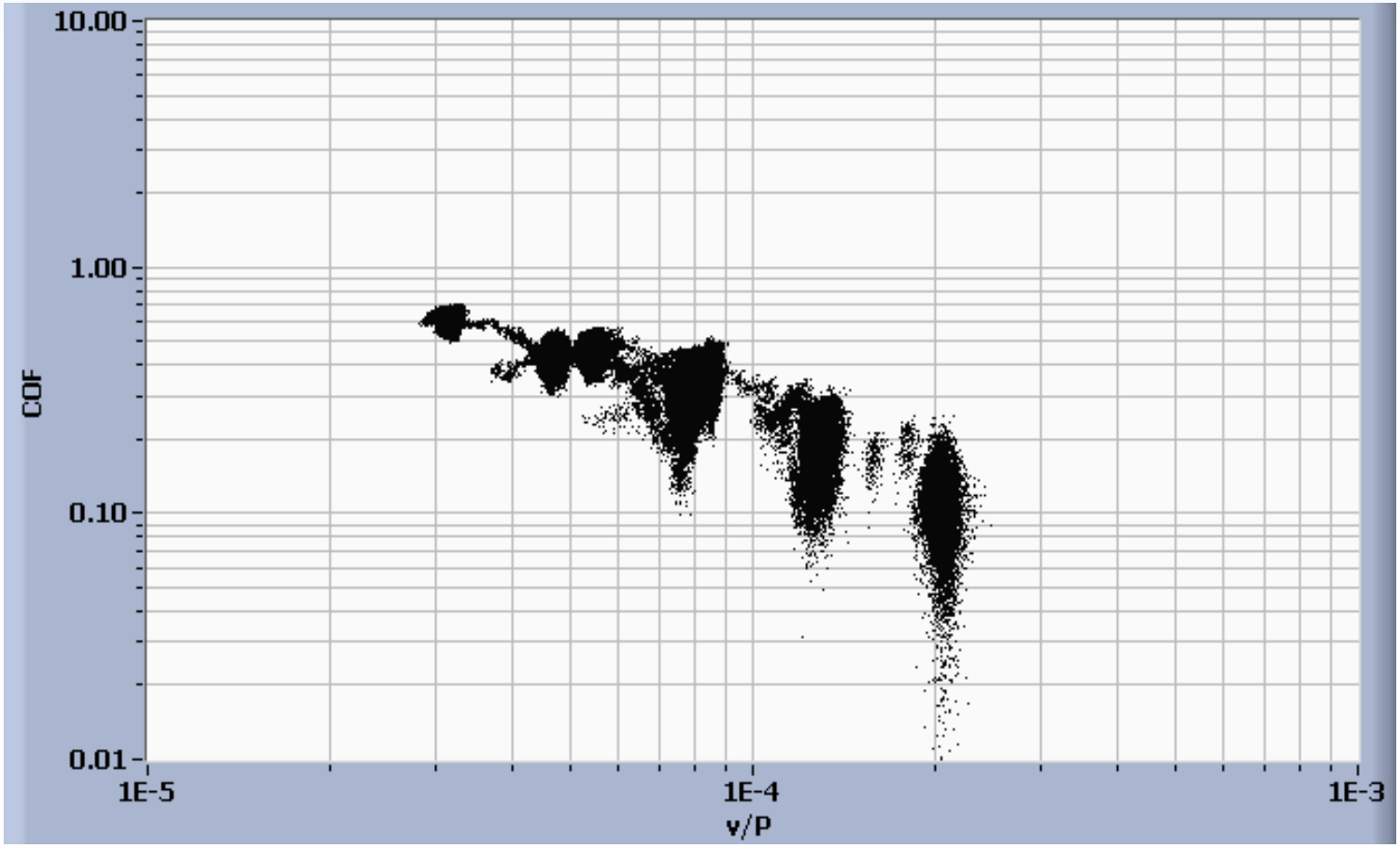
‘Traditional’ Stribeck Curve

IC1000 K-groove – Copper – CMC EP-C600Y-75



‘New’ Stribeck Curve

IC1000 K-groove – Copper – CMC EP-C600Y-75

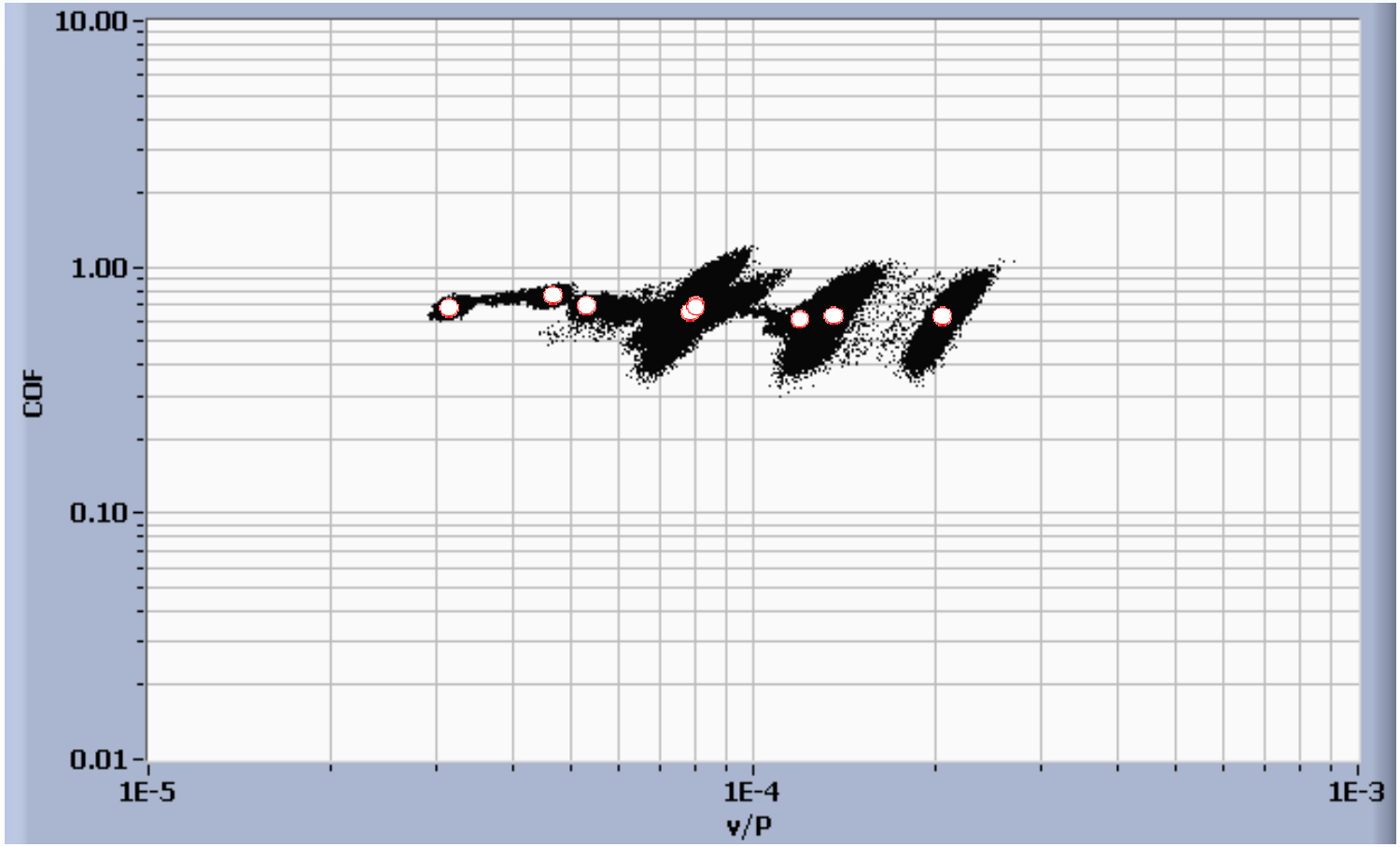


Case Studies re: Copper CMP

New Stribeck Curve – Mean and Fluctuations in COF

