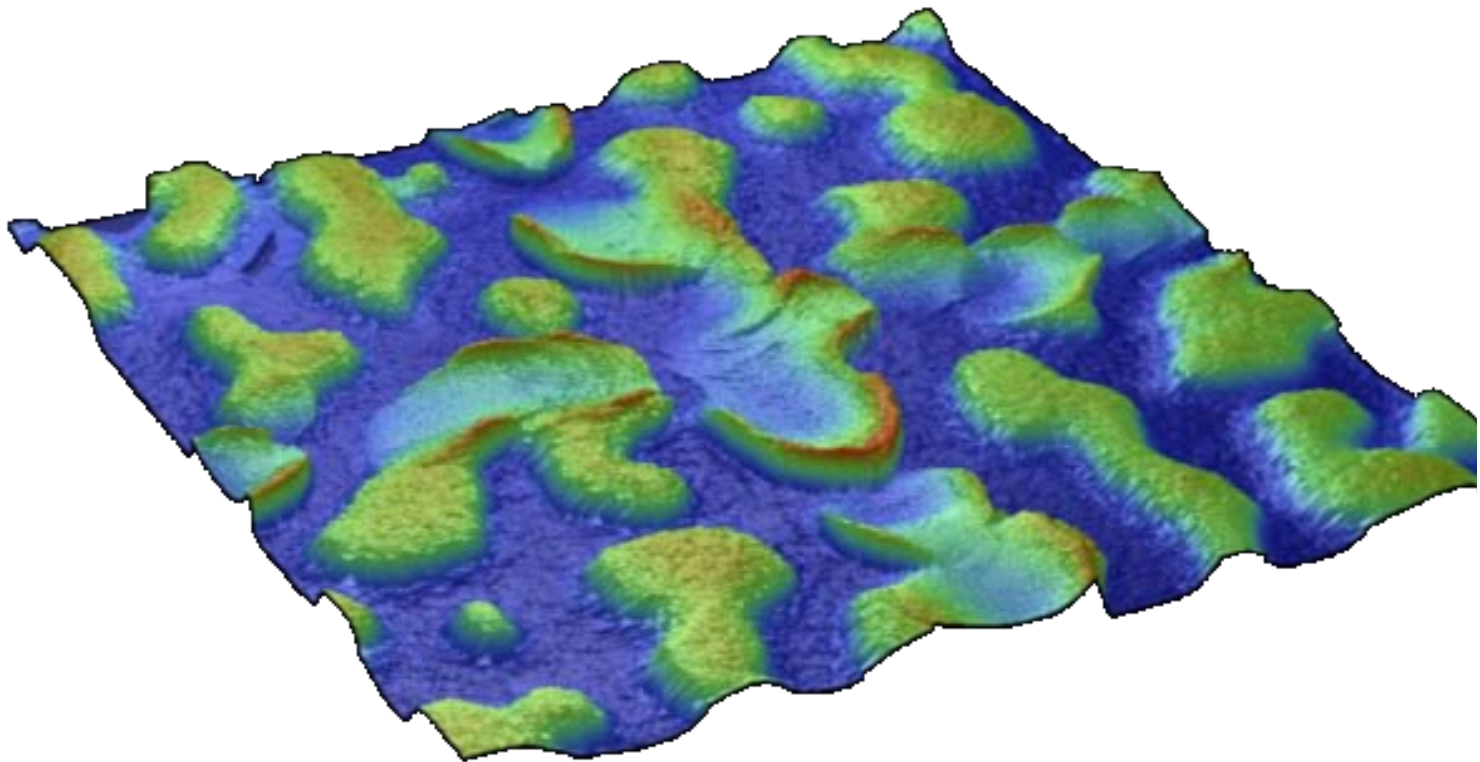


Ripefasthet til polypropylenoverflater

Terje Tofteberg – SINTEF Materialer og kjemi



Content

- What is a scratch?
 - How to apply a scratch in a repeatable fashion
 - How to quantify the quality of a scratch
- What makes scratches in PP special?
- Strategies for avoiding scratches
- The effect of one anti-scratch additive (Tegomer 100 from Evonik)



Technology for a better society

- 2200 employees. 400 in Oslo
- Our role:
 - Create value through knowledge generation, research and innovation
 - Develop technological solutions that are brought into practical use
 - Act as an R&D partner for industry and the public sector
 - Develop new industrial companies

