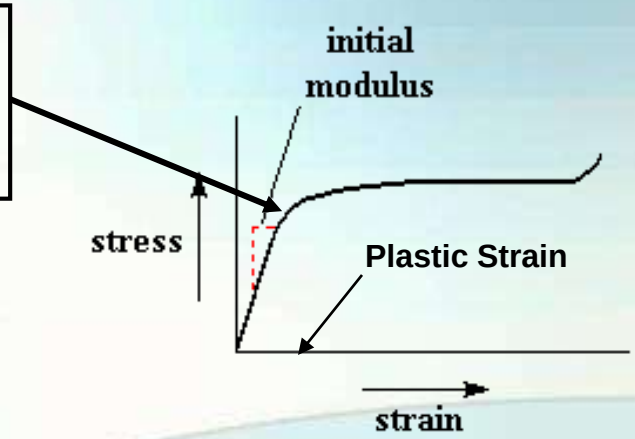
Super Durable Cover Lens Film

Richard Pokorny, Michelle Toy, Elisa Cross, Steven Solomonson
3M, St. Paul, MN, USA

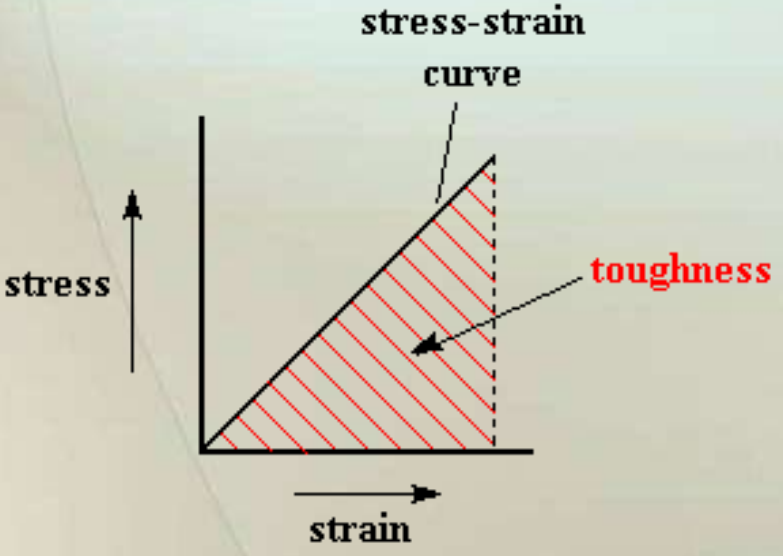
Scratch Resistance and Stress Strain Curves

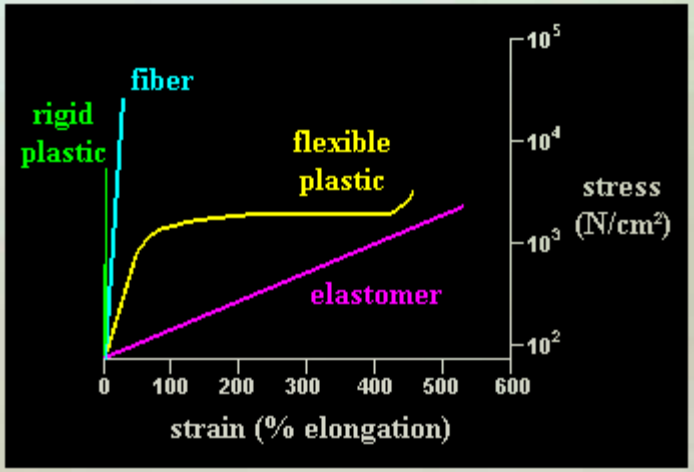
Force required for permanent deformation



Scratch Resistance is related to G_{sr} (storage modulus) and S_{pls} (Plastic Strain)

After Odian, George; *Principles of Polymerization, 3rd ed.*, J. Wiley, New York, 1991, p.34.





After Odian, George; *Principles of Polymerization, 3rd ed.*, J. Wiley, New York, 1991, p.34.