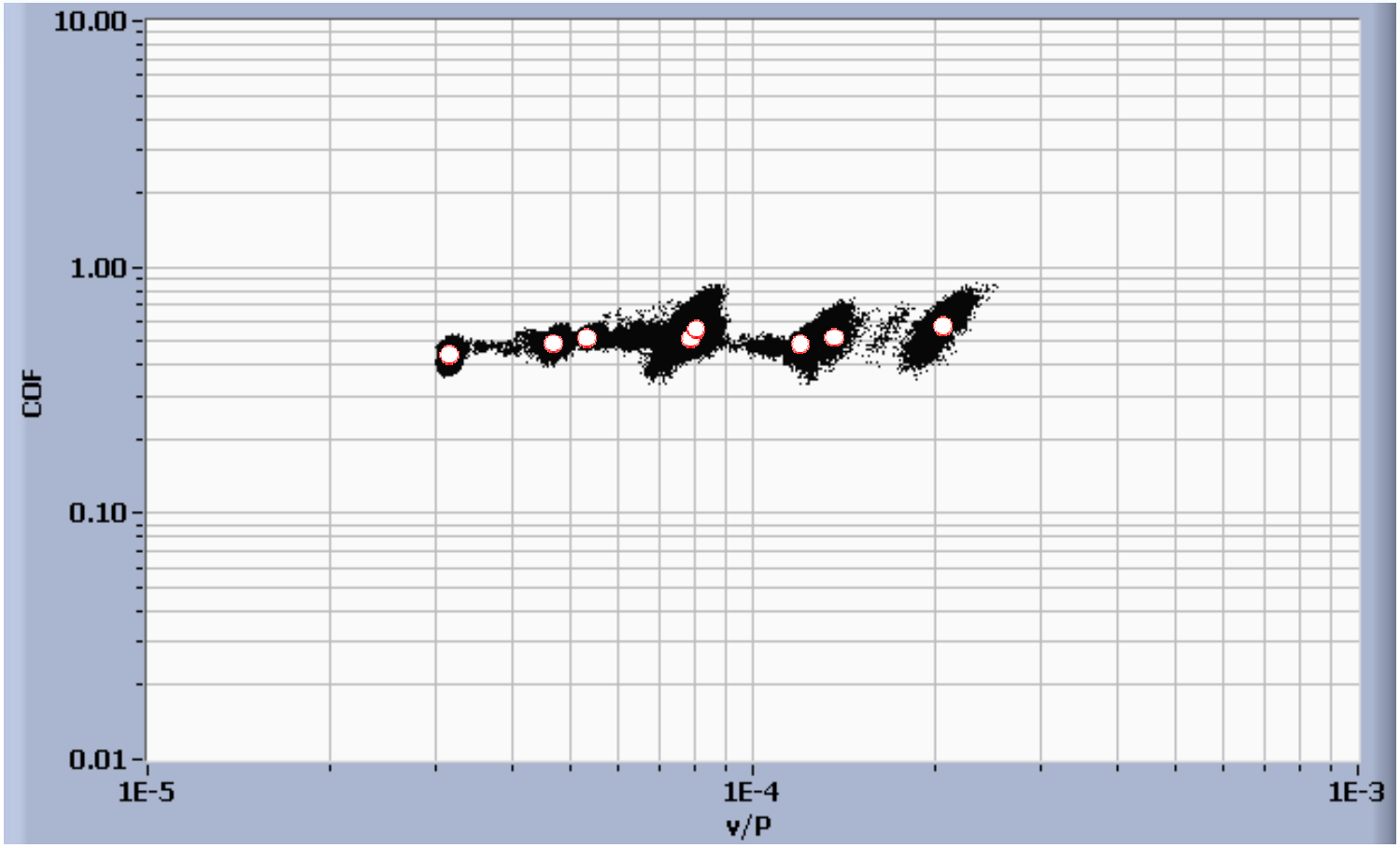
‘New’ Stribeck Curve

IC1020 M-groove – Copper – CMC EP-C600Y-75



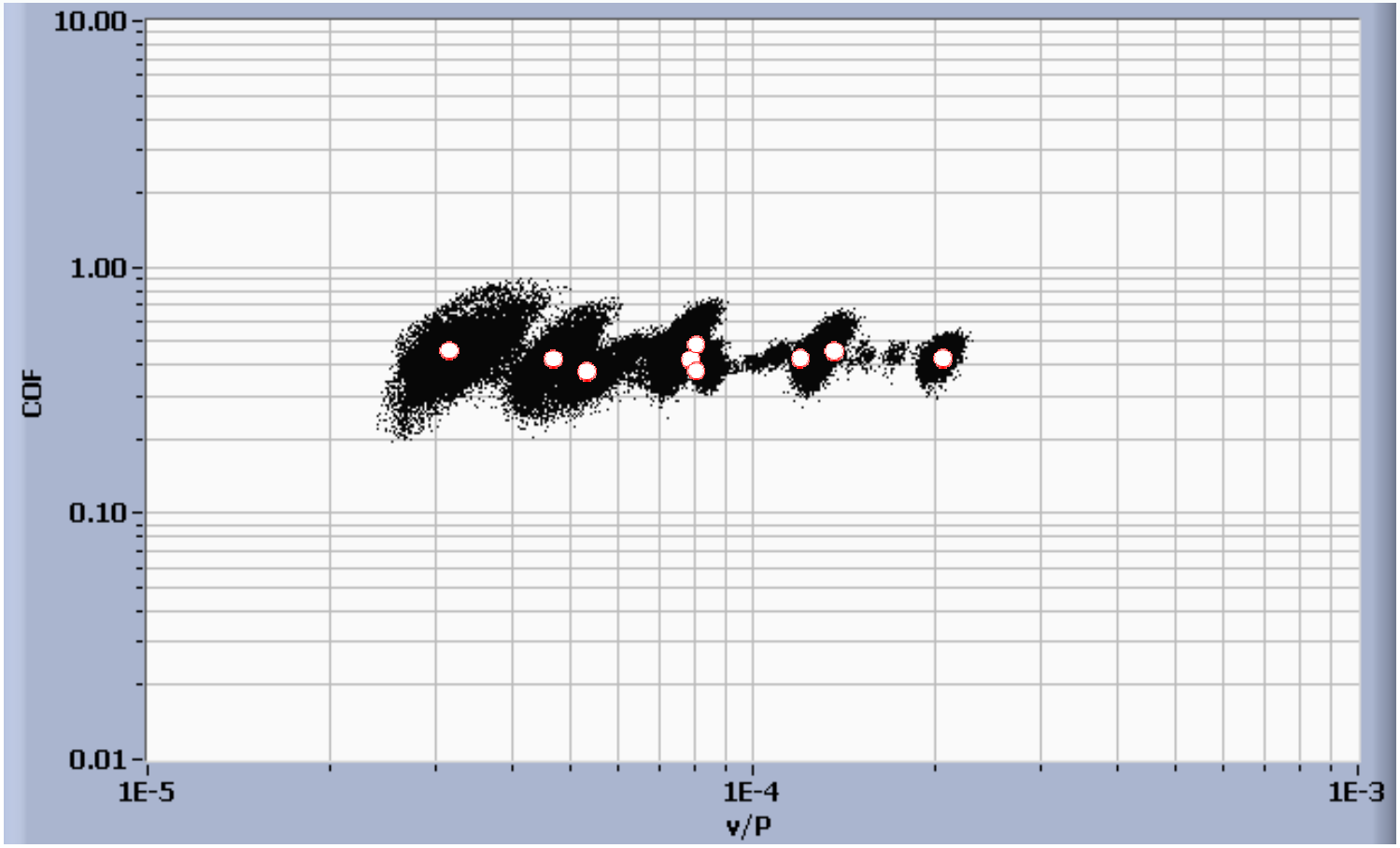
‘New’ Stribeck Curve

IC1020 M-groove – Copper – HCC HS-2H635



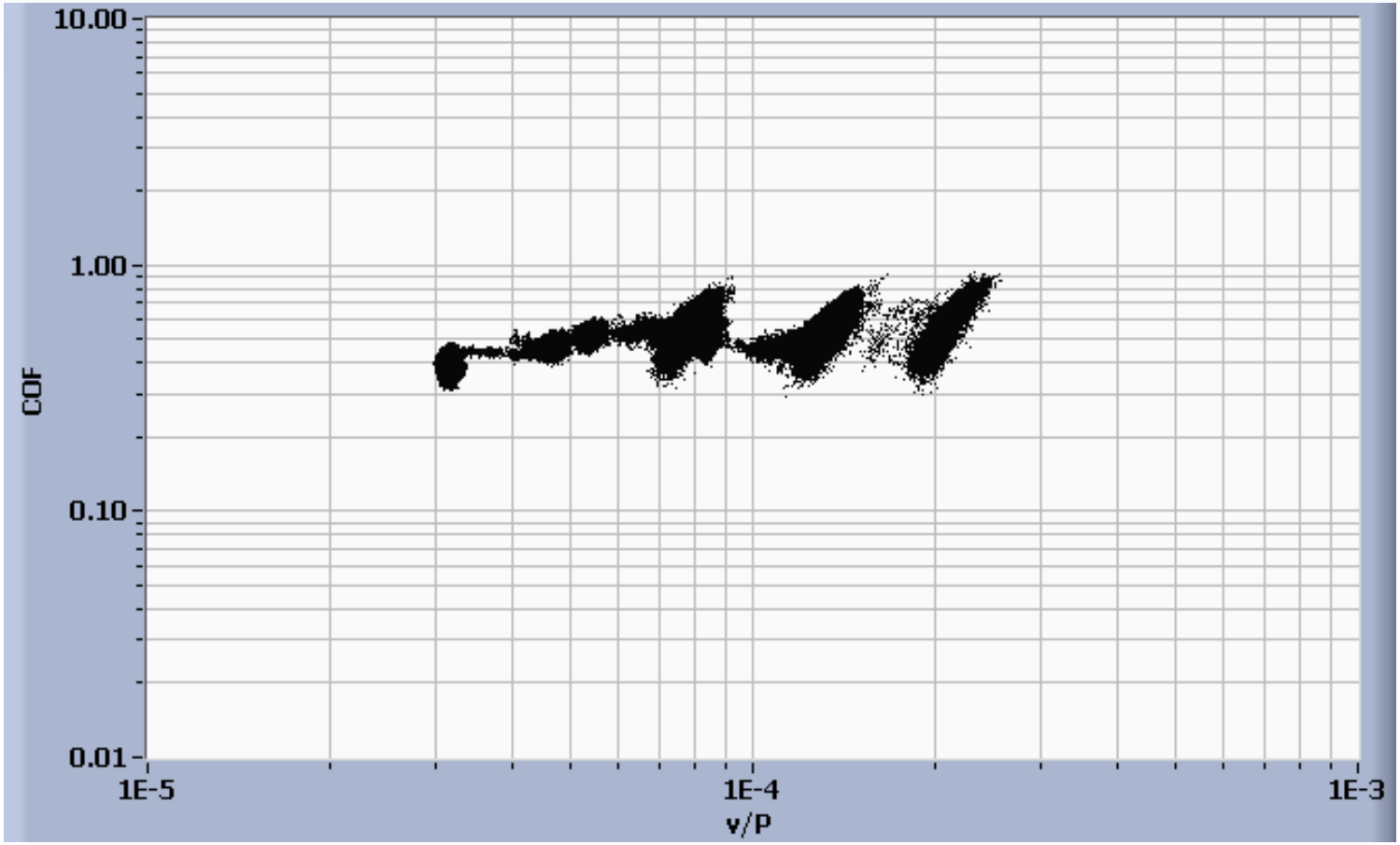
‘New’ Stribeck Curve

IC1020 M-groove – Copper – Fujimi PL-7103



