https://doi.org/10.1017/S1551929500063215 Published online by Cambridge University Press

Using the Atomic Force Microscope to Measure Roughness Characteristics of Acetabular Prosthetic Shells Used as Hip Socket Replacements

Shilest Jani*, Gary Williams, Dr. Silvio P. Marchese-Ragona and Briggs Christie; TopoMetrix, *Smith and Nephew Richards, Memphis, TN

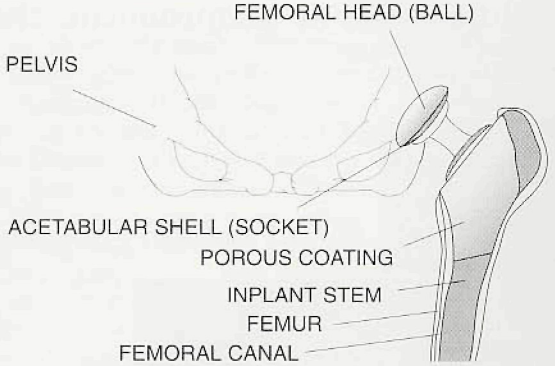


Figure1. Hip Socket Replacement

Total replacement of a diseased or traumatized hip joint is fast becoming one of the most common surgical procedures. The acetabular prosthetic shell is gaining widespread acceptance as a socket replacement for this procedure. Bio-materials research is providing a wealth of information regarding the life span, wear characteristics, and performance of these replacements, with a major clinical finding being the destruction of bone (osteolysis) at interfaces with the implants. Osteolysis is widely thought to be associated with the particulate wear debris released from articulation of the ball and socket. Formation and release of these particulates will depend not only on the relative motion occurring but also on the surface roughness of the replacement materials.

In this study we used the Atomic Force Microscope (AFM) to compare the internal surface topography of two acetabular shells, one polished to a mirror finish and the other unpolished (Figure 2). The ultimate goal of the study was to determine whether a polished shell reduces the amount of wear and tear on the ultra-high molecular weight polyethylene (UHMWPE) insert that is fitted between the shell and the Femoral ball (Figure 1).

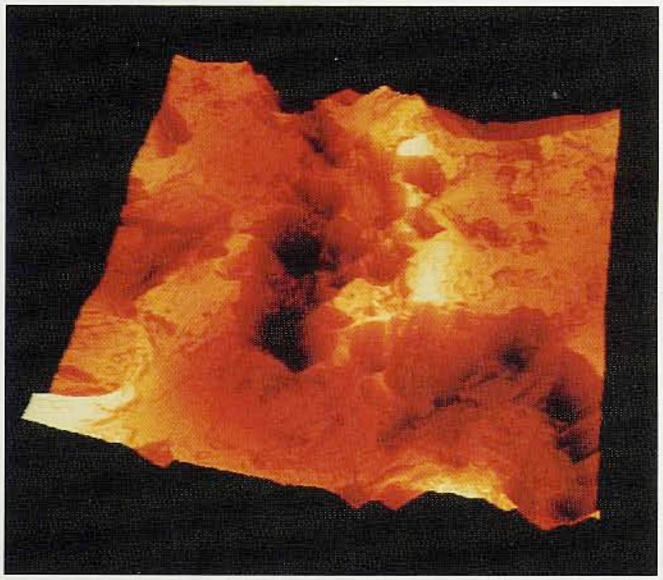


Figure 2. 3-dimensional AFM image of unpolished prosthetic hip replacement. Sample courtesy of BioMet.

The Femoral ball, constructed of either Cobalt-chrome or ceramic, replaces the worn head of the thigh bone and fits into a UHMWPE cup, which replaces the socket. The UHMWPE sleeve fits snugly into the acetabular shell, but experiences friction and abrasion due to the torsion and impact of movement by the human body. Billions of particles of the polyethylene and shell surfaces may be released into the socket area, collecting around the hip to cause potential abrasion and bone loss.

The two types of prosthetic joints used in our comparison were unused Ti 6Al 4v; one was polished and the other was not. As the measurement of nanometer scale roughness characteristics realize increasing importance in the life sciences, the Atomic Force Microscope (AFM) is providing 3-dimensional data, analysis, and imaging capabilities to researchers. The AFM benefits the analysis in the following areas:

- The AFM can accurately measure in 3 dimensions with nanometer resolution
- AFM imaging may be performed in ambient room conditions.
- Analysis software tools are used to acquire and present quantitative information.
- Concave or large surface areas may be sampled and imaged without damage.
- High aspect ratio probes measure height dimension accurately.