TAKTIL – Nye overflatekonsepter for kontorstoler

- Støttet av Forskningsrådet gjennom BIA-programmet (Brukerstyrt Innovasjonsarena)

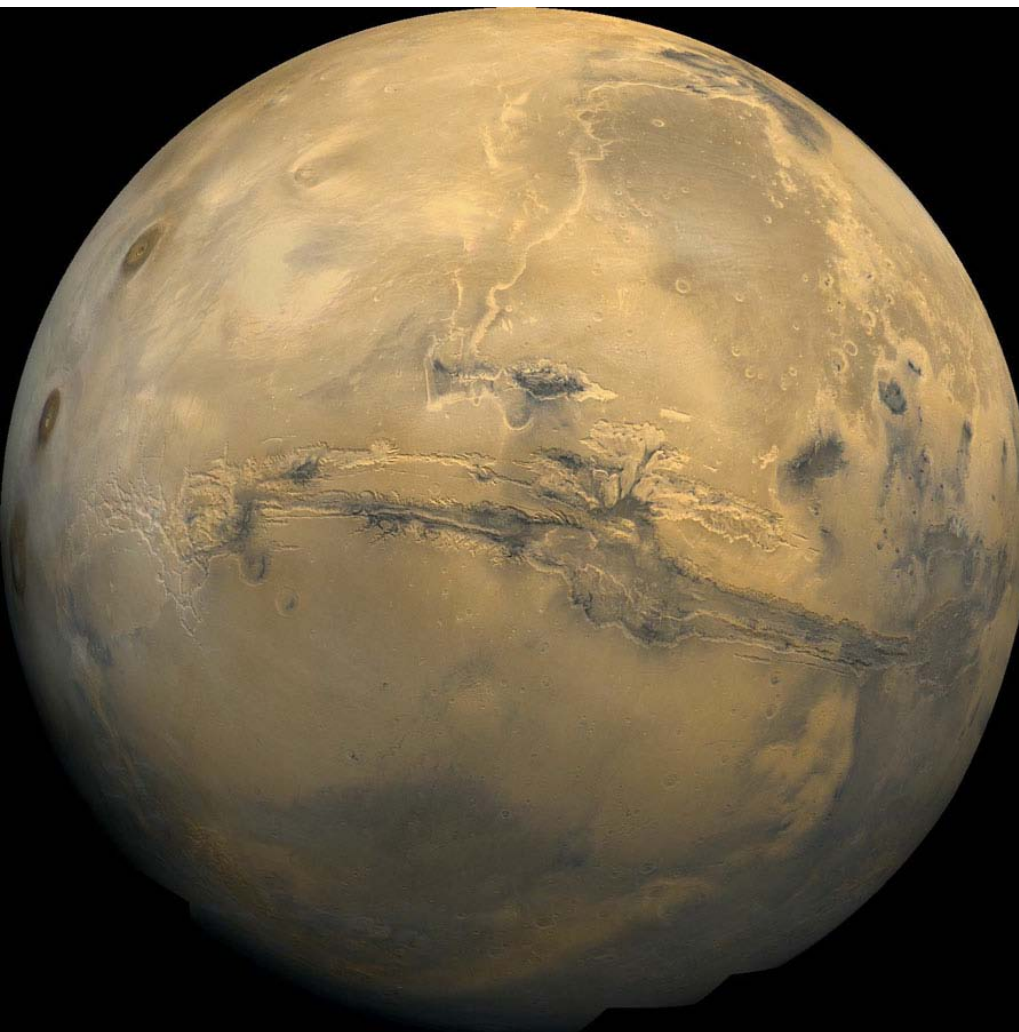
Mål

*Å utvikle konsepter for overflater av kontorstoler
med spesielle visuelle og taktile egenskaper*

- 50 prosent av FoU-investeringene i Norge gjøres av bedrifter som har BIA som eneste finansieringskilde
- BIA finansierer FoU-prosjekter som tar utgangspunkt i bedriftenes egne strategier
- Norske bedrifter får støtte til å kjøpe FoU-tjenester mot at de yter en egeninnsats



Solsystemets største ripe? - Valles Marineris på Mars



- 800 km lang
 - 30 km bred
 - 8 km dyp
-
- Ukjent opprinnelse, men sannsynligvis startet den som en sprekke da Mars kjølte ned for milliarder av år siden

