Stiction/Friction/Durability:

The Thin Film Media Plague

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Remarks on

STICTION/FRICTION/DURABILITY SOLUTIONS

FOR THIN FILM MEDIA

by

Don Mann

Dennis Waid suggested that this year instead of giving you the usual welcoming remarks, that I should instead tell you how to solve stiction/friction problems for thin film media once and for all.

I thought that was quite a complement until I found out that Dennis had already asked six thin film media manufacturers to tell how they have solved stiction/friction and they all declined. Since there are only six thin film media manufacturers that are shipping, that leaves me.

The stiction/friction problem is currently falling on the backs of the thin film media manufacturer and some of them are really struggling with this issue. I don't really understand why the head companies and the disk drive manufacturers haven't helped more. And, I hope we learn more about that here today.

In fact, thin film heads have made the stiction/friction problems worse; not better. It seems to me that there are some real opportunities for the head and disk drive companies to provide a part of the solution and achieve lower costs all around.

Now, it is actually easier to tell you about stiction/friction solutions that don't work than to define those that do. So I will start there.

In fact, in doing research for this talk, I discovered that there actually are only two problems to be solved:

One is:

"Media manufacturers make a lot of disks that have poor stiction/friction and they don't know why".

The second problem is:

"Media manufacturers make a lot of disks that have very good stiction/friction and they don't know why".

Stiction/Friction Maze - Figure 1

Most of us have probably been trapped in the stiction/friction maze at some time or another and have found out that you cannot solve stiction/friction by blindly going down a single minded path.

For example, surface lubrication looked like the solution; so we went down that path with blinders on and it started out pretty good. The initial friction and friction build up was better. But, with time contamination developed either in the manufacturing process or in the drive and high stiction was the result.

So we backed out of that dead end and went down the path of a rougher texture and that provided good friction and some immunity to contamination but friction build up and contact start/stops were poor and defects were a major problem.

Most textures today are still not in control and are the cause of poor yields.

Some then went down the kiss buff path which provided good glide, good head flight but failed build up because the surface was too smooth.

Then the buzz word became diamond like carbon for better build up and better durability and many have gone down that path. But is not done right, you will sacrifice yields and cost.

So one reason we still have stiction/friction problems with us today is that we tend to go down a single minded path until it blows up. And, it takes a while to realize that all of the paths on the stiction/friction maze are good solutions when each is considered a part of the overall system.

Lube/Carbon/Texture System - Figure 2

So, the first rule toward solving stiction/friction is to consider the lube, the carbon and the texture as a system.

Circle the wagons.

The stiction/friction problem can be contained if the lube, the carbon and the texture are matched to each other.

Why Has Stiction/Friction Been Such A Problem? - Figure 3

The reason is because we are playing with how many angels can dance on the end of a pin.

Consider that only 10 angstroms change in the disk texture can cause stiction/friction failure; and, only 10 angstroms of unwanted lube, contamination or moisture can cause stiction/friction failure.

In other words, a difference of only 10 angstroms can be the problem that causes stiction/friction failure.

Stiction/Friction Model - Thin Film Media - Figure 4

This next slide shows what I mean by the 10 angstrom problem and it is the stiction/friction model that I promised you.

This slide is plotted from actual data that I have accumulated over the past two years.

The ordinate, or vertical axis, is the coefficient of friction plotted as a function of the thickness, in angstroms, of typical disk surface additives such as lube, contamination and moisture.

A friction coefficient of 0.1 is very acceptable; while a coefficient of 1.0 is very unacceptable. Notice that surface roughness is a parameter here for three different disks. One with a 20 angstrom texture; one with a 40 angstrom texture; and, one with a coarser, 60 angstrom texture.

Now lets take just one example. Consider the disk that has an arithmetic average for texture roughness of 40 Angstroms.

Assume that there is supposes to be 35 angstroms of lube on that disk and if later 10 angstroms of contamination plus 10 angstroms of moisture are added in the disk drive, then that disk will fail stiction/friction.

Because, now there is 55 angstroms of stuff on the disk and the head will stick to it. A 40 angstrom texture cannot support 55 angstroms of additives on the surface.

Another way to use this model is to hold the lube plus contamination plus moisture constant at 35 angstroms. And, specify your texture to be 40 angstroms.

