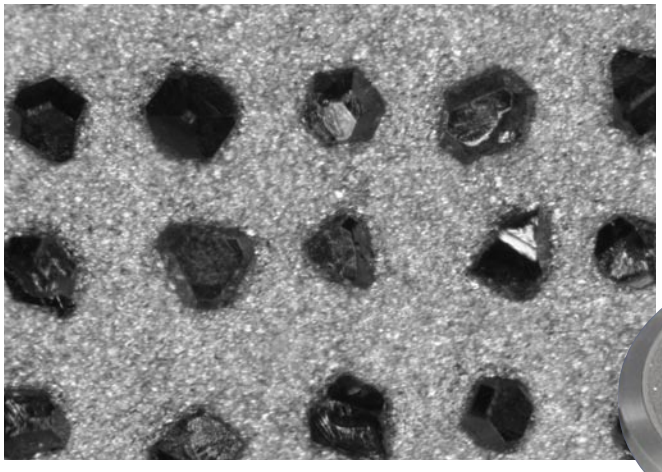
Application Brief

3M
Electronics

3M™ Diamond Pad Conditioner A165 for Copper CMP with 200mm Applied Materials Mirra™ and 300mm Applied Materials Tools

This application brief describes the use of 3M™ Diamond Pad Conditioner A165 for 200mm copper polish on an Applied Materials Mirra™ with a Titan™ Head and for 300mm copper polish on an Applied Materials Reflexion™ LK with a Profiler™ Head. The results from 1400 and 750 wafer marathons using in-situ conditioning on Platen 1 and Platen 2 show a stable and repeatable removal rate combined with excellent defect performance. This note also presents Accelerated Life Testing that is used to ensure A165 pad conditioners provide long life.

Controlling consumable properties is fundamental to optimizing CMP process performance and minimizing variability. 3M A165 pad conditioners deliver consistent process performance. These conditioners are manufactured using 3M's patented sintering and patterning technology that provides for control of diamond placement, diamond exposure height, and disk front-side flatness. This application brief describes the use of 3M's A165 pad conditioners for 200mm and 300mm copper processes on Applied Materials polishers.



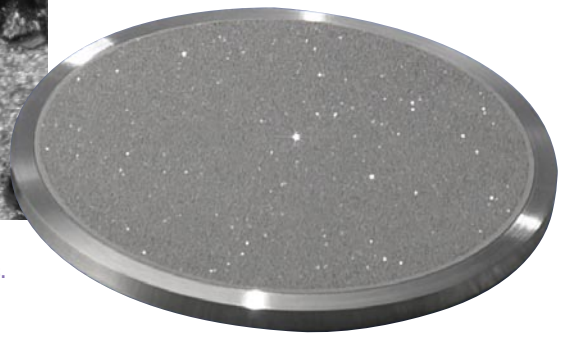
Patented 3M sintering and patterning technologies enable controlled diamond placement, exposure height and conditioner front-end flatness.

Smaller feature sizes and the drive to increase yields require higher performance and low cost of ownership (CoO) in Copper CMP

As the semiconductor market continues to move to smaller feature sizes, the need for superior chemical mechanical planarization (CMP) performance is increasing. Simultaneously, semiconductor manufacturers are seeking increased yields and lower cost of ownership.

Copper CMP is especially challenging because of several unique features. First, it is a primary driver of device electrical performance so a consistent polish, die to die and wafer to wafer, is critical. Second, during the process of copper CMP there are multiple films to polish, each with different degrees of hardness and varying chemistries. Third, copper polish is usually performed on metal line structures which have a low tolerance for dishing and erosion. This challenge is further exacerbated by underlying incoming topography variation.

Optimized pad conditioning is fundamental to stable copper CMP process performance. Additionally, optimized pad conditioning has a significant impact on the overall cost of ownership through its effects on conditioner life, pad life and slurry usage.