Automotive Scratch Damage Occurrence

1. Mar- 75%
2. Rough Trough- 15%
3. Crack- 6%
4. Delamination- 3%
5. Chipping- 1%

Increasing Z Axis Force or speed

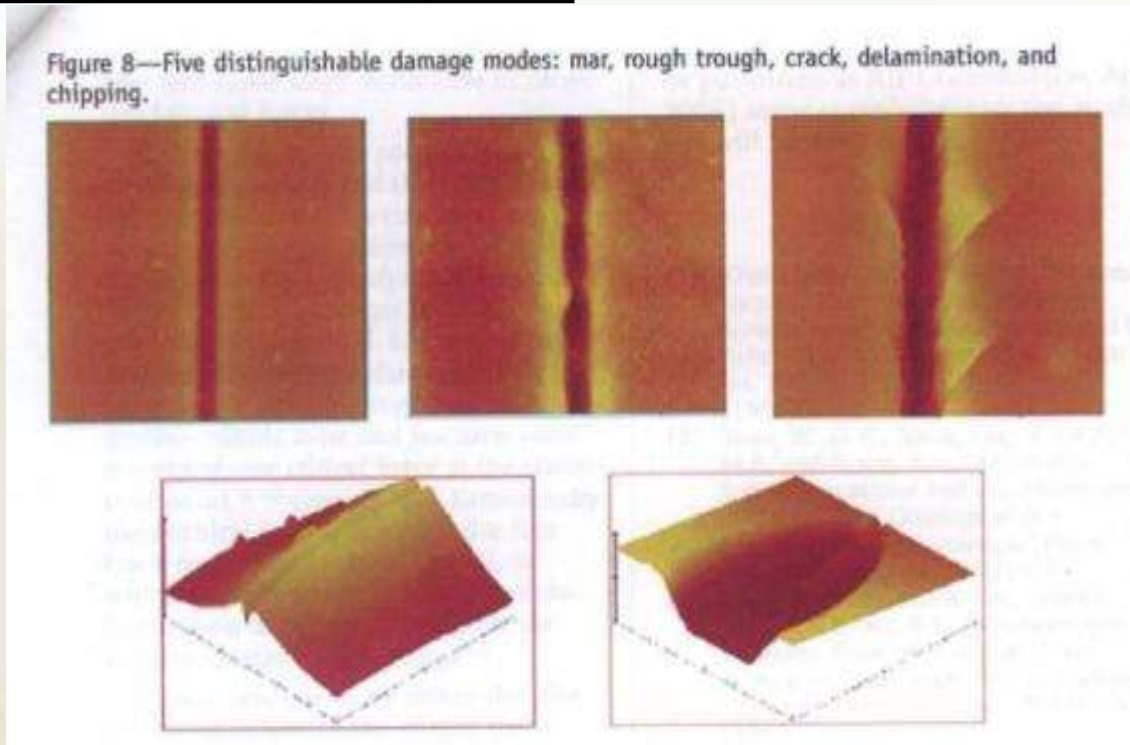
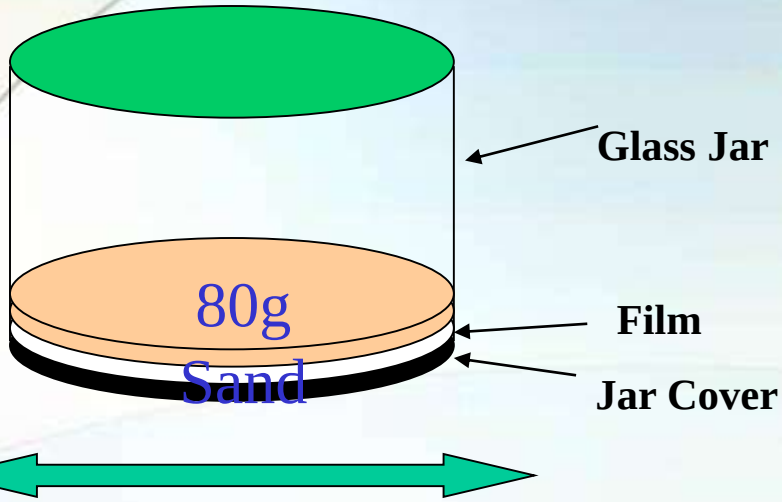


Figure 8—Five distinguishable damage modes: mar, rough trough, crack, delamination, and chipping.