Concave surfaces have been difficult to investigate by AFM because of probe geometrics. To overcome this obstacle, a plastic replica was produced (Figure 3) by depositing a drop of liquid nitrocellulose replicating material onto a small area of the clean concave surface of each acetabular shell. Once dry, double-sided tape was gently pressed onto the now solid replica, pulled away from the surface, and placed onto an AFM sample holder.

A high aspect ratio SuperTip™ (10:1 typical) was used to scan both samples at 500 x 500 pixels. Figure 4 shows the line profile of the replica from the unpolished shell and compares the replica line profile from the polished shell (Figure 5) by scaling both to the greater topography of the roughness sample (2957 nm).

- Continued on Page 16

Using the Atomic Force Micrsocope to Measure Roughness Characteristics of Acetabular prosthetic Shells Used as Hip Socket Replacements

(Continued from Page 14)

Figures 4 and 5 also compare topographic views of the surface and quantitative roughness values to numerically characterize the unused surfaces of the differing acetabular prosthetic shells. The unpolished surface measures a total area height dimension of 2918.54 nm compared to only 134.71 nm for the polished surface. Single line roughness measurements and Ra values (average departure from a mean line) from both surfaces also illustrate these differences. AFM examination of similar surfaces after they are removed from service are expected to reveal further information regarding material deterioration.

It is hoped that the quantitative data from these experiments may establish a basis of study that will improve future prosthetic device performance and ensure the highest quality of life for their recipients.

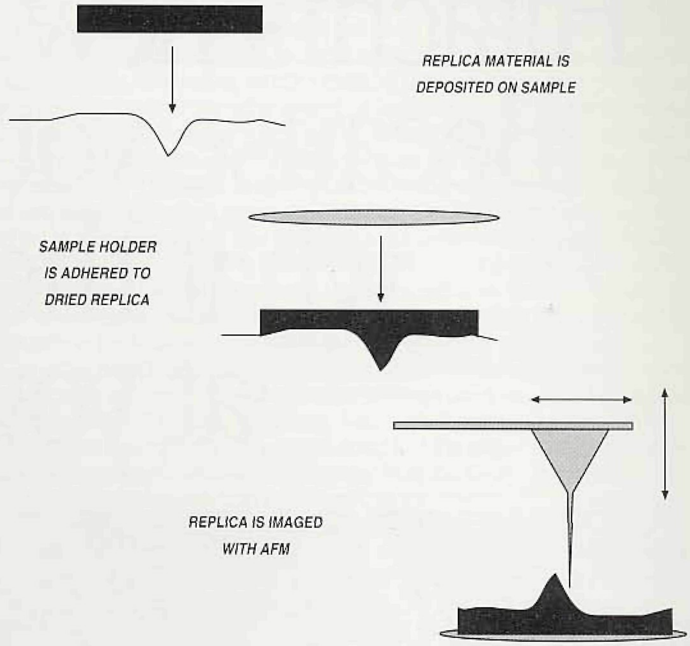
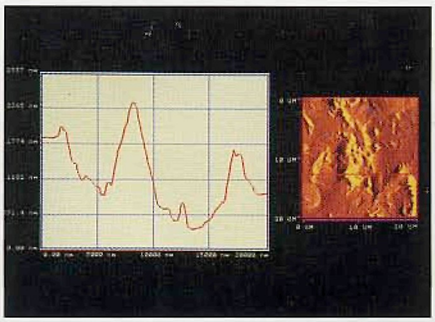


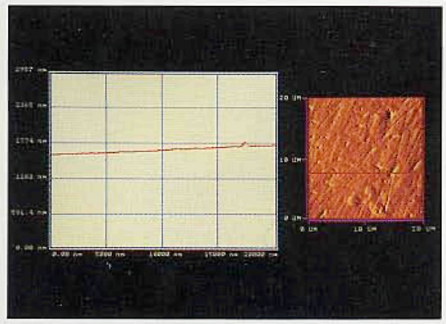
Figure 3. Use of replica for AFM imaging.