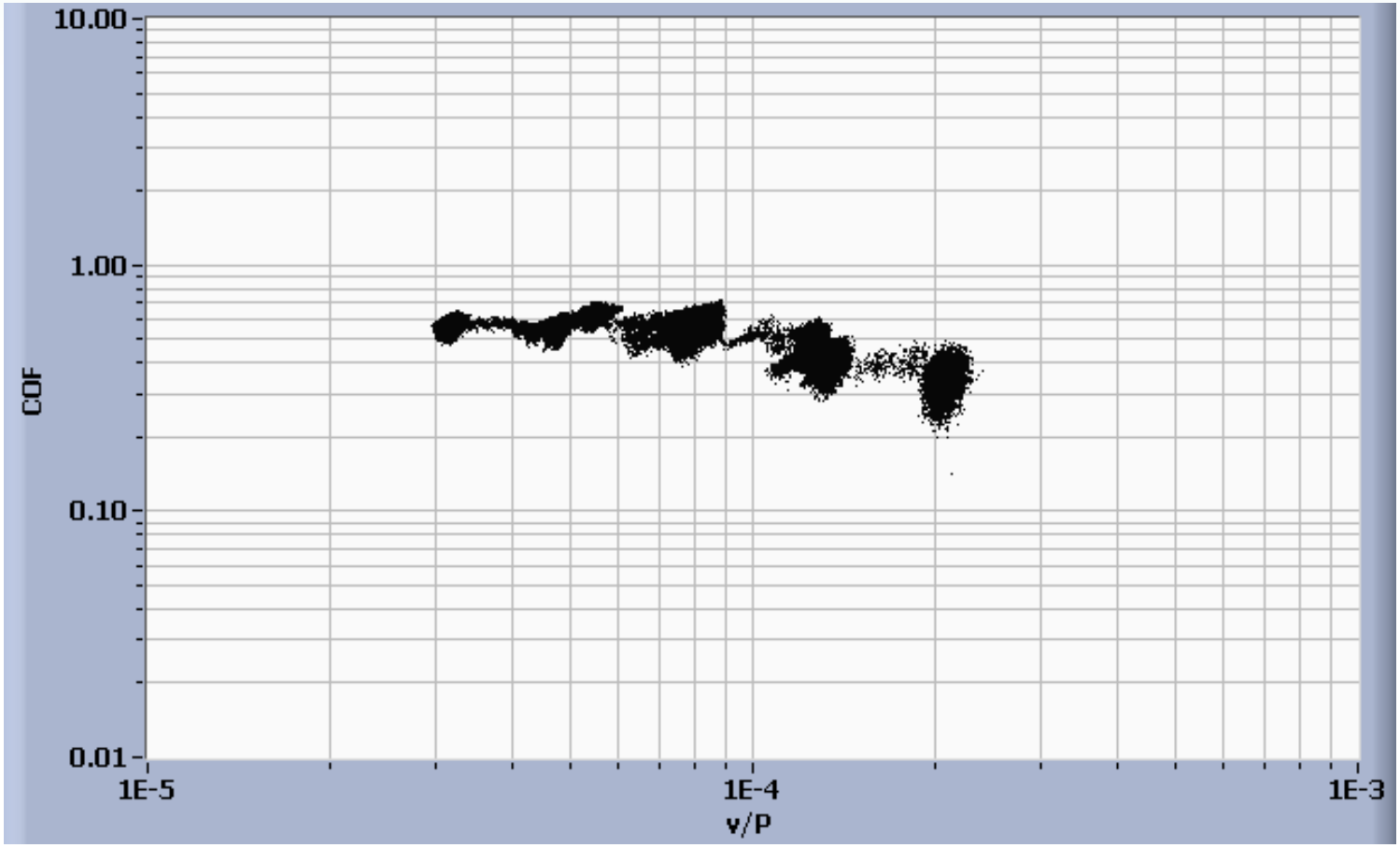
‘New’ Stribeck Curve

D100 – Copper – HCC HS-2H635



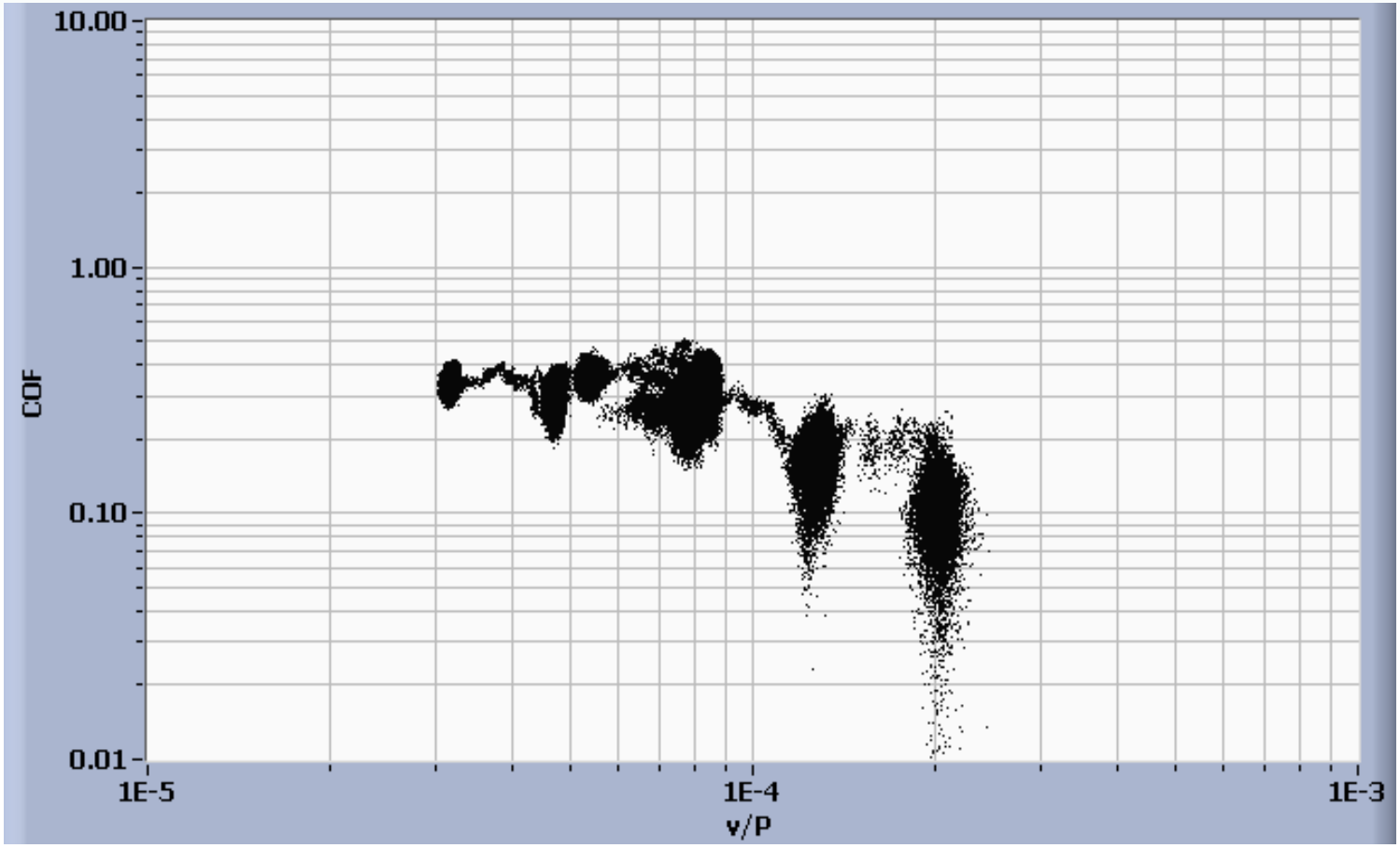
‘New’ Stribeck Curve

D100 – Copper – Fujimi PL-7103



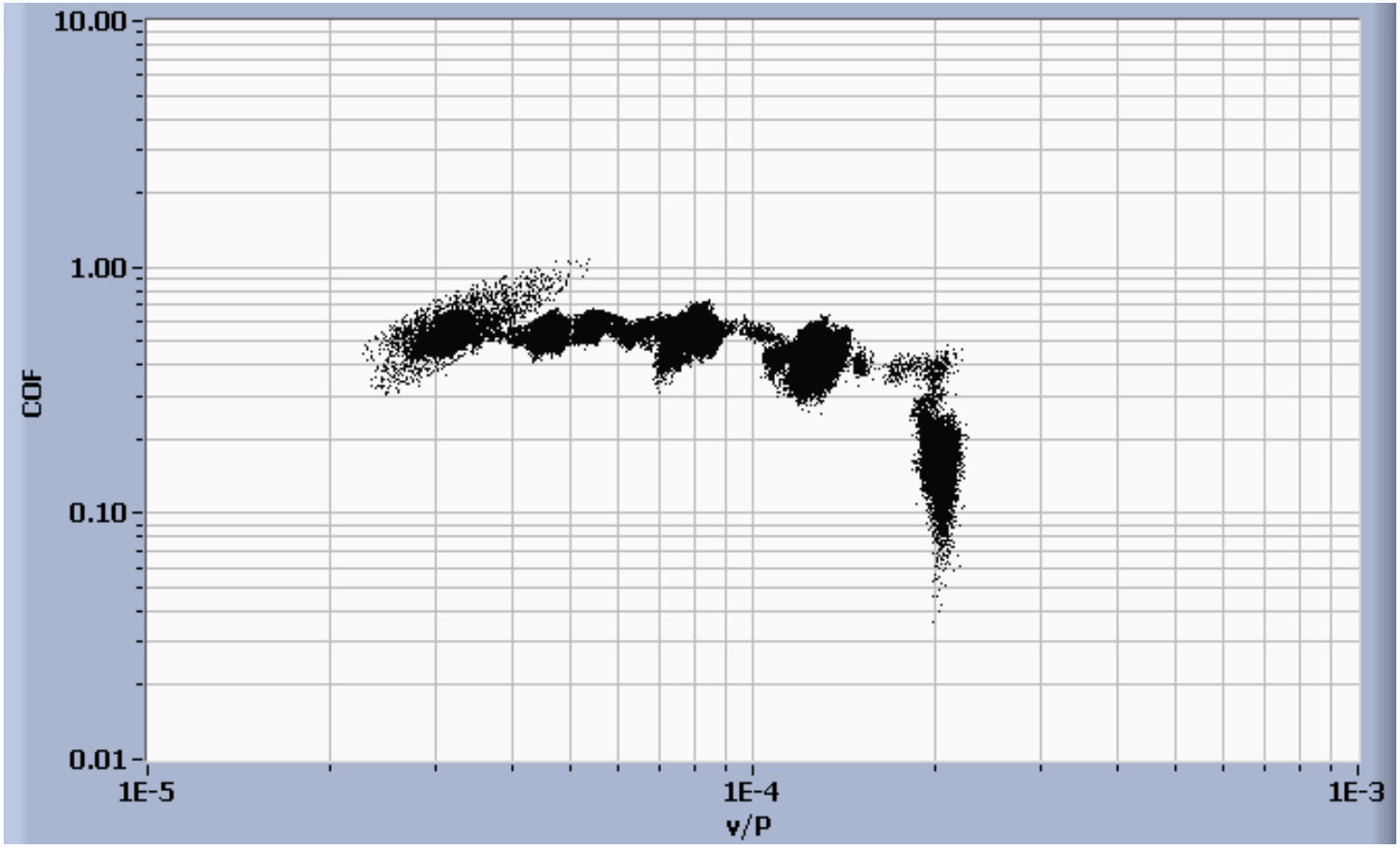
‘New’ Stribeck Curve

IC1000 K-groove – Copper – HCC HS-2H635



‘New’ Stribeck Curve

