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Mr. Thomas E. Steffner, CEO
Better Than New, LLC
211 Healing Bluff Road
Chattanooga, TN 37407

Dear Mr. Steffner:

The purpose of this letter is to report to you the results of friction tests in our laboratory using samples treated with your RF-85 process.

Linear reciprocating pin-on-disk tests were performed on two sets of materials. One was 440C stainless steel, heat treated to a hardness of 58-62 Rockwell C. The samples consisted of a 0.125 inch diameter ball and a flat disk of the same material polished to an arithmetic average surface roughness R_a of 20 nm. This material was chosen for relevance to some of the parts used in our electromechanical safety devices for weapons. The other material was silicon, chosen for relevance to microfabricated advanced safety devices. In this case, a sphere of SiO_2 0.125 inches in diameter was tested against a piece of single crystal silicon wafer. The silicon contains a natural oxide, so this contact represents SiO_2 sliding against itself. The roughness of the SiO_2 sphere was better than 10 nm R_a, and the silicon wafer was atomically smooth.

The tests were conducted in a dry nitrogen atmosphere (< 10 ppm O_2, and < 100 ppm H_2O) using a 98 mN applied load (10 grams force) between the ball and the disk. The average sliding speed was 3.0 mm/s, and sliding was unidirectional along a 1.5 mm long wear track. That is, the ball slid in one direction along the disk for 1.5 mm while friction force was recorded, then the ball was lifted and returned to the starting position for the next sliding cycle.

For both types of materials, we prepared and cleaned two sets of identical samples. One set was tested here with no surface treatment, and the other was sent to you for the RF-85 treatment. When those returned, we cleaned the samples in acetone and alcohol, and then tested them under identical conditions to the cleaned samples. Three friction measurements were performed at each test condition.

Figure 1 shows the results of tests with 440C steel. The friction coefficient for the untreated surfaces exhibits a starting value near 0.3, followed by an increase in at least one case to values close to 1.0. High friction and erratic changes in friction coefficient are indicative of adhesive wear and particle generation which is accompanied by damage to the metal surface. On the other hand, the friction coefficient for the surface treated with RF-85 exhibit friction coefficient values between 0.10 and 0.15, with little change during the 1000 cycle test. The RF-85 treatment has evidently resulted in a low shear strength surface layer on steel.

Figure 2 shows the results of tests with an SiO_2 ball sliding on silicon. The starting friction for untreated surfaces is near 0.4, while that for the RF-85 treated surfaces is near 0.1. Friction coefficient for the untreated surfaces rapidly decreases to values comparable to the treated surfaces. This is likely due to debris production during sliding of the untreated surfaces, and interfacial shear accommodated by third-body (particle) motion at the interface.

In summary, the RF-85 treatment appears to provide an effective, low shear layer on stainless steel that can maintain low friction coefficient during unlubricated dry sliding in nitrogen for at least 1000 cycles under the test conditions used here. While there appeared to be some improvement in the initial friction coefficient for sliding of silicon dioxide surfaces, the steady-state friction coefficient exhibited only minor improvement with the RF-85 surface treatment. The difference in start-up behavior is likely due to decreased wear particle production in the case of the RF-85 treated surfaces.