No problem until the texture process suddenly starts producing a 30 angstrom surface instead of the desired 40.

Now, the disk doesn't work anymore because there are 35 angstroms of stuff on a 30 angstrom texture. And, you probably wont even know it until a lot of disks have been produced.

A simple Dektak or mechanical profilometer will not show a 10 angstrom reduction in texture roughness.

How Big (Small) Is An Angstrom Anyway? - Figure 5

I said earlier that we are playing with how many angels can dance on the head of a pin.

Well, 10 angstroms is about the size of one angel.

The information on this slide was provided by the American Scientific Library and has been reproduced here to scale to show you just how small an angstrom is.

It is 10 angstroms from one edge of this slide to the other.

The three hydrogen atoms bonded to the single carbon atom are shown to scale in relationship to the 10 angstrom dimension.

In other words, 10 angstroms is about the size of 5 carbon atoms laying side by side.

Yet I can tell you for sure, that a <u>10 angstrom increase in lube thickness,</u> or <u>10 angstroms more contamination</u> or <u>10 angstroms less texture can cause stiction/friction failure.</u>

<u>Texture Quiz</u> - <u>Figure 6</u>

Now its time for the texture quiz.

From the standpoint of stiction/friction which disk do you think works best, Brand "A" or Brand "B"?

This view of a thin film disk surface was taken by a WYKO optical profilometer using digitized light interference patterns with a field of view of 20 mils by 20 mils and a vertical resolution of three angstroms.

Brand "A" looks a lot nicer and has a coarser texture of 70 angstroms in the radial direction.

Brand "B" looks like a ploughed field and is actually smoother in the radial direction with a 50 angstrom texture.

OK make your choice of which disk you think is the best while I change slides.

<u>Texture Quiz Answer</u> - <u>Figure 7</u>

How many picked brand "B"?

Brand "B" is best because although it is smoother in the radial direction it is much coarser in the tangential direction and presents less surface area to the head.

Note that a radial measurement by a mechanical profilometer would never have found this difference.

Both of these disks; brand "A" and brand "B" are commercially available but the brand "B" disk is qualified for stiction/friction by nearly all the drive manufacturers.

The brand "B" disk is also much more immune to secondary contaminants produced by a disk drive.

So, in analyzing your disk texture you must take into account the roughness in at least two directions with equipment that can measure a large zone with a vertical accuracy of at least five angstroms.

What Does It Take To Solve Stiction/Friction? - Figure 8

So what does it take for a thin film disk manufacturer to solve stiction/friction?

It takes a minimum of a one year time commitment spent in relentless pursuit of a system solution.

You have to find the correct combination of carbon, lube and texture through many, many designed experiments and at a cost of typically 1.5 million dollars.

Specifically What Must Be Considered? - Figure 9

Carbon

How does your carbon grow? The carbon grows epitaxially so the magnetic underlayers will effect stiction/friction as well as hardness and hydration.

It is important to find the correct level of hydration for your carbon. Either too little or too much moisture in the carbon can cause high friction.

The carbon thickness, number of targets and if you use a corrosion inhibitor strongly effects durability.

Texture

The radial texture roughness vs the tangential texture roughness must be considered with coarseness vs defects the primary tradeoff.

The smoothing effects of kiss buff and carbon fill in must be considered.

The burnish - lube sequence is an important consideration.

Each of these texture considerations require a lot of designed experiments to achieve the correct combination.

Lube And Other Stuff On The Disk Surface

Lube thickness control to within 5 angstroms is required.

Wettability, migration and contamination control are all tied in together. Wettability is largely determined by how well you control the disk's environment prior to lube.

A point here to remember is that all grades of Freon contain some amount of hydrocarbon contamination; usually around wave number 2400 by FTIR measurement.

Also remember that all disk drives, especially at high temperatures, will contaminate the disk to some extent and your particular carbon, texture and lube combination must be able to tolerate it.

How Do You Solve Stiction/Friction? - Figure 10

Now to tie all this together I will give you an example of a stiction/friction solution.

Carbon

For the carbon, use 3 targets to get 200 Angstroms of total carbon thickness at a working gas pressure of 5 millitorr. Find the best hydration point for the carbon by experiments and use Chromium interspersed within the carbon as a corrosion inhibitor.