Sand Abrasion-

Low z axis force

Taber Linear Abraser

Medium z axis force

Pencil hardness

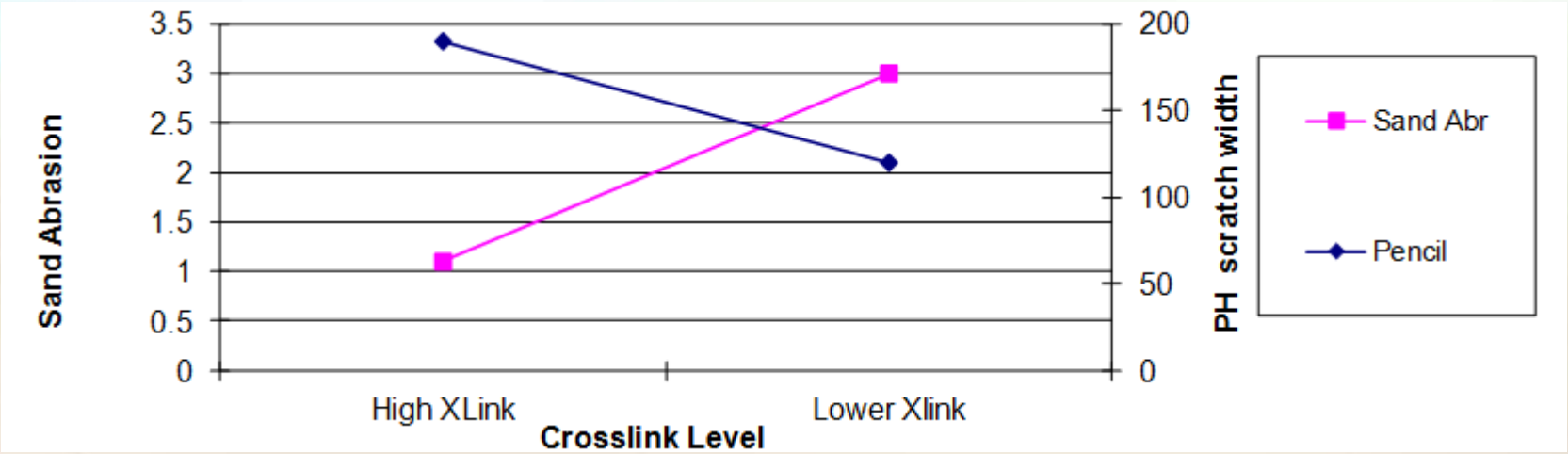
Very high z axis force

A Taber Abrader

Medium z axis force

Hard Coat Performance

Different hard coat formulations give different rankings in tests with different z axis force. This is due to varying failure modes. High z axis forces can lead to cracking and chipping of brittle coatings. Since they have such a high modulus these same coatings can do well in a low z axis force test



- Sand Abrasion (delta haze) and