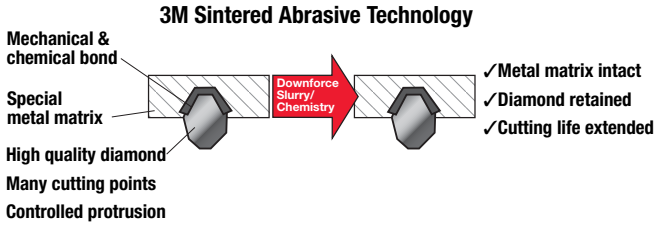


The 3M™ Diamond Pad Conditioner A165

3M™ Diamond Pad Conditioners are made with proprietary processes that enable the controlled sizing and placement of diamonds to optimize CMP performance

3M™ Diamond Pad Conditioners A165 are designed for excellent and stable process results while also obtaining long pad conditioner life. Controlling consumable properties is fundamental to optimizing CMP process performance and minimizing variability. Pad conditioning is required to obtain and maintain an acceptable removal rate and stable process performance. Diamond pad conditioners are the most widely utilized form of pad conditioning in production fabs today. Pad conditioners refresh (or wear) the pad surface during CMP wafer processing to maintain a uniform pad surface. Pad conditioning helps maintain optimal pad surface roughness and porosity ensuring slurry transport to the wafer surface and the removal of CMP residuals. Without conditioning, the pad surface will "glaze" and removal rates will rapidly decline.

The A165 pad conditioners are made with 3M's patented sintering technology. The sintering process results in a strong chemical and mechanical substrate-diamond bond that minimizes diamond loss due to bond failure. The proprietary nickel alloy metal matrix is designed to resist corrosion and maximize diamond adhesion.



The A165 pad conditioners are also manufactured with precision sizing and placement of the diamonds. The patented Diamond Free Exclusion Zone provides a diamond free zone on the outer perimeter of each conditioner . This exclusion zone reduces the possibility of diamonds coming loose due to poor anchoring or higher unit pressure. The controlled diamond placement in the grid and the complete lack of diamonds in the exclusion zone can be seen in Figure 1.

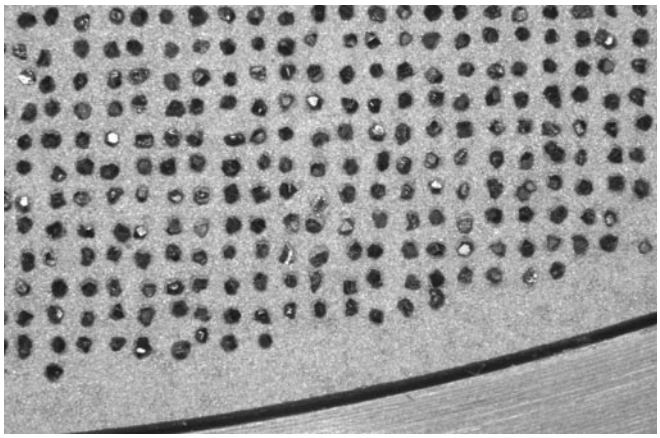


Figure 1: 3M controlled diamond placement and Diamond Free Exclusion Zone.

Pad conditioner topography is an important characteristic of pad conditioners. Figures 2 and 3 show the topography of a 3M and a competitive conditioner, respectively. Note how the peaks of the 3M diamonds are all distributed within 20µm of each other. Figure 3 demonstrates a competitor's surface topography can be less controlled and the diamond peaks vary.

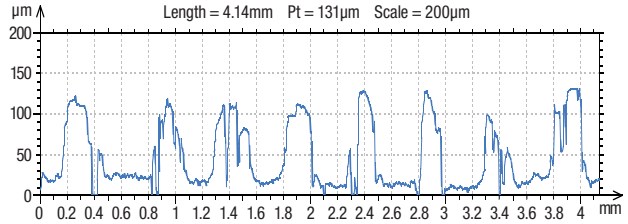


Figure 2: A165 pad conditioners surface topography. Note how the peaks of the 3M diamonds are all distributed within 20µm of each other.

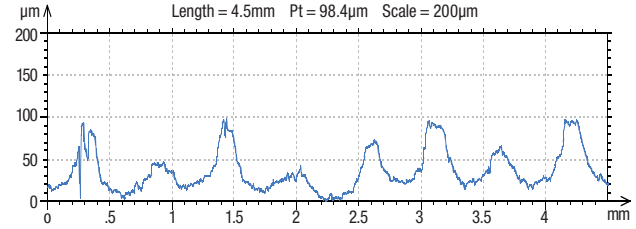


Figure 3: Competitor's surface topography.