Texture

The texture roughness could be 60 angstroms radial and 35 angstroms tangential with kiss buff topology. Carbon fill in shields should be used in the sputter process.

Lube

The lube should be an inert fluorocarbon put on in a modified drain tank with the disk environment tightly controlled prior to lube.

The Bad News - Figure 11

Now that you know how to solve stiction/friction/durability, I'm afraid I have to tell you the bad news.

The bad news is:

"The stiction/friction/durability problems are going to get worse."

Lower head flying heights require sliders with smaller air bearing surfaces which creates higher pressure per unit area on the disk which accelerates the durability problem.

The higher bit density requirements require smoother media which greatly increases the disk sensitivity to lube, texture and contamination and stiction/friction gets worse.

The Good News - Figure 12

But, the good news is:

"Whoever solves stiction/friction/durability for thin film media once and for all owns the market be it for media, heads or disk drives".

Thank you very much!

FIGURE 1

Thin Film Media Stiction/Friction/Durability Solution Maze

Enter at your own risk!

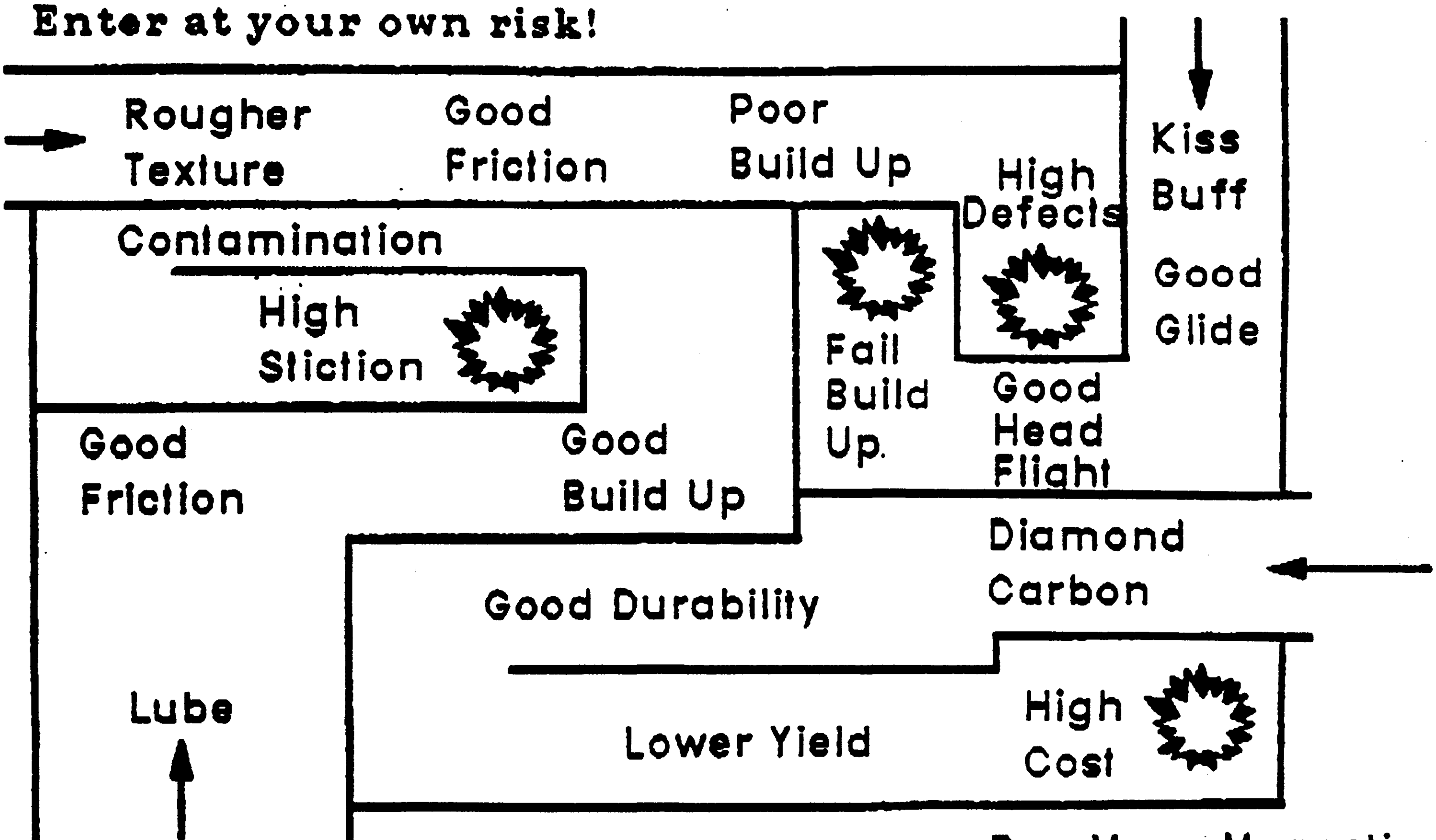

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FIGURE 2

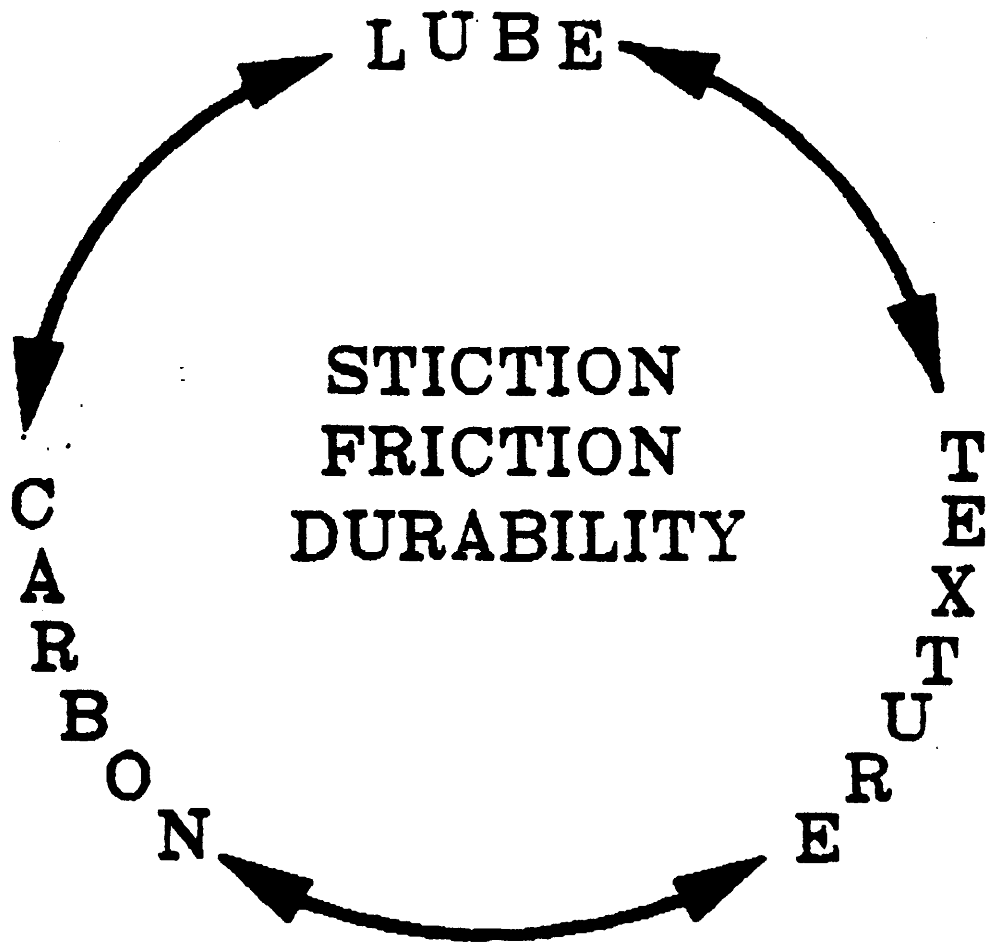

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FIGURE 3

Why Has (Is) Stiction/Friction Plagued Thin Film Media?