Sincerely,

Michael T. Dugger

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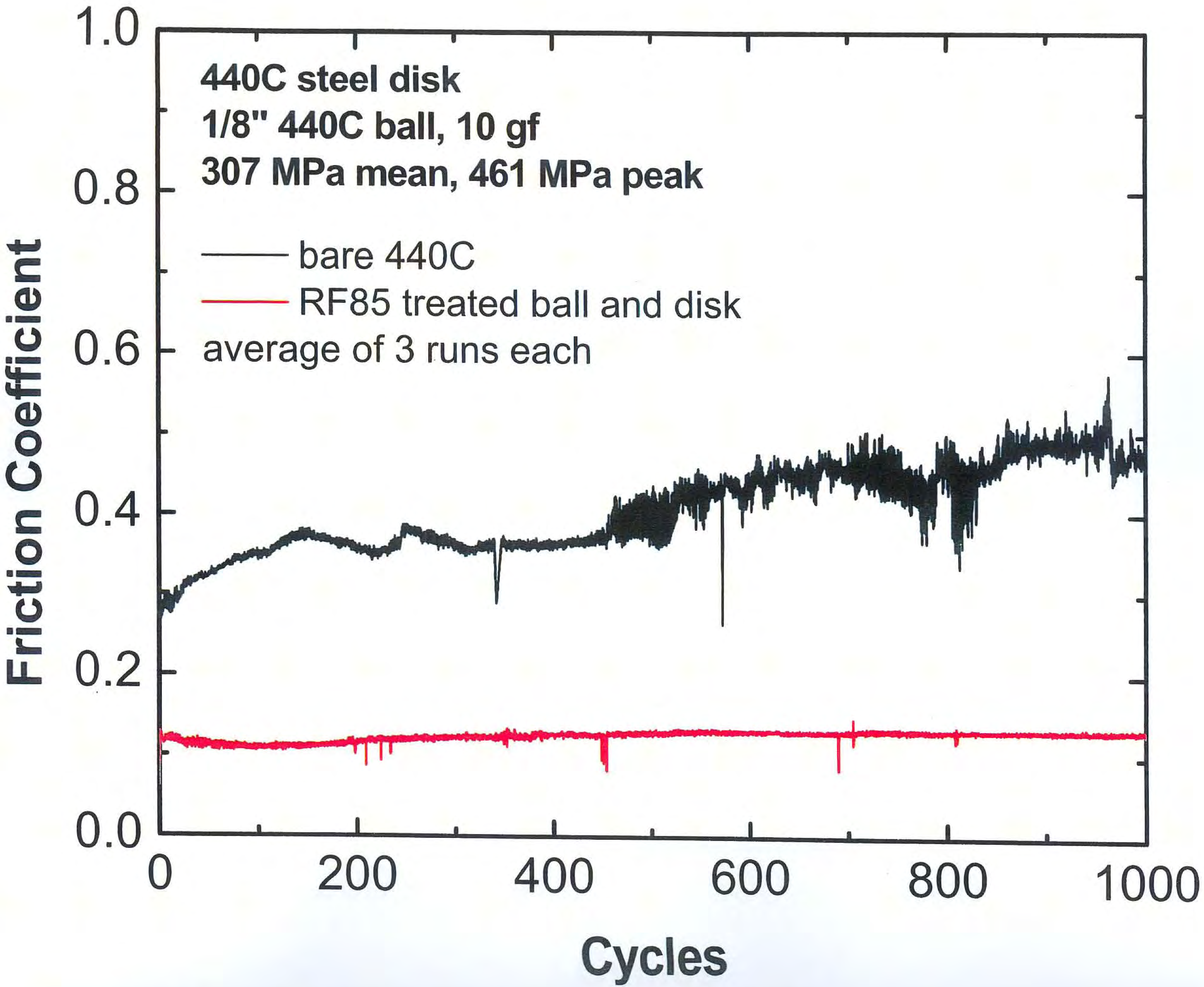
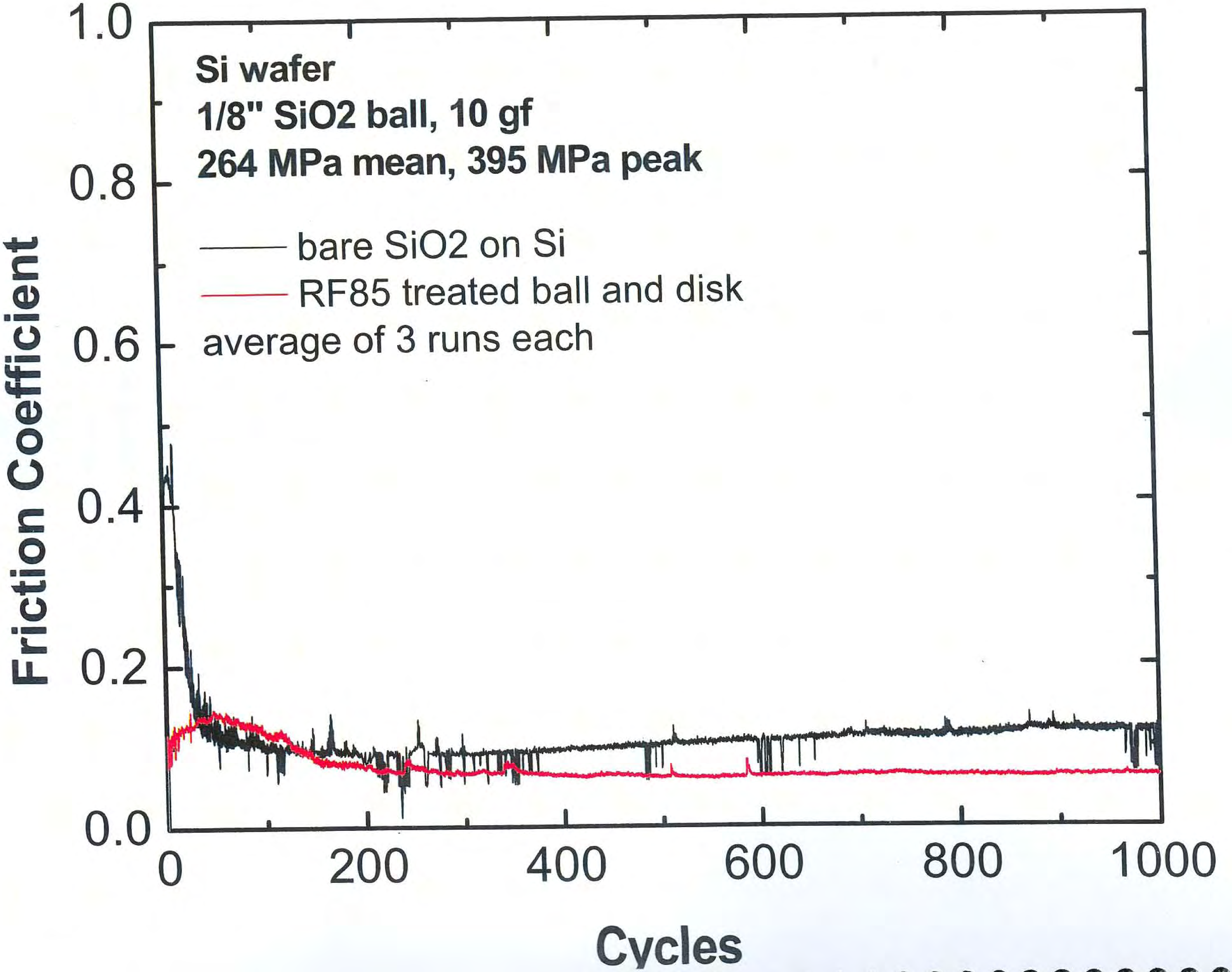

440C steel disk
1/8" 440C ball, 10 gf
307 MPa mean, 461 MPa peak
bare 440C
RF85 treated ball and disk
average of 3 runs each
Friction Coefficient
1.0
0.8
0.6
0.4
0.2
0.0
0
200
400
600
800
1000
Cycles


Si wafer
1/8" SiO2 ball, 10 gf
264 MPa mean, 395 MPa peak
bare SiO2 on Si
RF85 treated ball and disk
average of 3 runs each
Friction Coefficient
1.0
0.8
0.6
0.4
0.2
0.0
0
200
400
600
800
1000
Cycles