Mohs hardness scale for minerals

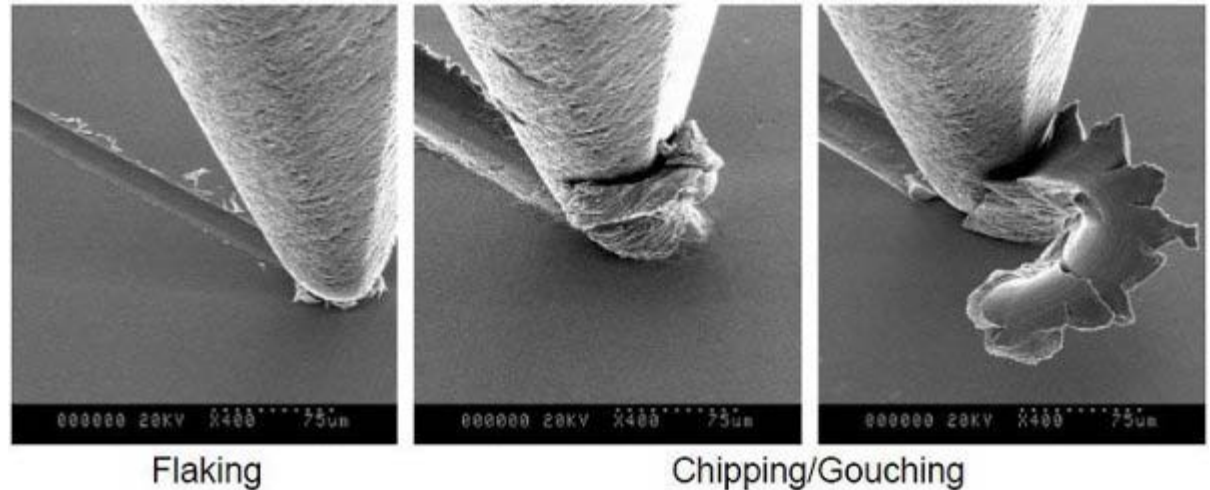
- Used to quantify scratch resistance of minerals
- Diamond was given a value 10, talc 1
- A mineral with a higher value on the Mohs scale will leave a scratch on a mineral with a lower value

- | | | |
|----|---------------------|---|
| 1 | Talc | ← |
| 2 | Gypsum | |
| 3 | Calcite | |
| 4 | Fluorite | |
| 5 | Apatite | ← |
| 6 | Orthoclase Feldspar | |
| 7 | Quartz | |
| 8 | Topaz | ← |
| 9 | Corundum | |
| 10 | Diamond | ← |



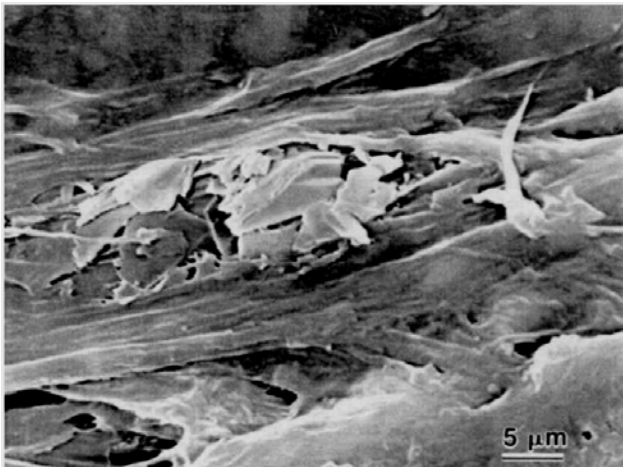
Scratch resistance of polymers

- Polymers are generally soft and are thus highly susceptible to scratches
- Injection moulded parts often have a skin zone with different properties from bulk

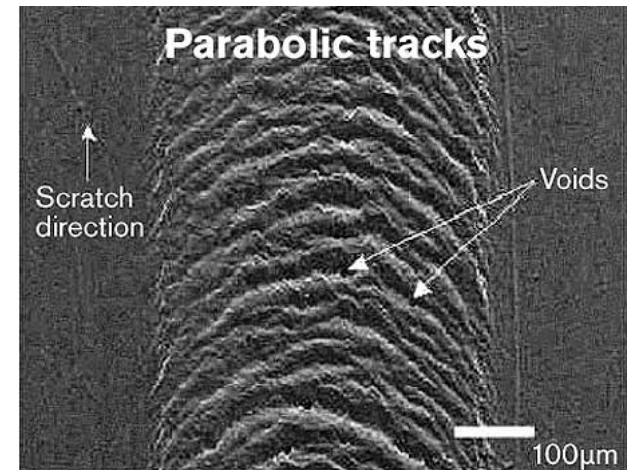


Scratching of PP samples

- Stress whitening
 - Small voids appear and scatters light. More pronounced in copolymers.
- Mineral fillers
 - Particle – matrix delamination leads to light scattering.
- Viscoelastic flow instabilities
 - Parabolic tracks – scatters light and increases brightness