  Pencil Hardness (scratch width, microns)

Super Durable Hard Coat

Goal is to replace glass cover lens with a hard coated plastic lens. This will enable thinner, lighter, more durable displays.

Cover Lens Film Requirements

Needs to be glass-like in terms of

1. Abrasion Resistance
2. Appearance
3. Touch- Friction- “haptics”
4. Stiffness

But also:

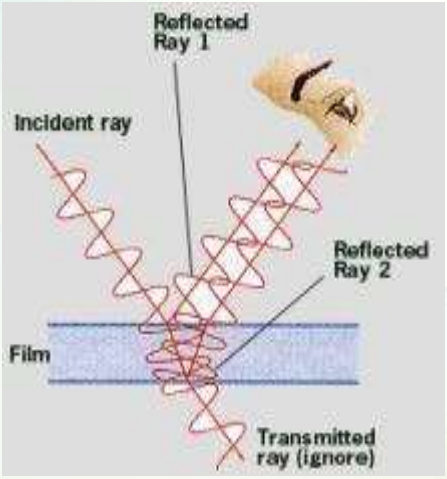
1. Flexible
2. Light weight
3. Shatterproof
4. Thin

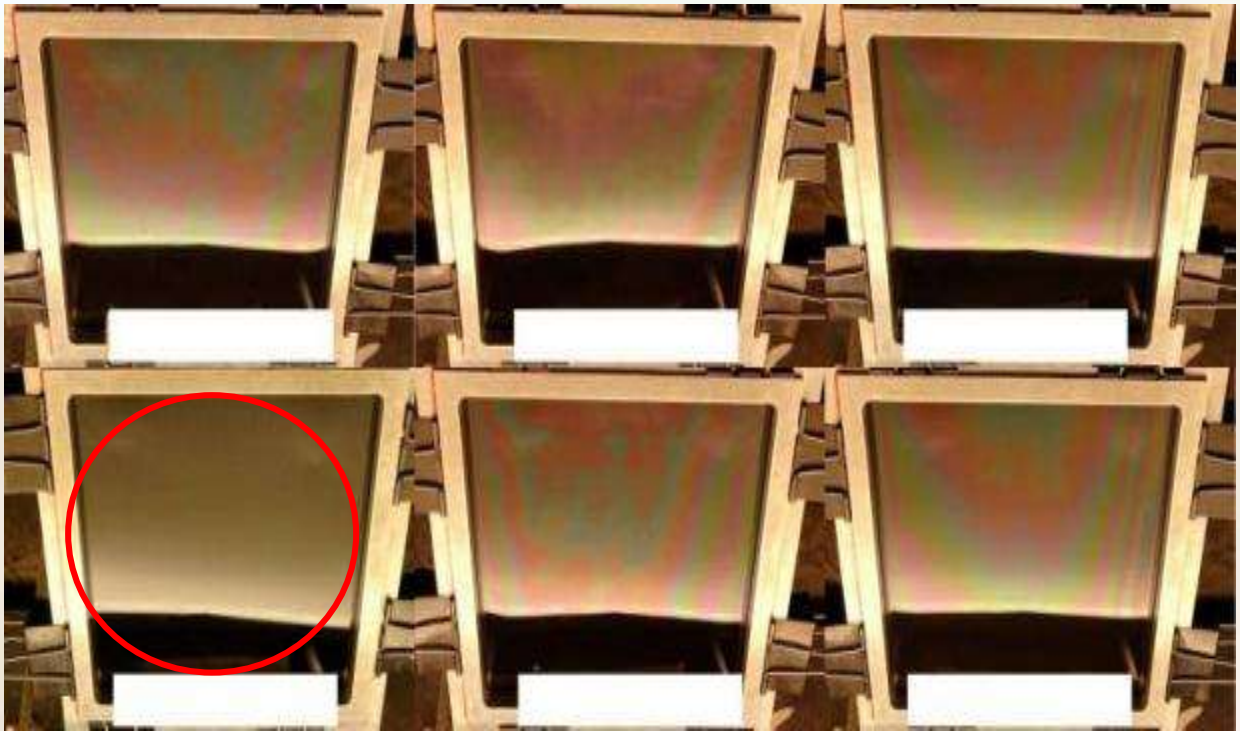
Requirement: Glass-Like Appearance

11µm Hard Coat
(RI = 1.5)

