VLBA ACQUISITION MEMO #327

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To: VLBA Data Acquisition Group

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Subject: A physical model for the effect of relative humidity on edge contact deposits

Motivation

It is now clear that high humidity is a major contributor, if not the sole cause, of deposits which eventually lead to edge damage of tapes run at high speed. A physical model may be useful in controlling the problem.

Layers of water molecules

While it is well known that a film of water forms on a surface when the RH reaches 100% (the dew point) it is less well known that invisible layers of water form at lower humidities. Figure 1 (taken from the Handbook of Thin Film technology edited by Maissel and Glang) shows the surface resistance of various substrates as a function of the relative humidity. The resistance variation is explained by the formation of layers of water molecules on the surface with a monolayer (single molecular layer) being formed at between 30 and 40% RH building up to about 10^4 layers at 90% RH. Depending on surface energies involved, the tape edge and/or the edge bearing surfaces are probably coated with these films of water. [The tape abrasivity (head wear) is noted to have a humidity dependence that follows a curve with humidity that looks similar to the curve of surface conductance.]

Time constant for layer formation and evaporation

For an evaporation rate of 10^{-4} g cm^{-2}s^{-1} a single molecular layer of 3 x 10^{-8} cm thickness is lost or gained in 300 μsec which is short enough that the number of layers of water on the tape edge will be entirely determined by the RH of the air in the vacuum column area and will not depend on the water stored in the tape pack.

Model for deposition of sticky layer

Where the edge contacts the precision plate alumina inserts and front door the layers of water and their contaminants will be stripped off and adhere to the fixed surface. The amount of this deposit will depend on the humidity and the length of tape run through the transport. The volume of deposit is given by

$$Vdnaf \sim 1.4 \times 10^{-3}\ cm^3\ per\ hour$$

where V = tape velocity (8m/s ~ 3 x 10^4m/hour)
d = tape thickness (16µm)
n = number of molecular layers (assume 10)
a = thickness of monolayer (3 x 10^{-10}m)
f = fractional contaminant volume carried by each water molecule (assume 1)

Some qualitative observations in support of this model

1] "Film like" deposit is formed in region following edge contact area - see Figure 2. [The total extent of this deposit generated in 18,000 feet of travel at 50% RH was estimated to be about 10^{-5} cm^3.] The hypothesis is that this film increases the friction of the edge bearing surfaces and also insulates the surfaces which in turn leads to very heavy deposits and melting when the tape is run at high speed.

2] Film deposit depends only on RH in vacuum column area. Applying heat in this area to reduce RH to under 30% completely eliminates deposit formation.

3] In very high RH environment (~ 70 - 100%) a similar deposit if formed without tape motion in all areas where there is air leakage between the tape edge and the edge bearing surfaces. [Presumably in this case the contaminants are those which occur naturally in the air.]

Method of elimination of harmful deposits

Always operate the transport in an environment with RH < Rhcritical or heat deck plate to reduce RH in the vacuum column area to under Rhcritical. At this time Rhcritical is thought to be between 30% and 40%.

More work to be done

1] Determine chemical nature of deposits to find the origin of the contaminants which form the film.

2] Determine the critical RH for formation of water layers on the tape edge more accurately. [Perhaps a literature search will give us the answer. Other possibilities are a) better determination RH for zero deposit, b) perform surface resistivity measurements.]

3] See if the nature or quantity of deposits depend on the tape type or condition [Initial tests suggest that the "film like" deposit formation does not depend on the tape.]