SEM image talc – matrix delamination. PP with 20% talc, *Polym. Eng. Sci.* **40**, p 944



Scratch in unfilled PP block copolymer, SAE World Congress 2011.

Strategies for avoiding scratches in PP

- **Increase the hardness**
 - Increase the crystallinity - e.g. use iPP
 - Exchange PP with filled PA or metals
 - Avoid rubber additives
- **Reduce the visibility**
 - Avoid cavitation agents - avoid mineral fillers
 - Use surface coated fillers for better matrix – particle bonding
 - Add texture on the same size scale as anticipated scratches
- **Reduce the friction**
 - Antiscratch additives

Standardized scratching

- **Definition of scratching**

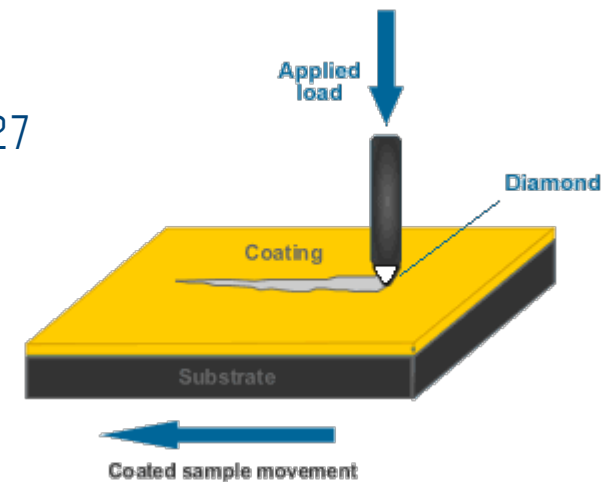
To make a thin shallow cut or mark on a surface with a sharp instrument

- **Scratch application**

- Can be performed according to standards e.g. ASTM 7027
- Defines forces, tip geometry, velocity, temperature

- **Scratch evaluation**

- Visual inspection
- Changes in gloss or brightness (ISO EN 2813)
- Change in topography
- No universal standard. Different practice for different materials

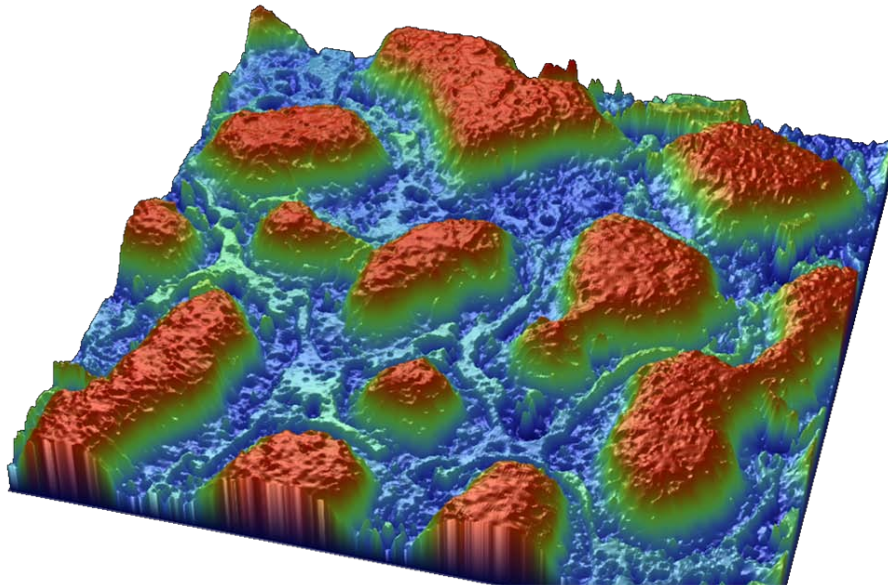


Scratch quantification

Variable	Level of observation	Counter measure
Lower sales Product returns	Consumer satisfaction	
Test panel ranking	Visual inspection	Surface texture
Brightness Gloss	Basic optical properties	Avoid cavitation agent
Scratch width Scratch depth	Topography	Increase hardness Reduce friction