IC1000 K-groove – Copper – Fujimi PL-7103



Case Studies re: Oxide CMP

New Stribeck Curve – Mean and Fluctuations in COF

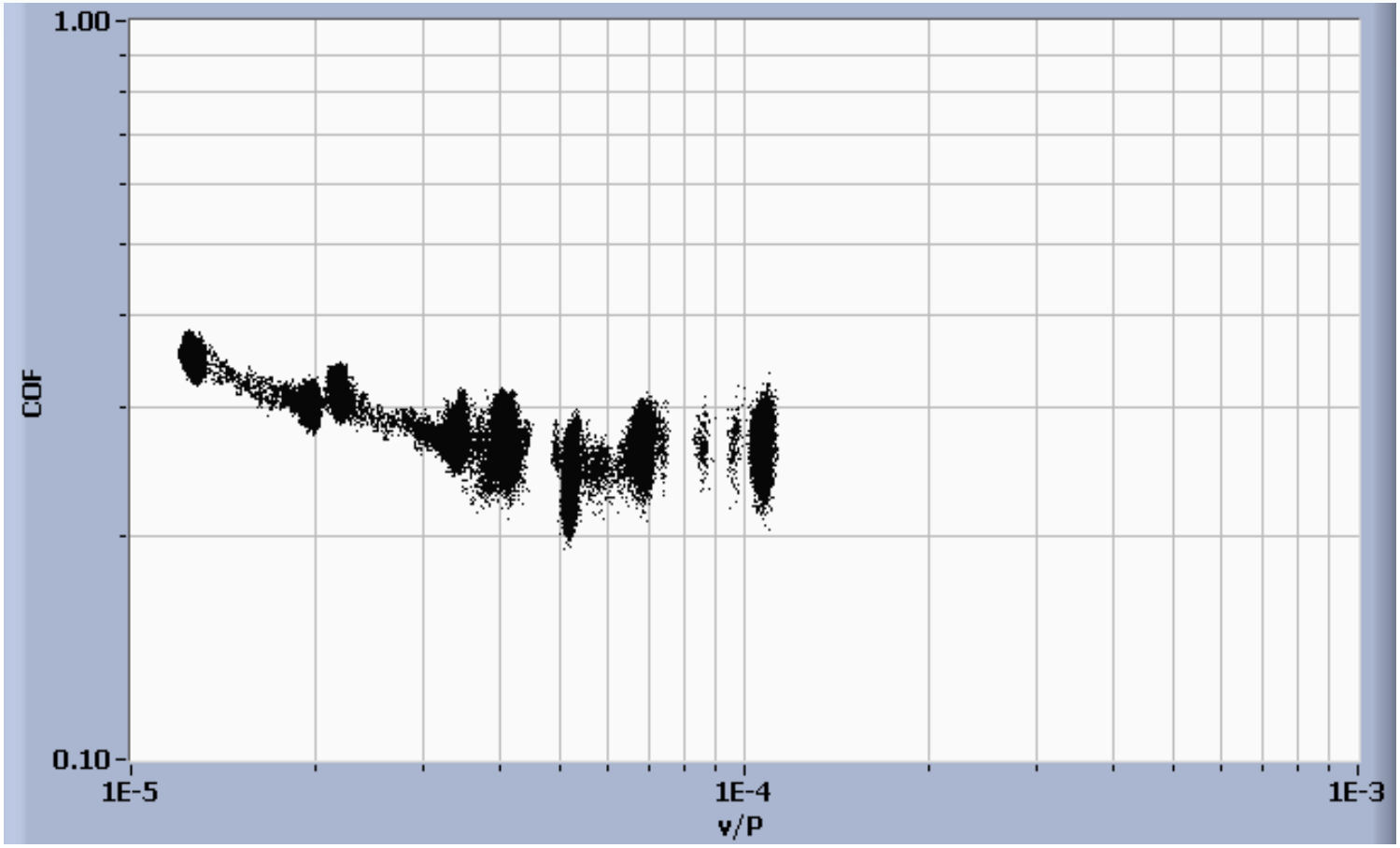
Experimental Conditions

Oxide CMP

- Wafers = 300-mm blanket oxide wafers
- Wafer pressure = 2.0, 4.0 and 6.0 PSI
- Sliding velocity = 0.6, 1.0 and 1.5 m/s
- Slurry flow rate = 300 cc/min
- Slurry = Klebosol 1508-50 and Fujimi PL-4217
- Pad = CMC D100, DOW IC1000 K-groove and Dow IC1000 M-groove
- Conditioner = 3M A165
- Conditioning force = 6 lb_f
- Conditioning = In-situ at 95 RPM & 10 per minute sweep frequency
- Polishing time = 130 seconds