Primer

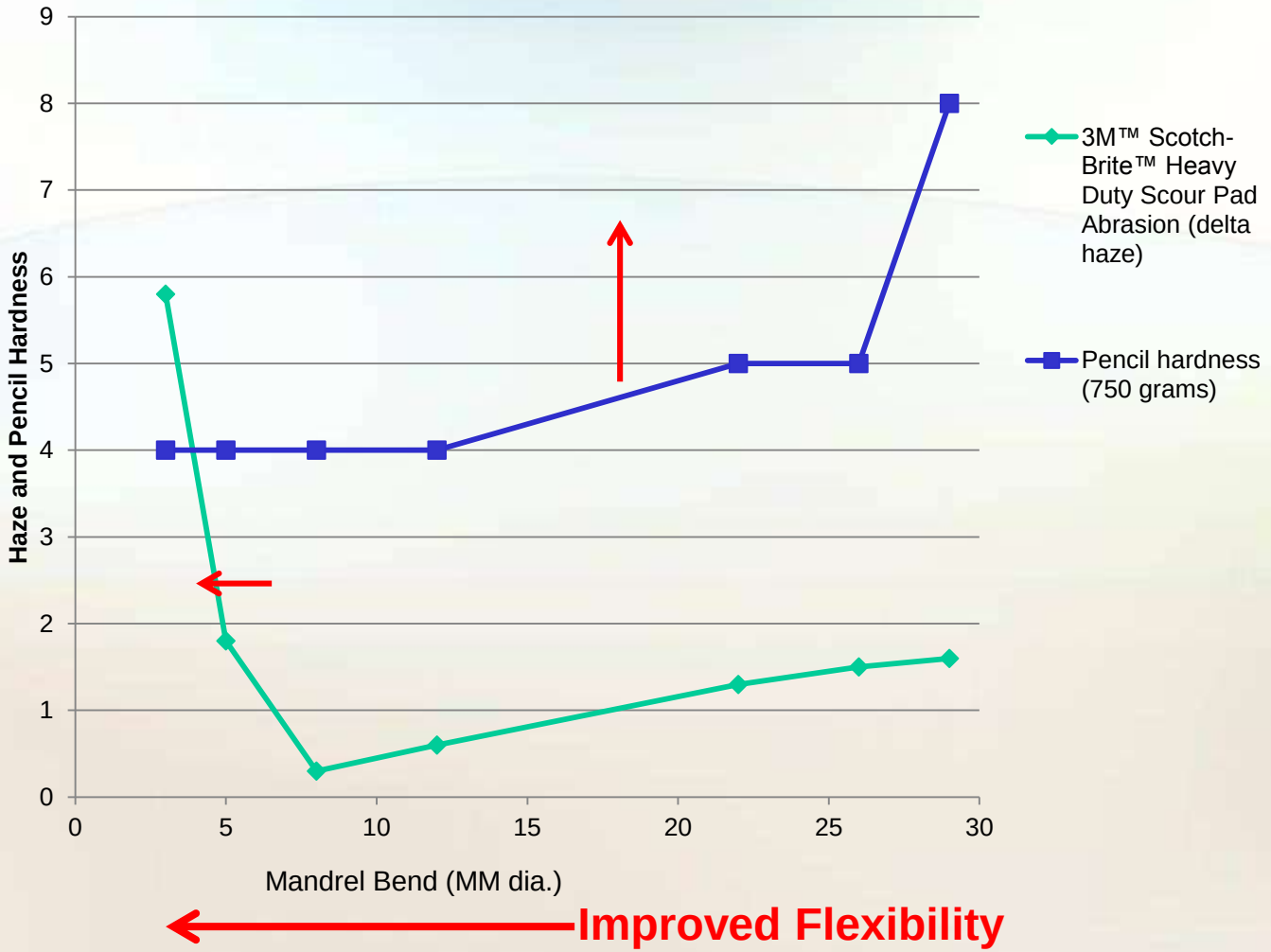
3-10 mil Primed PET





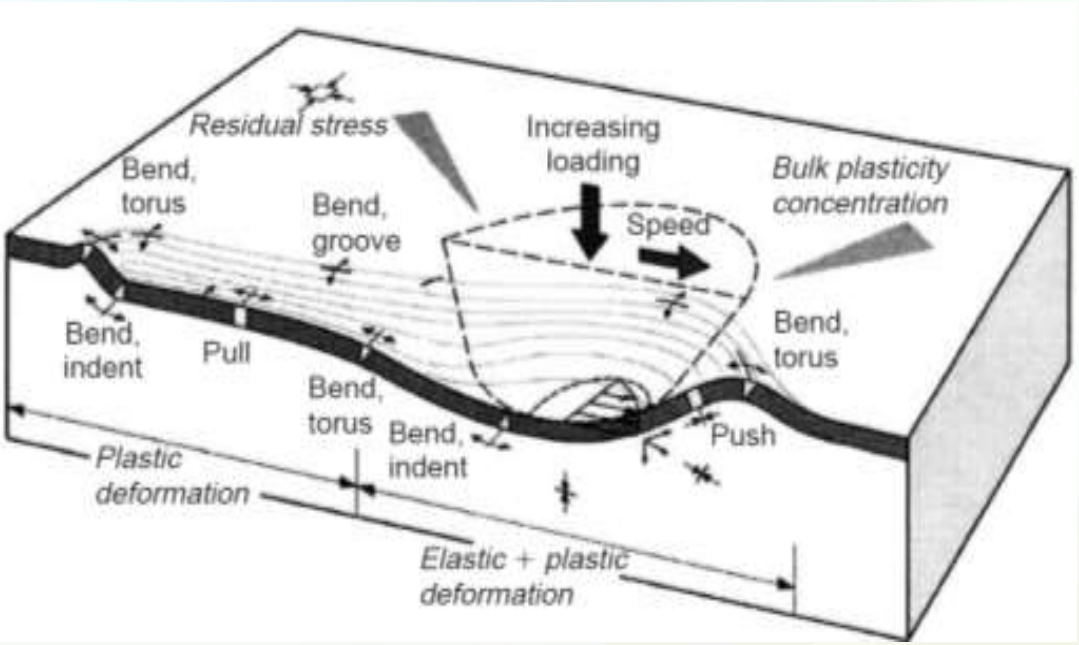
Requirement: Abrasion and Flexibility

Hard Coats with improved technology can be abrasion resistant and flexible



Trends are constant however improved hard coat technology (red arrows) can shift curves

Pencil Hardness Test Forces



Issues with Pencil Hardness Test

1. Variability
2. Substrate Affect
3. Backside Scratches
4. Unrealistic Force Used
5. Single Pass Test
6. Doesn't relate to Display Damage