Surface textures

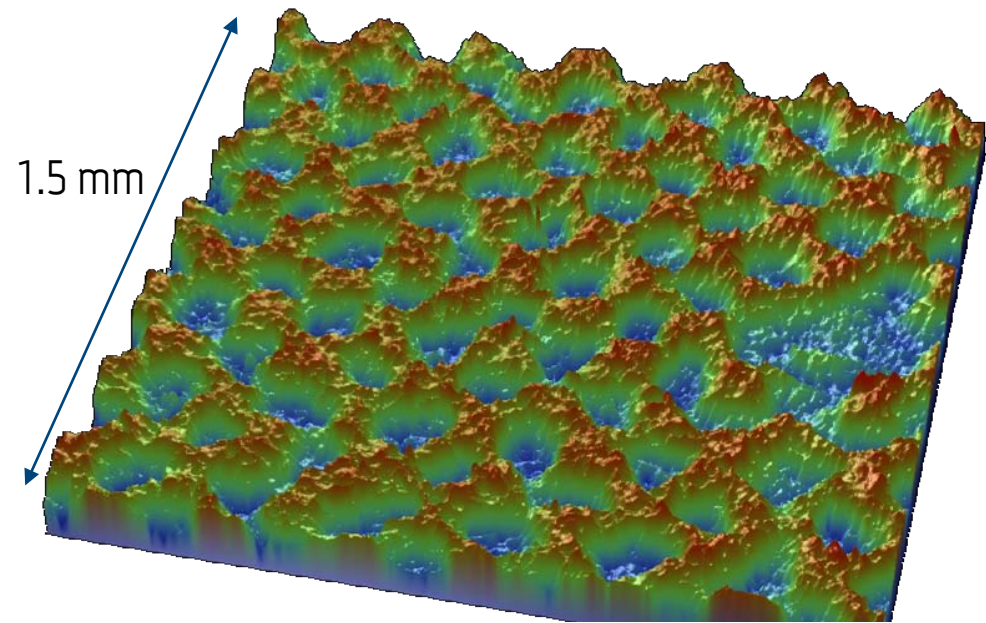
- Injection moulding of test samples
- Replacable mould insert
- Have tested 10 different surface textures



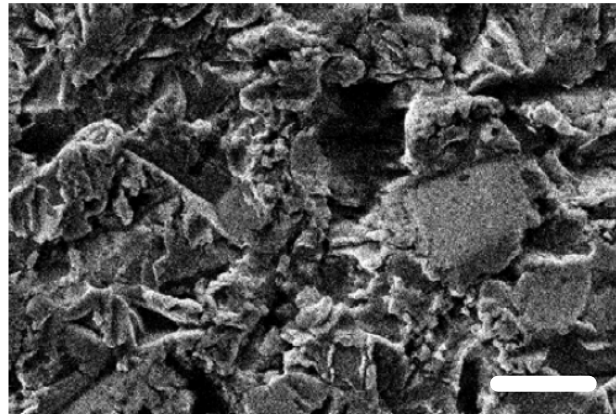
Typical grained surface texture

Surface textures

- Several levels of textures
 - Smooth tactilly
 - Matte visually
- Low scratch resistance