Product Recommendation

The 3M™ Diamond Pad Conditioner A165 is a recommended conditioner for copper processing of 200mm and 300mm wafers. Recommended typical process settings are shown in Table 1. Table 2 shows recommended break-in settings.

Table 1: Recommended typical conditioning recipe settings (processing).

Parameter	200mm			300mm		
Platen	P1	P2	P3	P1	P2	P3
Downforce (lbs)	6	6	4	7	7	4
Sweep Rate (#/min)	12	12	12	12	12	12
Conditioner Speed (rpm)	95	95	95	105	105	105
# Conditioning Zones	10	10	10	10	10	10
% Conditioning	50-100%	50-100%	50-100%	50-100%	50-100%	50-100%

Table 2: Recommended typical conditioning recipe settings (pad break-in).

Parameter	200mm	300mm
Platen Speed	100	105
Downforce (lbs)	6	7
Sweep Rate (#/min)	12	12
Conditoner Speed (rpm)	95	95
Conditioner Zones	10	10
Time (sec)	900	1200

3M™ Diamond Pad Conditioner A165 Performance

The A165 pad conditioner was used in 200 mm and 300 mm copper polishing marathons. The 200 mm marathon included a 1400 wafer extended run and the 300 mm marathon included a 750 wafer extended run. The copper polishes are accomplished in three steps. First, platen 1 (P1) is used to clear the wafer of bulk copper. Removal rates on P1 are generally high and the wafer polishes until a set time is reached. In the second step, platen 2 (P2) is used to do final removal of copper. Removal rates are less than half of those used on P1 and the P2 process is usually stopped through the use of an endpoint signal. Minimal overpolish is used to compensate for non-uniformity, while minimizing dishing and erosion. For the final step, platen 3 (P3) is used. P3 processing has two purposes: a) to remove any barrier film and b) to remove some oxide film as a topography adjustment as well as scratch removal. Figures 4-11 show the consistent polish performance the A165 pad conditioner provided.

Stable removal rates and low wafer to wafer non-uniformity during copper polishing marathons are shown in Figures 4-7. The pre- and post-copper thickness diameter scan were measured by RS75 with a 5 mm edge exclusion. The 200 mm and 300 mm marathons each lasted for 20 hours of conditioning with no trends in removal rate, non-uniformity, topography or defectivity. This allows us to conclude the A165 pad conditioner life expectancy is likely to be greater than 20 hours under these test conditions.

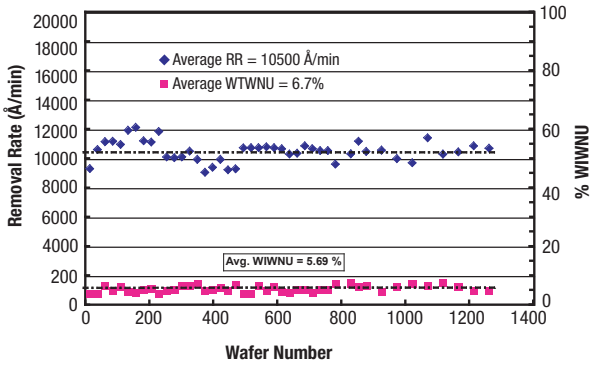


Figure 4: Platen 1, 200 mm bulk copper removal performance during 1400 wafer marathon. Cu removal rate averaged 10555 Å/min. Wafer to wafer non-uniformity is 5.71 %.

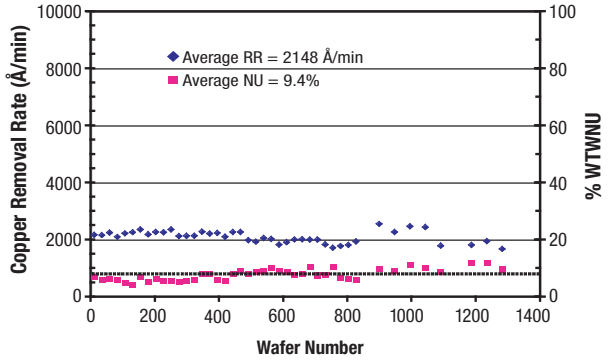


Figure 5: Platen 2, 200 mm final copper removal performance during 1400 wafer marathon. Cu removal rate averaged 2148 Å/min. Wafer to wafer non-uniformity is 9.4 %.