Variability of Pencils

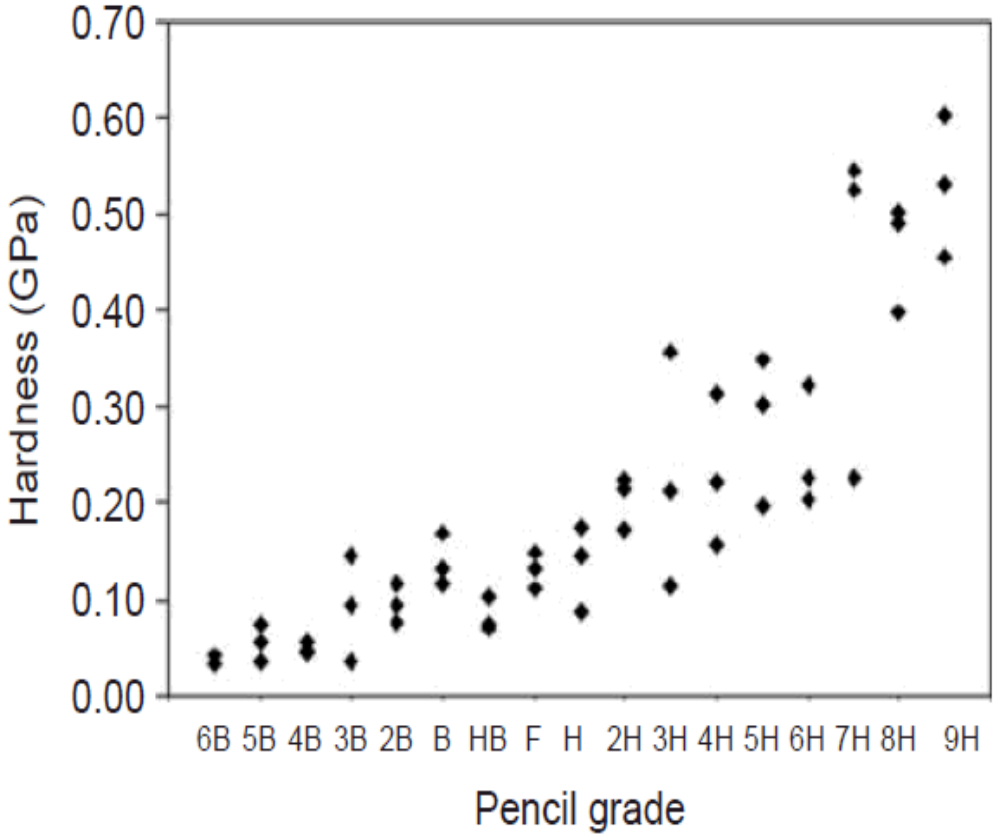
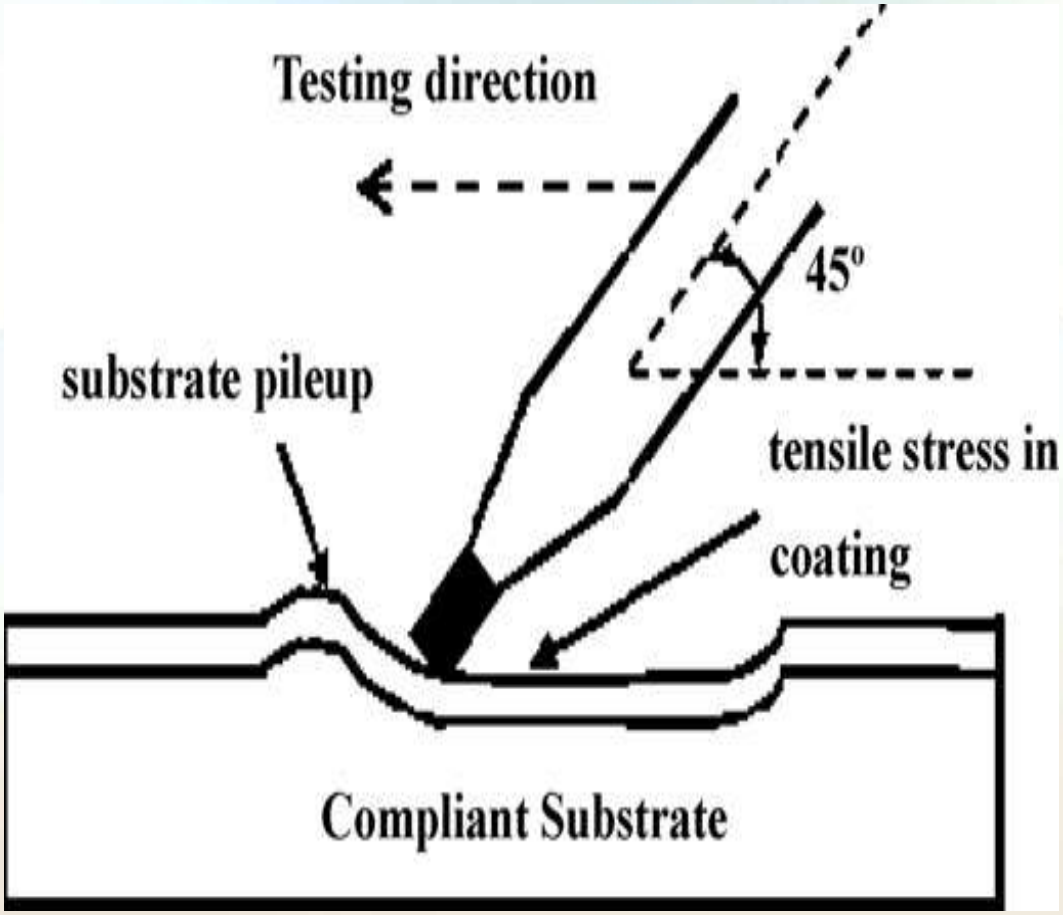


Fig. 14.12. Nanoindentation hardness of the whole series of pencil leads.

Substrate Affect



(Fig. 4 In **“**Scratch resistance of brittle thin films on compliant substrates”, Materials Science and Engineering A 493 (2008) 292–298