Area Roughness	
Ra	337.37 nm
RMS	429.86 nm
Z Avg.	1755.73 nm
Z Max	2918.54 nm

Line Roughness	
Ra	464.86 nm
Rp	864.13 nm
Rpm	499.95 nm
Rt	2294.62 nm
Rtm	1407.32 nm

Figure 4. Unpolished shell line profile, topographic view and roughness values



Area Roughness	
Ra	7.51 nm
RMS	10.33 nm
Z Avg.	36.74 nm
Z Max	134.71 nm

Line Roughness	
Ra	10.59 nm
Rp	97.90 nm
Rpm	34.48 nm
Rt	133.42 nm
Rtm	51.18 nm

Figure 5. Polished shell line profile, topographic view and roughness values

New WinEDS Version 2.0 includes full quantitative analysis software for Microsoft Windows™ 3.1

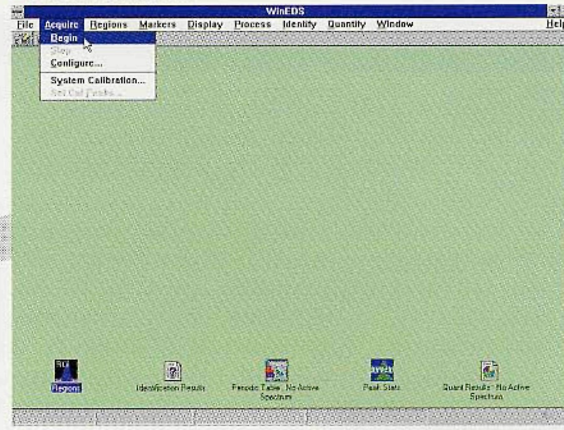
Featuring . . .

- ZAF OR PRZ MATRIX CORRECTION
- AUTOMATIC ANALYSIS SETUP
- FAST!!! - 10 ELEMENT ANALYSIS UNDER 0.5 SEC
- CUT AND PASTE RESULTS INTO YOUR FAVORITE WINDOWS™ WORD PROCESSOR

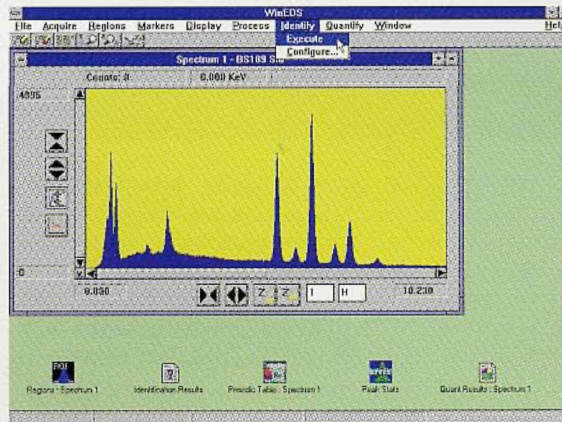
Quantitative results can be quickly printed or pasted into your favourite Word Processor.

WinEDS version 2.0, the latest upgrade of the affordable PC analysis system for Microsoft Windows™ 3.1 now includes full quantitative analysis. Choose from ZAF or PRZ matrix corrections. Our exclusive WinEDS Automatic Analysis Setup intelligently configures analysis parameters according to the elements identified. Quantitative results are only a few quick mouse clicks away! WinEDS will even automatically determine common oxide formulas for mineral analysis. WinEDS Version 2.0 also features the fastest spectral scrolling in its class, vastly superior to most so called mainframe analysers.