Summary of Process Performance

This application brief describes the use of A165 pad conditioner for 300mm copper polish on an Applied Materials Reflexion™ LK CMP Tool with a Profiler™ head. The results from a 750 wafer marathon using in-situ conditioning on Platen 1 and Platen 2 show a stable and repeatable removal rate combined with excellent defect performance.

Platen 1 Removal Rate at 0.8 psi in 750 Wafer Marathon

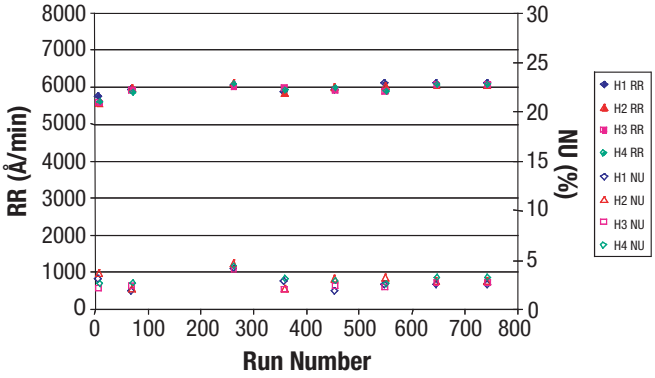


Figure 6: Platen1, 300mm bulk copper removal performance during 750 wafer marathon. An averaged Cu removal rate of 5941 Å/min is obtained with an averaged 2.9% within wafer non-uniformity during 750 wafers run. Note low variability between the four heads for both removal rate and non-uniformity. Additionally, there are no trends at the end of the marathon.

Platen 2 Removal Rate at 0.8 psi in 750 Wafer Marathon

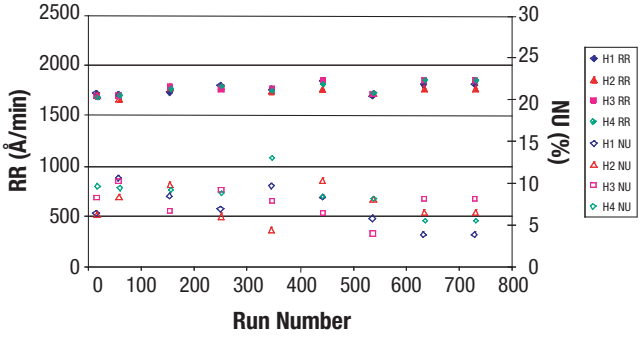


Figure 7: Platen 2, 300mm final copper removal performance during 750 wafer marathon. The Cu removal rate averaged 1762 Å/min. Within wafer non-uniformity averaged 7.6% during the 750 wafer extended run. Again, note the lack of trends at the end of the marathon.

Dishing and erosion data after copper polishing are shown in Figures 8-9. Average dishing at 50 50 µm lines on MIT 754 wafers is less than 100Å, and maximum dishing is less than 400Å. Average erosion data at 25 25 µm array on MIT 754 wafers are less than 100Å and maximum erosion is less than 200Å. The P3 polishing time is 60 seconds.

Topography (50 50 Lines) of MIT Wafers in 750 Wafer Marathon

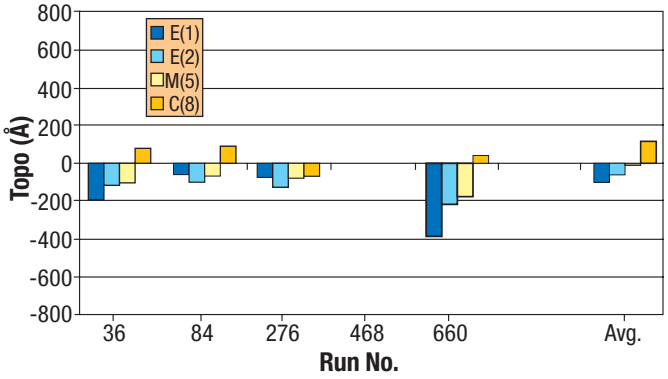


Figure 8: Stable Dishing Performance on 300mm patterned wafers. MIT pattern wafers were polished in 750 wafer Marathon to measure topography performance. Average dishing at 50 50 µm lines on MIT 754 wafers are less than 100A and maximum dishing is less than 400A.