Single Pass Test

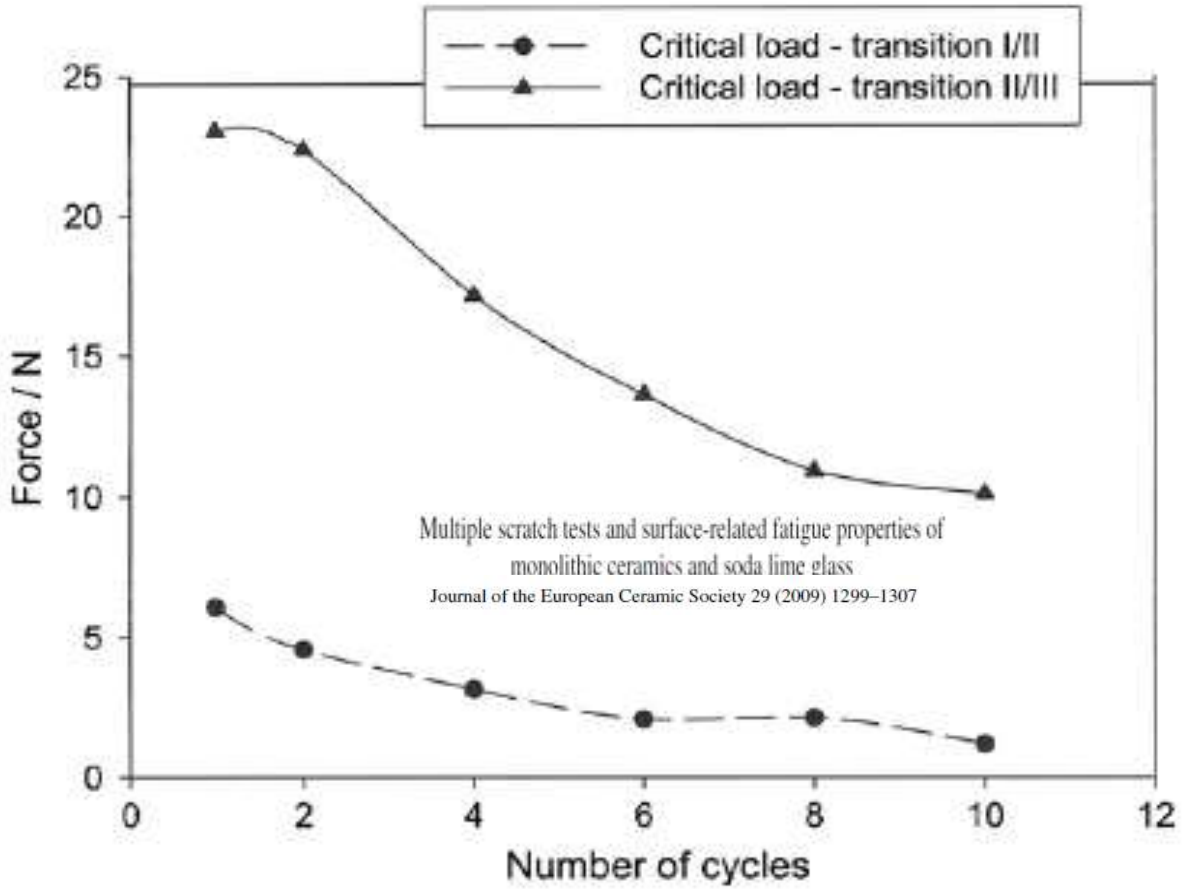


Fig. 4. Critical loads for cracking (transition I/II) and chipping (transition II/III) as a function of the number of cycles (in glass).

Glass (and other brittle materials) dramatically loose strength when they are scratched multiple times vs. just one scratch.

Doesn’t relate to Display Damage

The final issue is that this test is not relevant to real display damage. Despite even std. glass doing very well in the pencil hardness test in real life it gets scratched. Real damage is caused by either some type of abrasive grit (like under a cleaning cloth) or a metal object. We are investigating scratch tests that either use ScotchBright (abrasive grit) or steel (metal)

Alternative Abrasion Methods provide Practical “Real Life” Tests

ABRASIVE PARTICLES

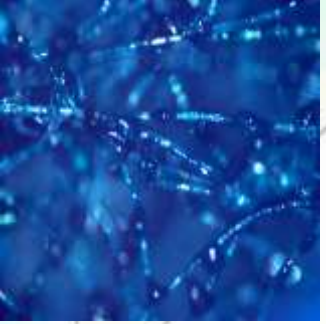
(3M™ Scotch-Brite™ Heavy Duty Scour Pad , 0.25cm^2)
4 passes – 1kg

DULL METAL (keys, coins)

(uses a 1.6mm steel rod
20 passes-2000 grams)