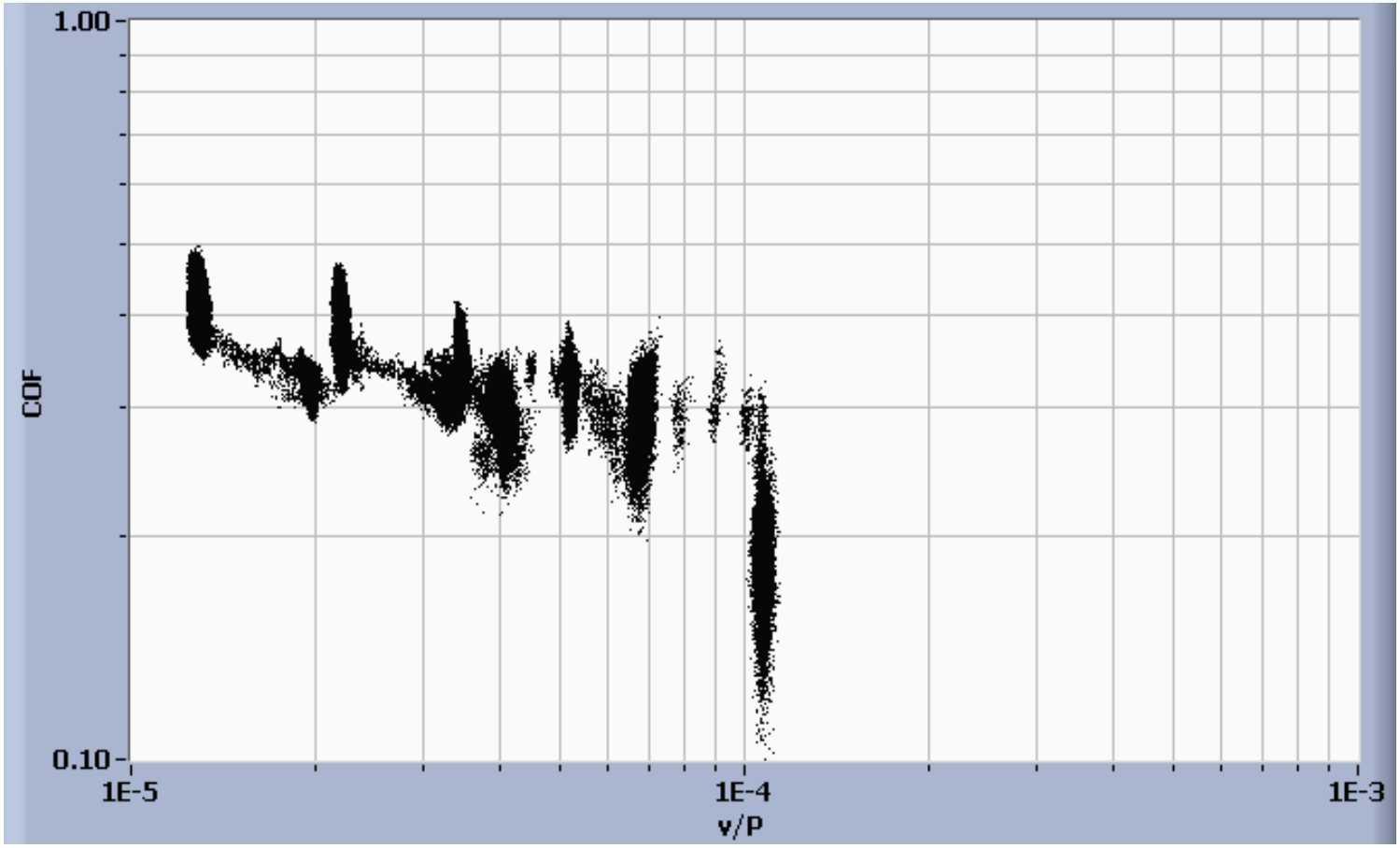
‘New’ Stribeck Curve

D100 – Oxide – Fujimi PL-4217



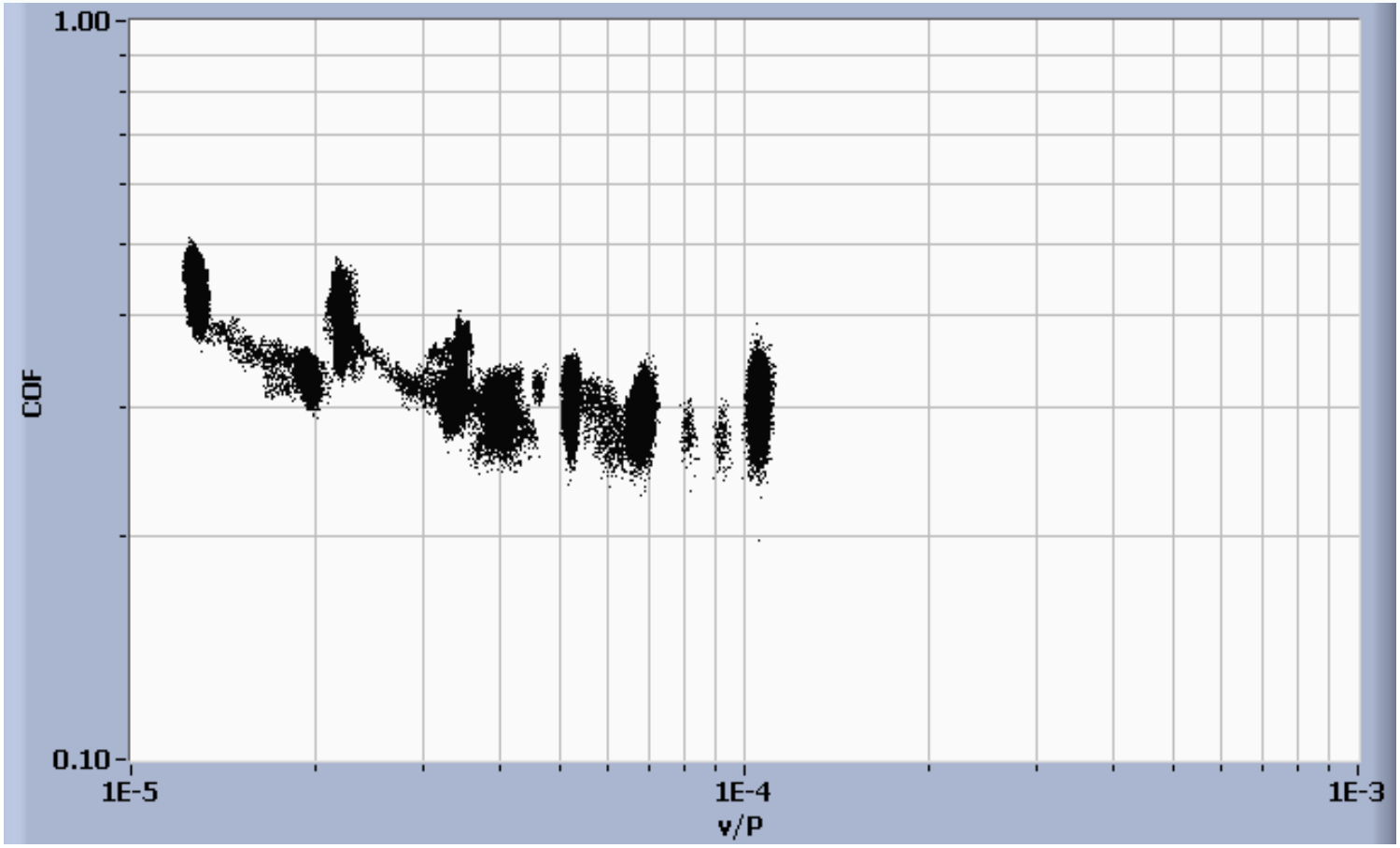
‘New’ Stribeck Curve

IC1000 K-groove – Oxide – Fujimi PL-4217



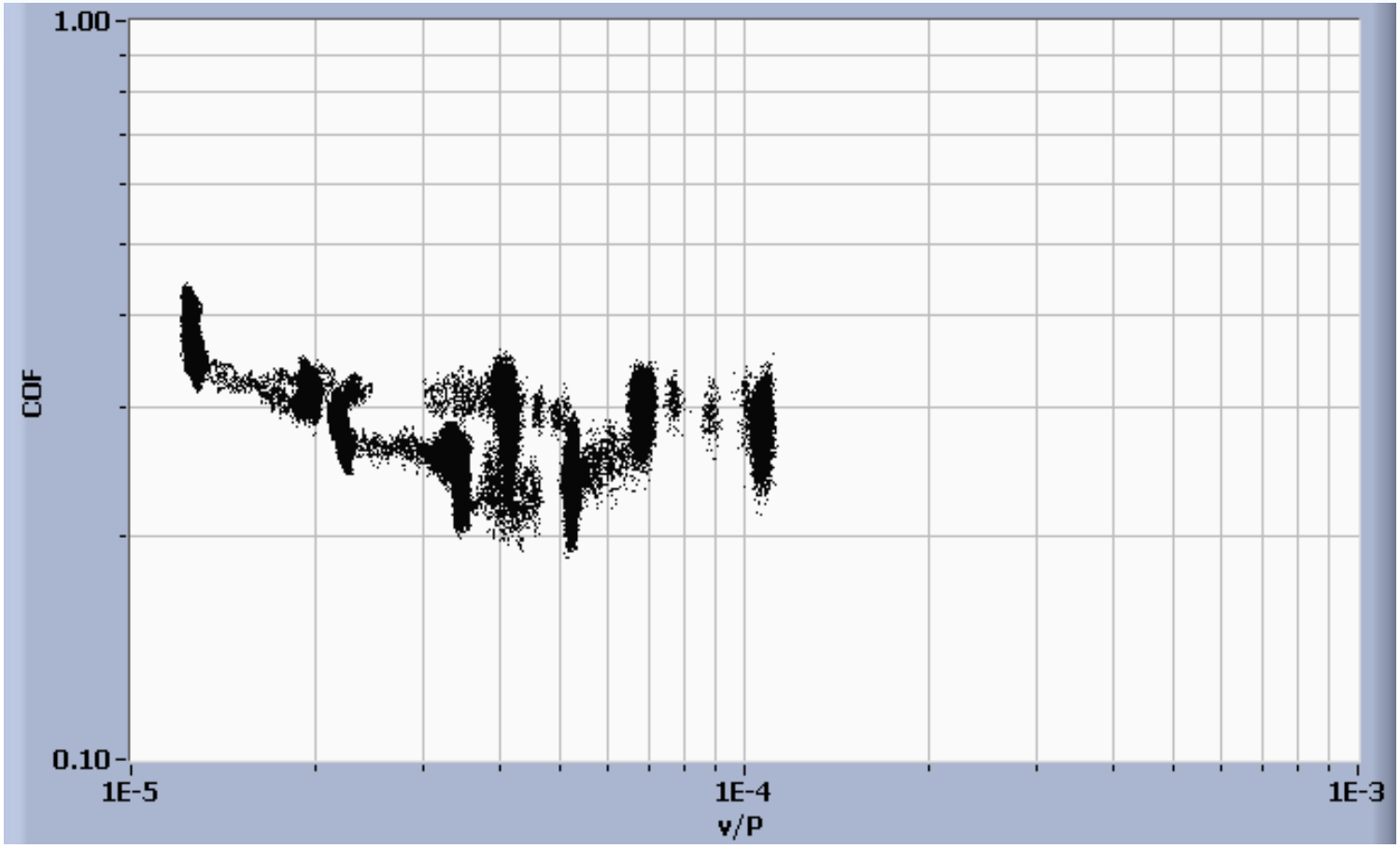
‘New’ Stribeck Curve

IC1020 M-groove – Oxide – Fujimi PL-4217



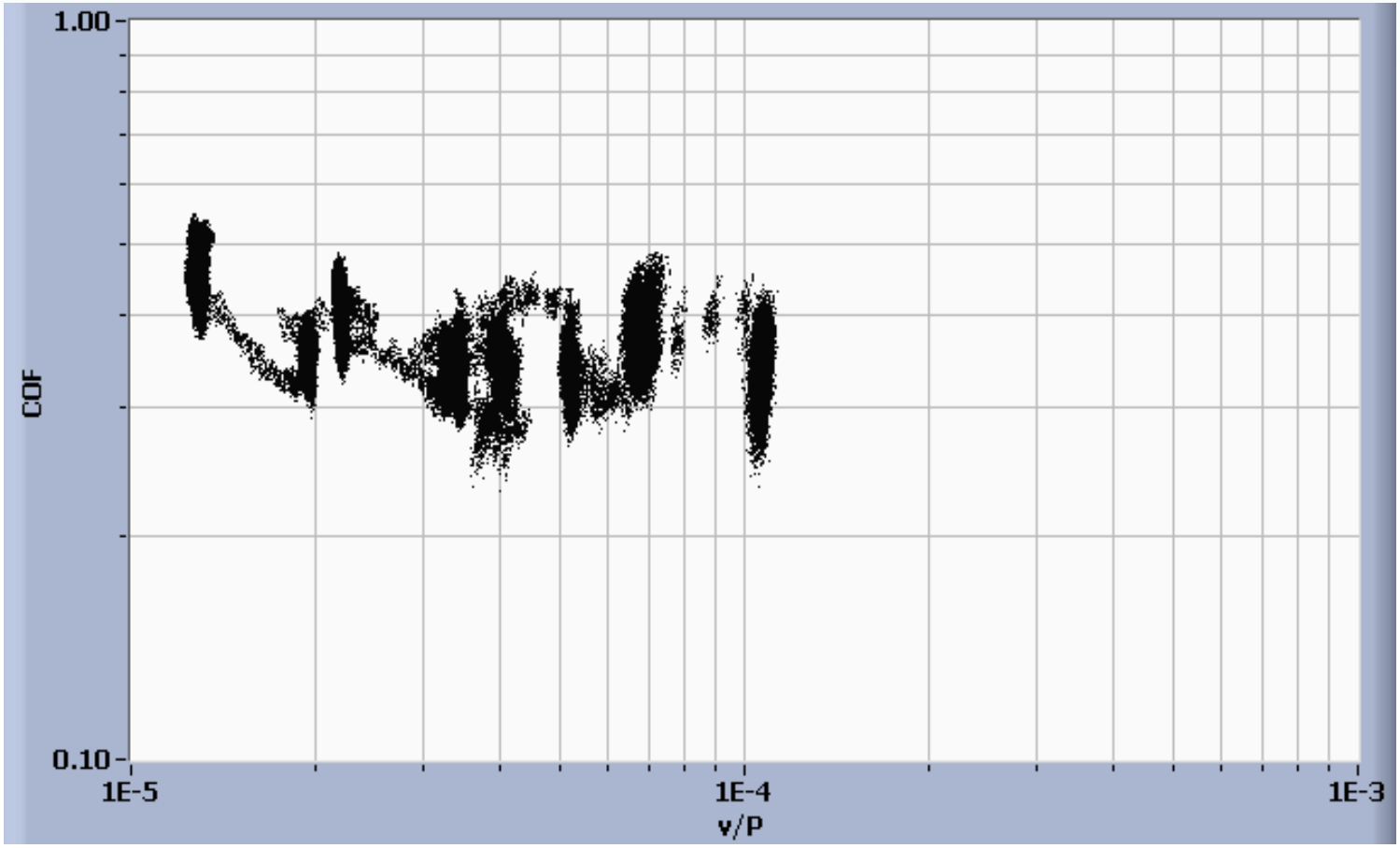
‘New’ Stribeck Curve

D100 – Oxide – Klebosol 1508-50