Topography (25 25 Array) of MIT Wafers in 750 Wafer Marathon

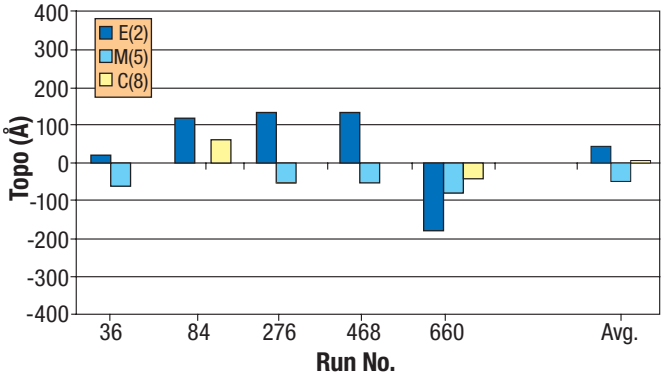


Figure 9: Stable Erosion Performance on 300mm patterned wafers. Average erosion at 0.25 0.25 µm array on MIT 754 wafers are less than 100A and maximum erosion is less than 200A.

Defect data after copper polishing on wafers are shown in Figures 10-11. Consistently low defect counts on double layer metalization patterned 200mm wafers and blanket PE-TEOS oxide 300 mm wafers are achieved.

Defectivity During 1400 Wafer Marathon

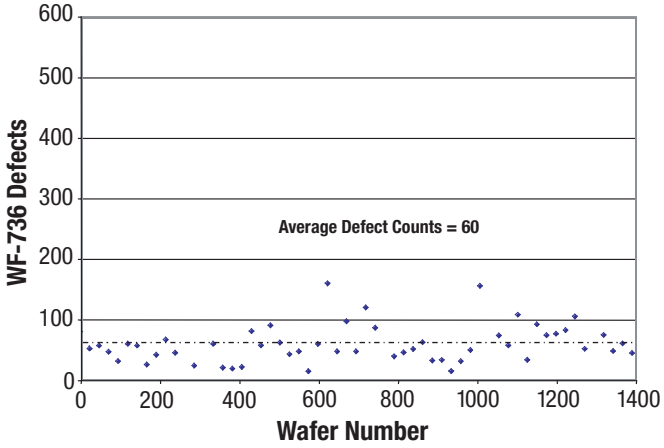


Figure 10: Double layer metalization pattern wafer defectivity performance during 200mm marathon. The 3M™ Diamond Pad Conditioner A165 provided very low defectivity throughout the entire marathon on Cu patterned wafers. The average defect count @ 0.2µm was 60 and the upper control limit (UCL = mean + 3s) was 165.

Defectivity During 750 Wafer Marathon

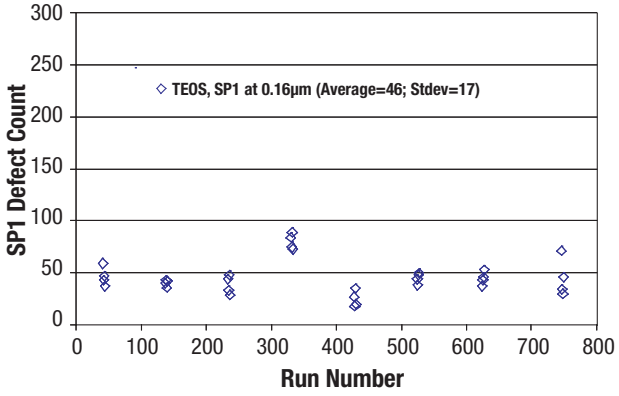


Figure 11: Defectivity performance during 300mm marathon. The A165 pad conditioner provided very low defectivity throughout the entire marathon on TEOS blanket wafers. All defect monitors are within spec (<200) during the 750 wafer marathon.

3M™ Cost of Ownership

3M is committed to providing a compelling cost of ownership for our customers. Accelerated life testing is one way to make sure 3M™ Diamond Pad Conditioners A165 provide value through reduced overall cost of ownership.