Because:

1. Only 5 to 10 angstroms change in disk surface topology can cause stiction/friction failure.

2. Only 5 to 10 angstroms of additional lube or contamination or moisture can cause stiction/friction failure.

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FIGURE 4

Stiction/Friction Model
Thin Film Media

Surface Roughness - A Parameter

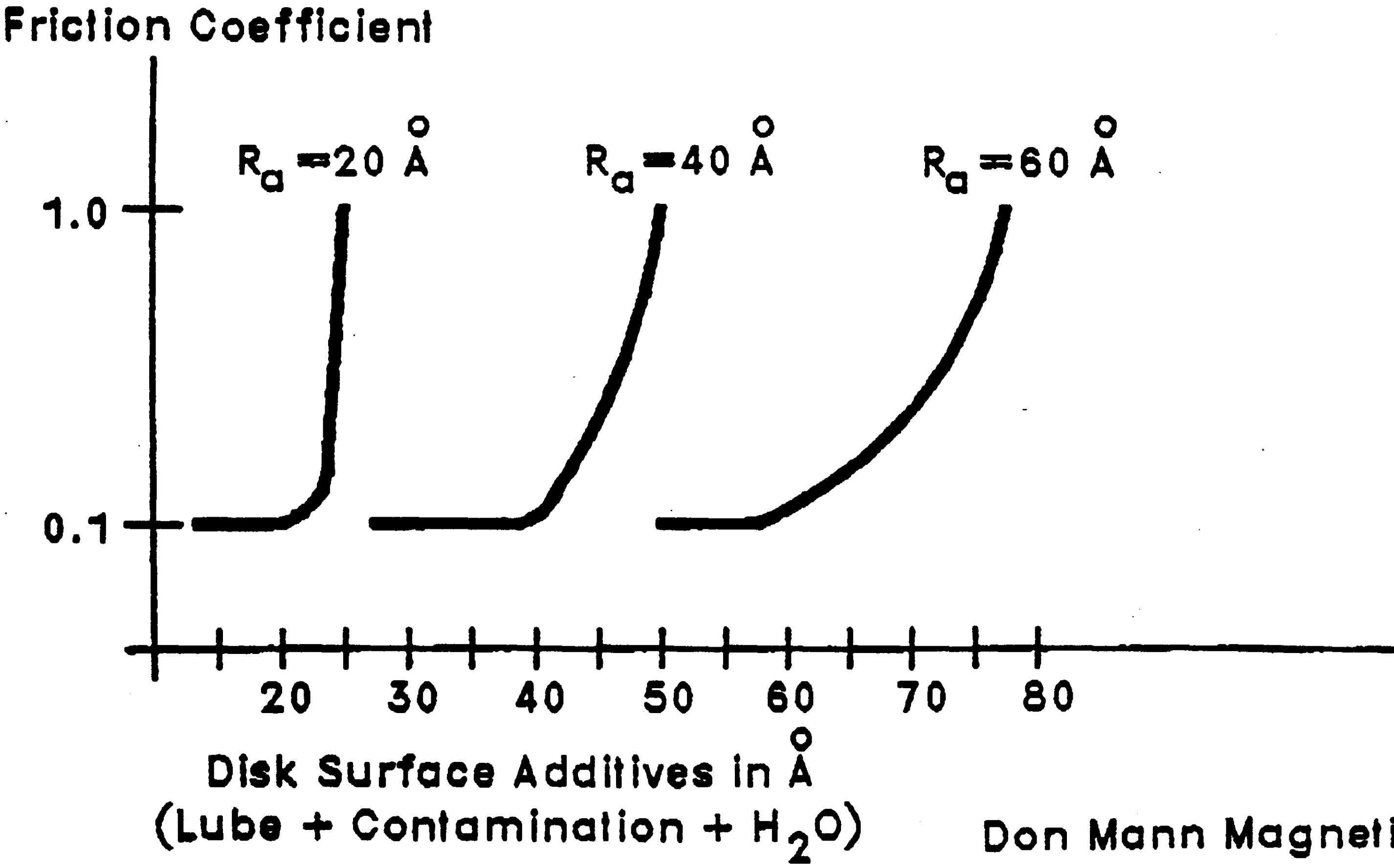

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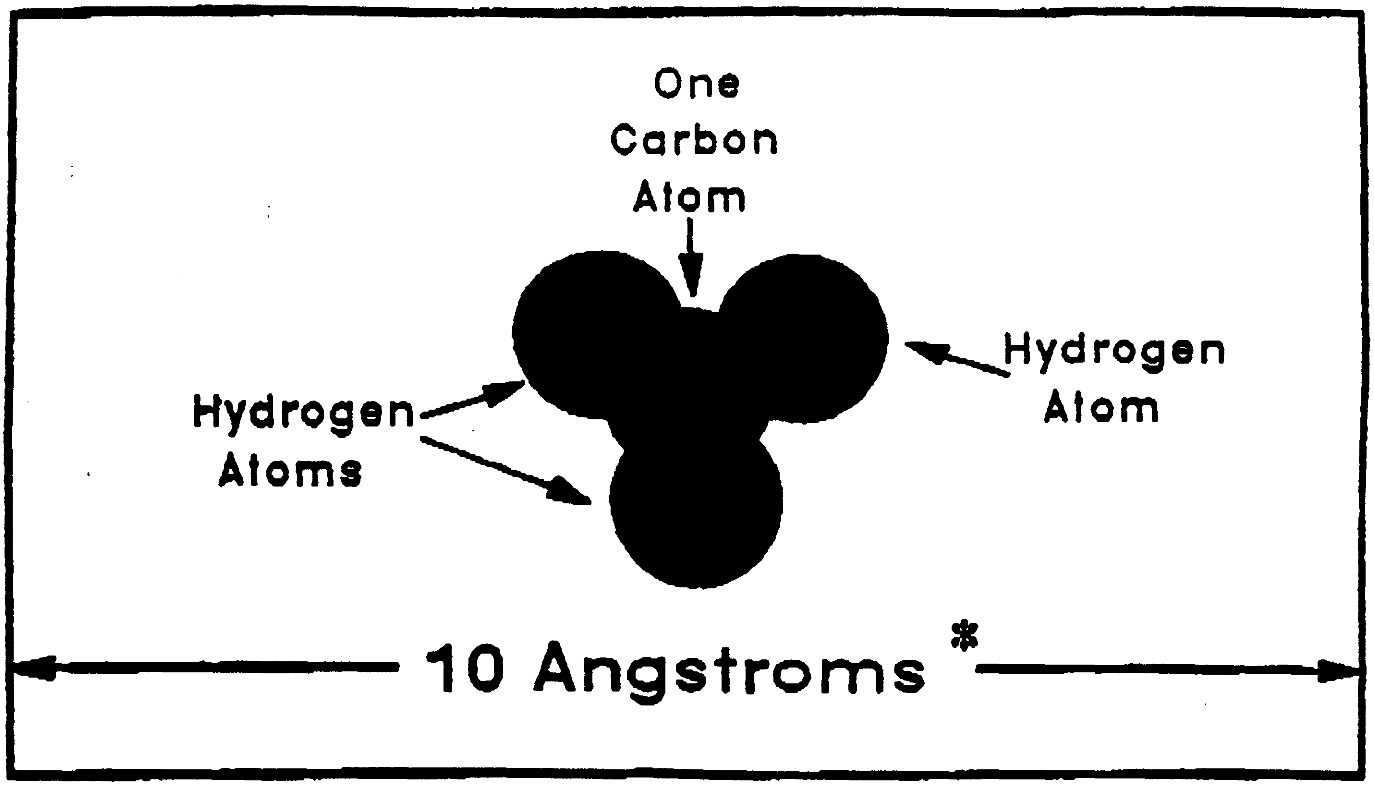
FIGURE 5

How Big (Small) is 10 Angstroms?