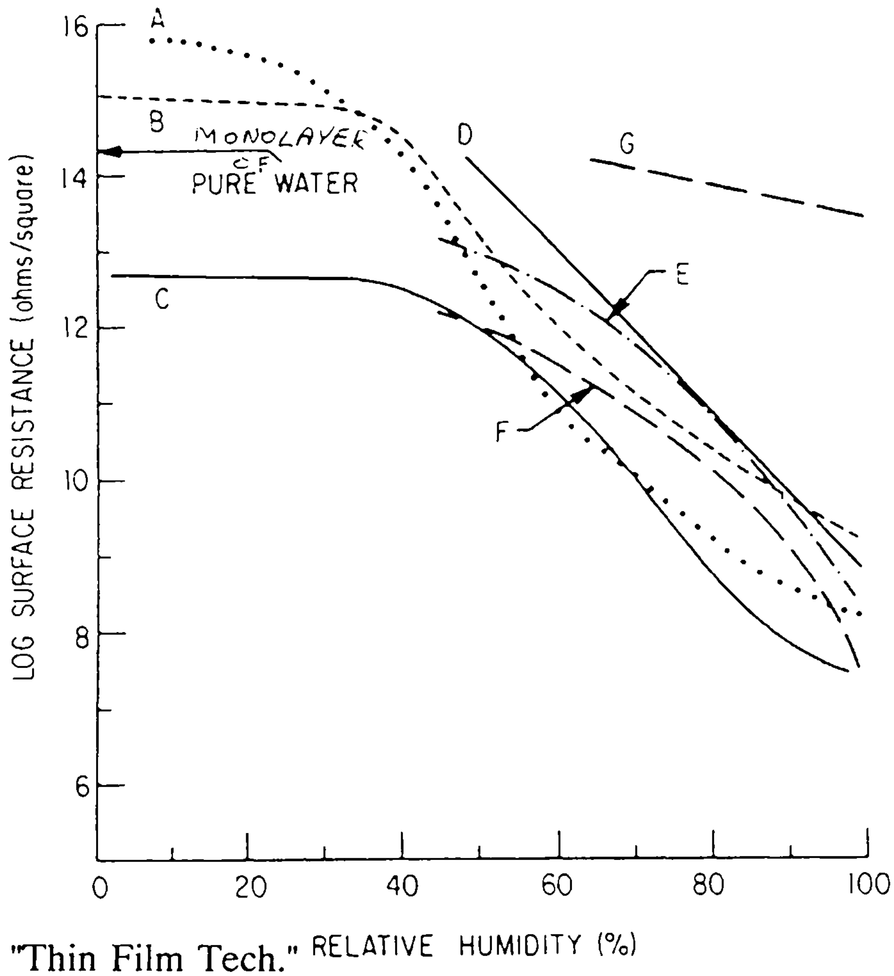

Figure 1 - From "Thin Film Tech."

Fig. 16 Surface resistance of various substrate materials as affected by relative humidity. *A* = fused silica; *B* and *E* = borosilicate glasses; *C* = soft glass; *D* = aluminosilicate glass; *F* = 99.5% alumina; *G* = silicone-coated borosilicate glass. (*Curves A, B, C, and G from Guyer,*[57] *courtesy of IEEE.*)

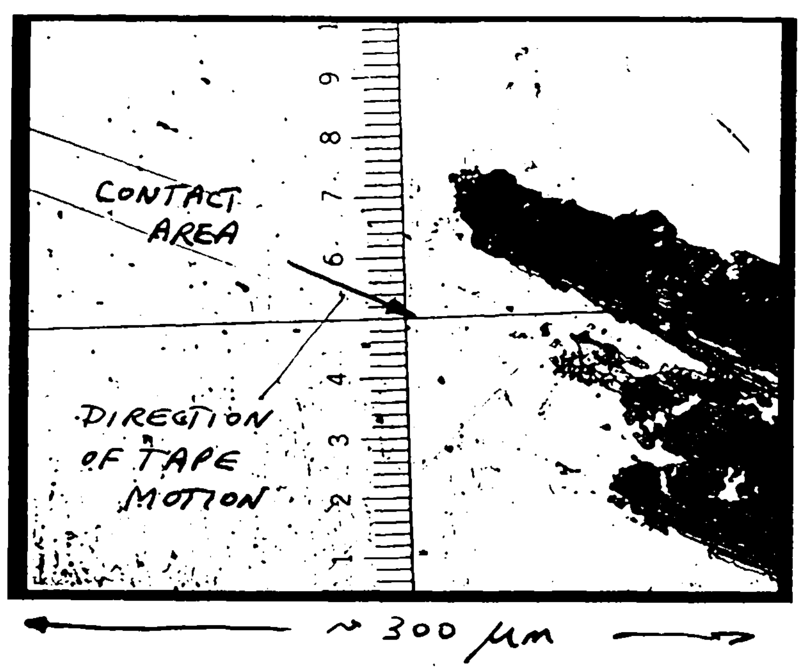

Figure 2 Deposits at 50% RH