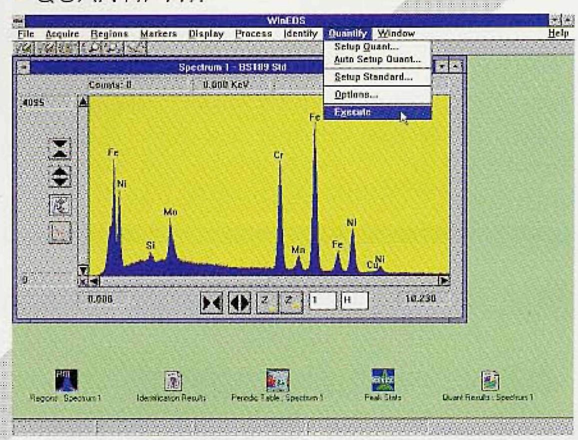
ACQUIRE…



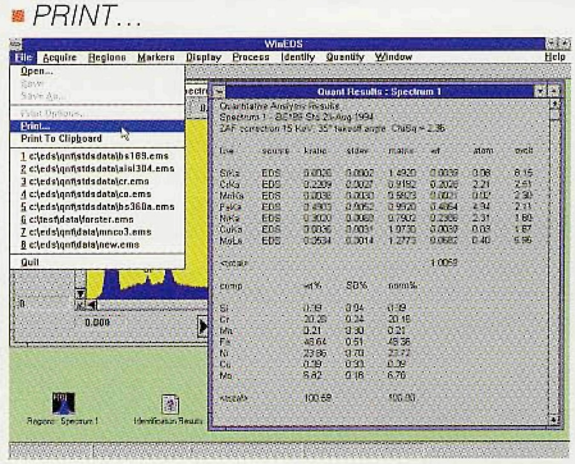
IDENTIFY…



QUANTIFY…



PRINT…



WinEDS VERSION 2.0

HIGH PERFORMANCE XRAY MICROANALYSIS

THOMSON SCIENTIFIC INSTRUMENTS PTY LTD
216 DRUMMOND STREET, CARLTON, 3053, VICTORIA, AUSTRALIA.
TELEPHONE: (03) 9663 2738 FAX: (03) 9663 3680

USA AGENT
EVEX ANALYTICAL INSTRUMENTS INC.
PRINCETON, NJ (908) 874-3800 FAX (908) 874 4647

Circle Reader Inquiry #9

USED EQUIPMENT FOR SALE

✓ VG-501 Field Emission STEM with high excitation objective lens, bright and dark field detectors, cold stage, microdiffraction scan coils, magnetic-sector EELS. Purchased in 1984. C.L. Foiles: (517)355-9713 or eMail Poiles@msupa.pa.msu.edu

✓ MILITARY RESEARCH LAB IS CLOSING - Military contractor is sell at drastically reduced prices its Sorvall MT-2B ultramicrotome, several Bausch and Lomb stereo microscopes and a Joyce Loebl (Mdl. 3C) and Perkin Elmer (Mdl. 1010G) microdensitometer for measuring minute differences in density changes. For spec. sheets call (202)544-0836.

✓ JEOL 100C with Kevex 7000 Spectrometer. Also Philips/EDAX 9100/60 X-ray microscope spectrometer. **Must Sell! Best Offer!** (601)264-9760

EMPLOYMENT OPPORTUNITIES

✓ **Sales and Application Support Specialist.** Immediate opening with manufacturer of digital cameras for microscopes. Provides technical support, demonstrates product, and helps develop sales and marketing materials. Requires B.S. degree in related field plus knowledge of microscopy, computer image acquisition, processing and output. Fax qualifications and resume to Leaf Systems Inc., Human Resources Dept., Fax: (508)460-8304 or mail to 250 Turnpike Road, Southborough, MA 01772.

✓ METALLURGICAL ENGINEER - Five years minimum experience in ferrous metallography, including extensive SEM/EDS expertise. Contact Rockwell Automotive, 2135 W. Maple, Troy, MI 48084. Atten: David Donegan.

✓ TECHNICAL CUSTOMER SERVICE & SALES - Immediate opening for qualified individual in the instrument sales division of our company. Experience with light microscopes required. Fax qualifications and resume to McCrone Accessories & Components: (708)887-7764)

JEST
For the Fun of it!

1. Indecision is the key to inflexibility.
2. You can't tell which way the train went by looking at the track.
3. There is absolutely no substitute for a genuine lack of preparation.
4. Happiness is merely the remission of pain.
5. Nostalgia isn't what it used to be.
6. Sometimes too much drink is not enough.
7. The facts, although interesting, are irrelevant.
8. The careful application of terror is also a form of communication.
9. Someone who thinks logically is a nice contrast to the real world.
10. Things are more like they are today than they ever were before.
11. Anything worth fighting for is worth fighting dirty for.
12. Everything should be made as simple as possible, but no simpler.
13. Friends may come and go, but enemies accumulate.
14. I have seen the truth and it makes no sense.
15. Suicide is the most sincere form of self-criticism.
16. If you think there is good in everybody, you haven't met everybody.
17. All things being equal, fat people use more soap.
18. If you can smile when things go wrong, you have someone in mind to blame.
19. One-seventh of your life is spent on Monday.
20. By the time you make ends meet, they move the ends.
21. Not one shred of evidence supports the notion that life is serious.
22. The more you run over a dead cat, the fatter it gets.
23. There is always one more imbecile than you counted on.
24. This is as bad as it can get, but don't bet on it.
25. Never wrestle with a pig. You both get dirty and the pig likes it.
26. The trouble with life is that you're halfway through it before you realize that it's a "do it yourself" thing.
27. Never try to teach a pig to sing. It wastes your time and it annoys the pig

Credit and thanks to Enna Jettik, Hustle Miccroscope Supplies, for the above.