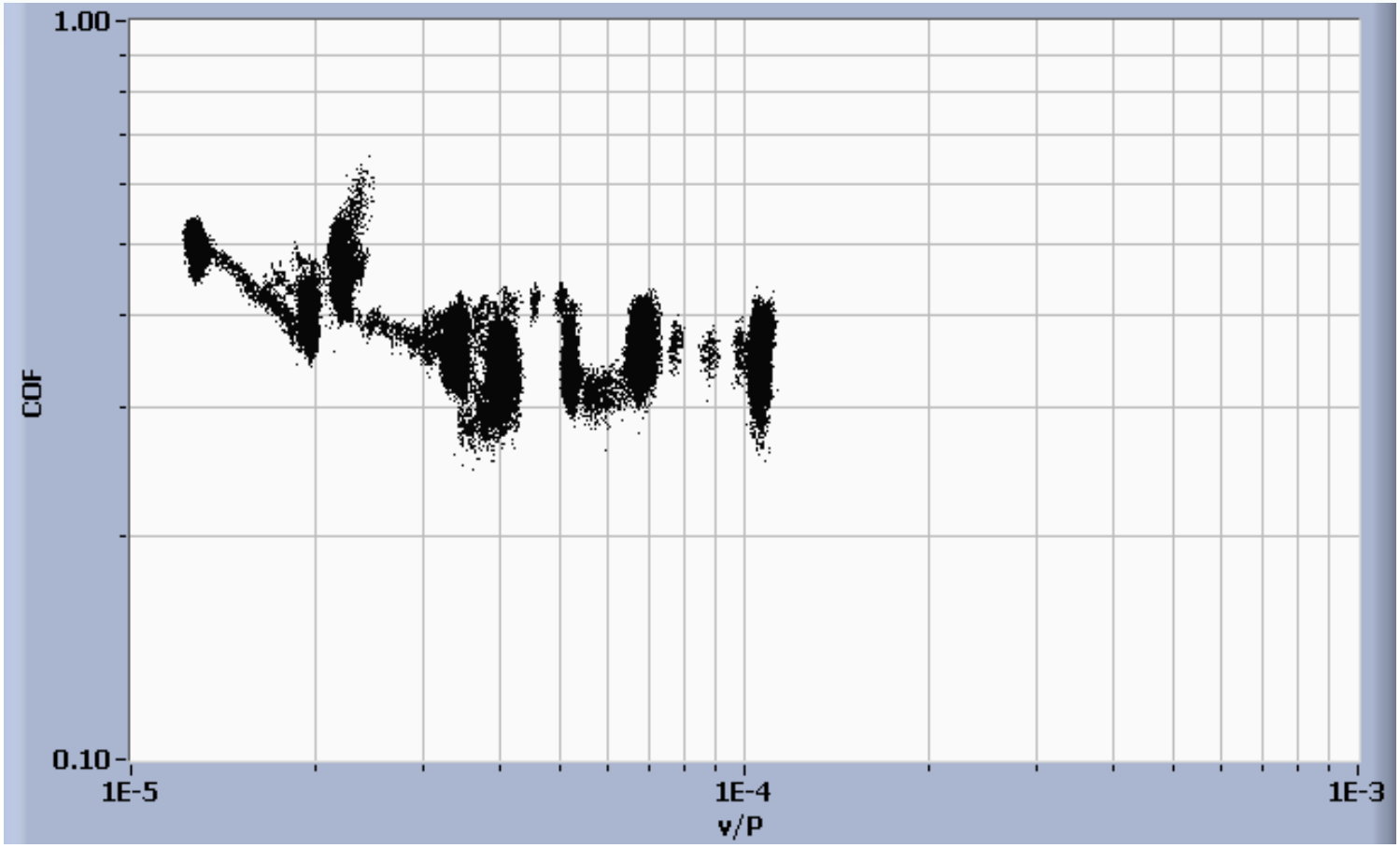
‘New’ Stribeck Curve

IC1000 K-groove – Oxide – Klebosol 1508-50



‘New’ Stribeck Curve

IC1020 M-groove – Oxide – Klebosol 1508-50



Summary

- A new method for obtaining the Stribeck curve corresponding to a set of consumables in CMP by only performing one wafer polishing experiment is presented.

- This new method is accomplished by use of polishers capable of simultaneously measuring shear force and down force (as well as real-time sliding velocity), and rendering a value for COF while simultaneously enabling a multitude of changes in pressure and velocity in real-time.

- Stribeck curves based solely on average COF are not the full explanation since fluctuations in COF can be dramatic and may be even more important than the mean values themselves.