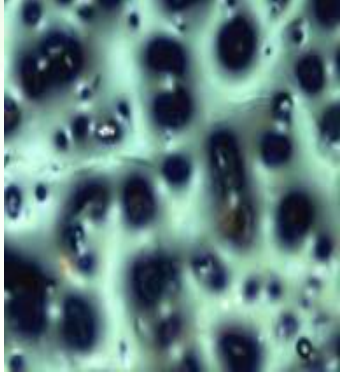
Cover Lens Film

Strengthened Cover GLASS



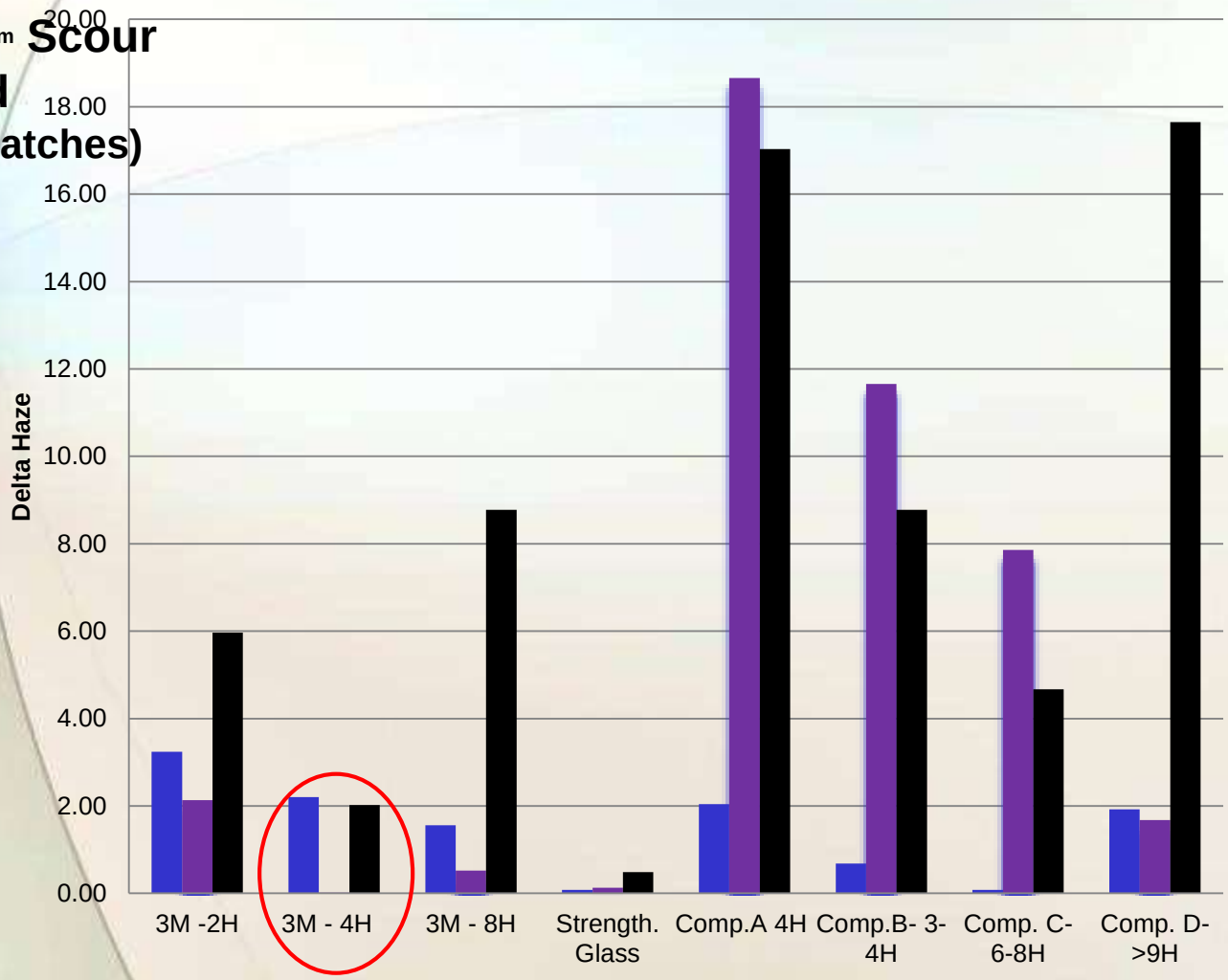
Abrasion Test Comparison

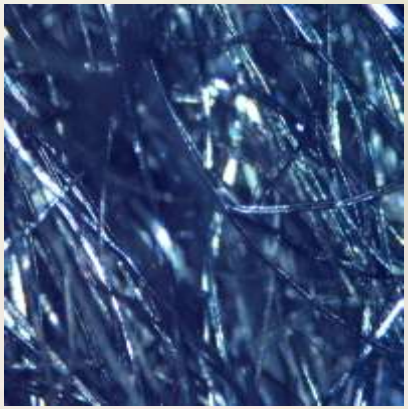
Choice of Test Makes a Difference
Need a test that relates to "real life"



SiC 800 Grit (scratches)

3M™ Scour Pad (scratches)





Steel Wool (cuts)

3M Hard Coat Technology Platform

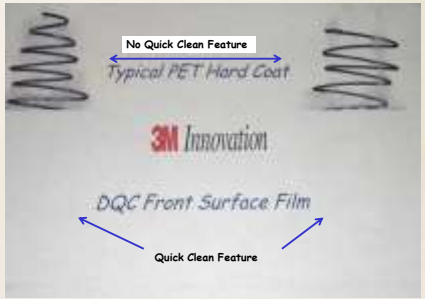
3M invented the first nanocomposite hard coat over 20 years ago.

Since that time we have continued to advance this technology with over 50 patents in a variety of areas.

Applications include: Displays, Electronics, Graphics, Dental, Window Films, Energy, etc.

- **Properties include: abrasion resistance**
- **Anti-smudge (Easy Clean)**
- **Anti-Fingerprint, Fingerprint Fading**
- **IR reflection**
- **UV absorption**
- **Anti-stat (controlling conductivity)**
- **Anti-lint (dust repellant)**
- **Low Reflection**
- **Anti-glare**
- **And Now: Super Abrasion Resistance!**

Lint Repellant



Anti-Smudge