Accelerated testing is done at the 3M applications lab using a small scale polisher. Industry standard slurries and pads are used. The A165 pad conditioners can be compared against existing 3M pad conditioners as well as the competitors' offerings. Figure 12 illustrates the A165 pad conditioner versus a competitor's conditioner in copper slurry.

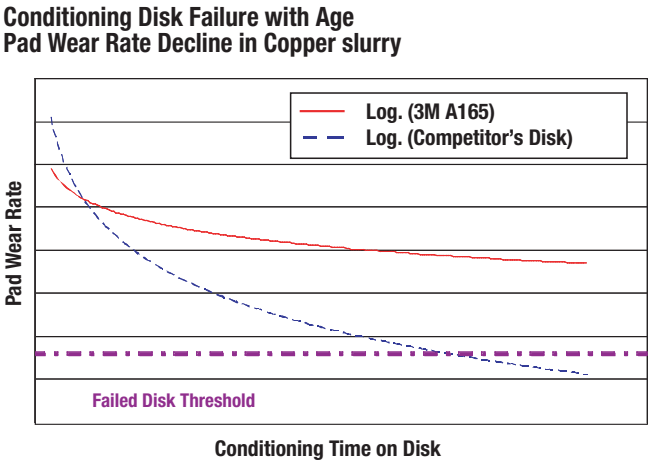


Figure 12: Comparison of pad conditioner life between A165 pad conditioner and a competitive product.

A valuable benefit of working with 3M is our capability of creating a pad conditioner with any level of pad wear rate the customer requires. This is especially useful for customers whose processes require a softer pad (low pad wear rate) or those who require ex-situ conditioning (high pad wear rate). See Figure 13.

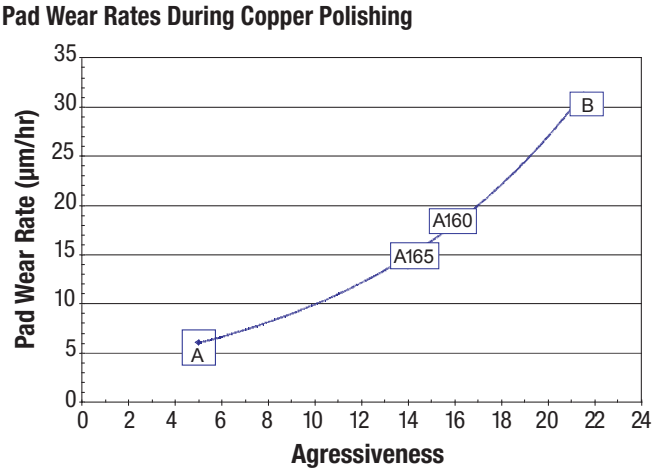


Figure 13: 3M diamond pad conditioner technology is capable of creating pad conditioners to meet pad wear rate requirements tailored to specific applications.

3M™ Diamond Pad Conditioner A165 for Copper CMP with 200mm Applied Materials Mirra™ and 300mm Applied Materials Tools

Typical Physical Properties

Properties	3M™ A165 Diamond Pad Conditioner
Diamond Size	250 µm
Pattern	Controlled placement
Form	Full disk with bevel
Carrier	304 stainless steel
Aggressiveness*	15-19
Flatness (mm)	0-100
Surface	Smooth sintered
Acid Resistance	Excellent

*Proprietary 3M test method.

World Wide Process Support and Technical Service

3M offers assistance to customers in developing and qualifying new processes for a wide range of applications including CMP, cleaning etching and drying, CVD chamber cleaning, and heat transfer fluids for thermal management in CVD, etch, lithography and test equipment. The specialists are backed by 3M application development centers located near fab sites in countries around the world.

United States
3M Performance Materials Division
800 541 6752

Brazil
3M do Brasil Ltda.
5519 3838 7000

Canada
3M Canada Company
800 364 3577

Europe
3M Belgium N.V.
32 3 250 7521

India
3M India Limited
Bangalore
9080 2231414

China
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China
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New Zealand
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64-9-444-4760

Australia
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61 2 9498 9333

Other Areas
651 736 7123 (U.S.)

3M Electronics Markets Materials Division
3M Center
Building 224-3N-11
St. Paul MN 55144-1000
800-810-8513
www.3M.com/electronics

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