* 10 Angstrom scale and size of atoms furnished
by Scientific American Library

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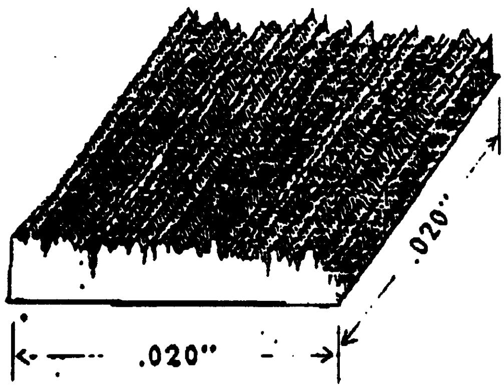
FIGURE 6

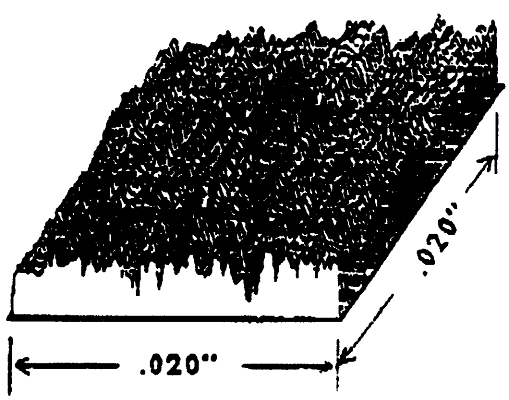
Texture Quiz



Brand A ?

Ra=70 Å

OR



Brand B ?

Ra=50 Å

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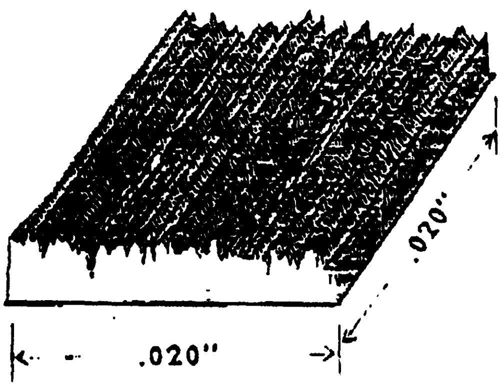
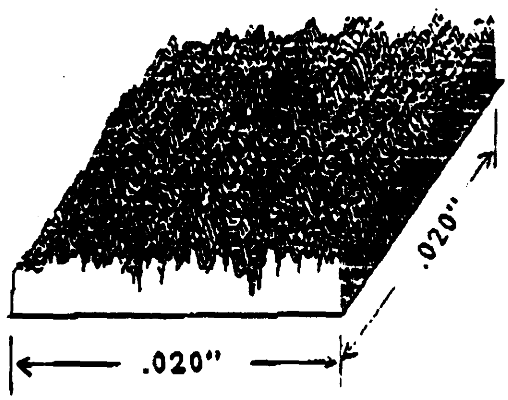
Texture Quiz



Brand A ?

- Ra=70 Å (Radial)
- Ra=15 Å (Tangential)



Brand B ?

- Ra=50 Å (Radial)
- Ra=35 Å (Tangential)

BEST !

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FIGURE 8

What Does It Take to Solve (Control) Stiction/Friction/Durability ?

Typical:

- One year minimum time committment
- Relentless pursuit
- System solution
- Correct combination of carbon/lube/texture
- Many, many designed experiments
- $1.2 to 2.0 million dollars

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FIGURE 9

What Must Be Considered:

Carbon:

- How does your carbon grow?
- Hardness & hydration?
- Thickness, number of targets, & corrosion inhibitor?

Texture:

- Roughness-radial vs. tangential ?
- Topology-kiss buff & carbon filled?
- Burnish-lube sequence?

Lube and other stuff on surface:

- Thickness control?
- Wettability/migration?
- Production contamination & future contamination immunity?

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FIGURE 10

Specifically, How Do You Really Solve (Control) Stiction/Friction/Durability?

Carbon:

- 3 targets- 200 angstroms thickness- 5 mtorr
- Controlled hydration
- Interspersed chromium corrosion inhibitor

Texture:

- Ra= 60 angstroms radial; Ra= 35 angstroms tangential
- Kiss buff topology & carbon fill in shields

Lube and other surface blights:

- Inert fluorocarbon; Drain tank with modifications
- Controlled environment prior to lube

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FIGURE 11

The Bad News Is: Stiction/Friction/Durability Problems Are Only Going to Get Worse.

Lower flying heights	Higher bit densities
Smaller ABS	Smoother media
Higher pressure head	Greater sensitivity to lube/texture/contamination
More durability problems	More stiction/friction problems

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FIGURE 12

The Good News Is:

Whoever Solves Stiction/Friction/Durability Owns the Market!

- Media
- Heads
- Drives

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