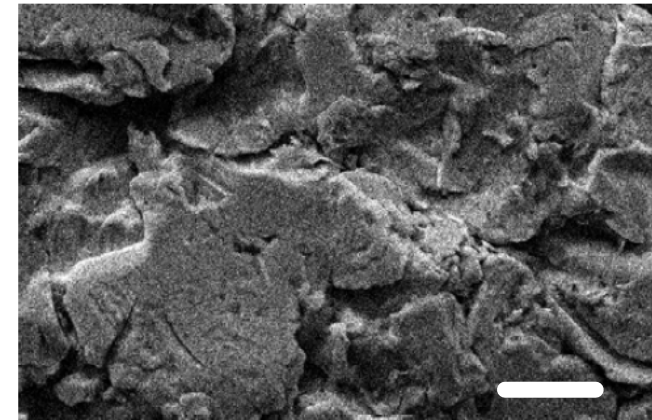


With Micromatte



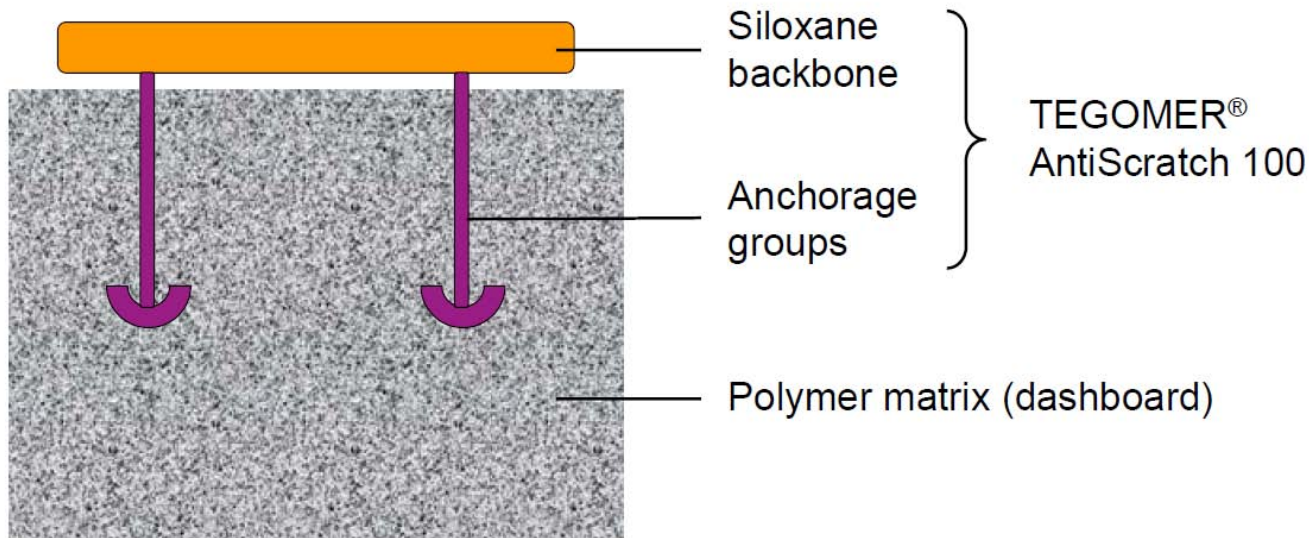
5 μm

Without Micromatte



5 μm

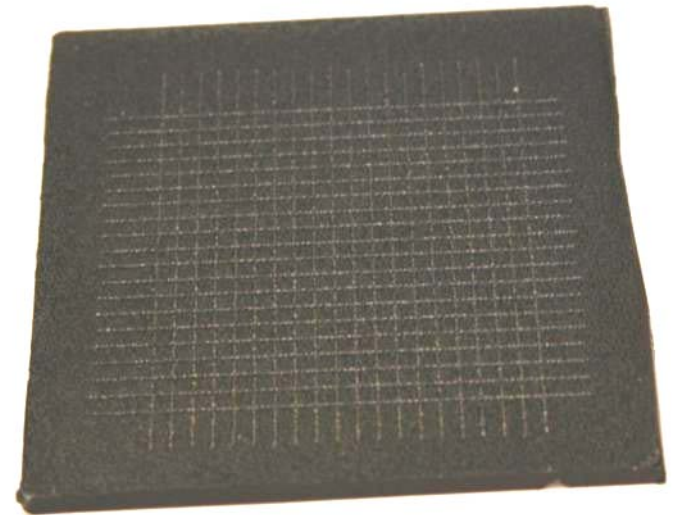
TEGOMER® AntiScratch 100 is a Permanent Slip Enhancer



- Reduces the friction of the surface
- Used in the automotive industry (car interior)
- Designed for talc filled PP
- Non – migrating

Scratch visibility and scratch resistance

- Injection molding of smooth and textured plates (60mm x 60 mm) in:
 - PP
 - PP + 2% antiscratch agent (Tegomer 100)
 - PP + 4% antiscratch agent (Tegomer 100)
- Scratching
 - 20 by 20 lines
 - Spherical tip diameter 1.0 mm
 - Force 10 N
 - Speed 1000 mm/min
- Characterisation of the scratched samples
 - Visual inspection
 - Brightness and gloss
 - Topography

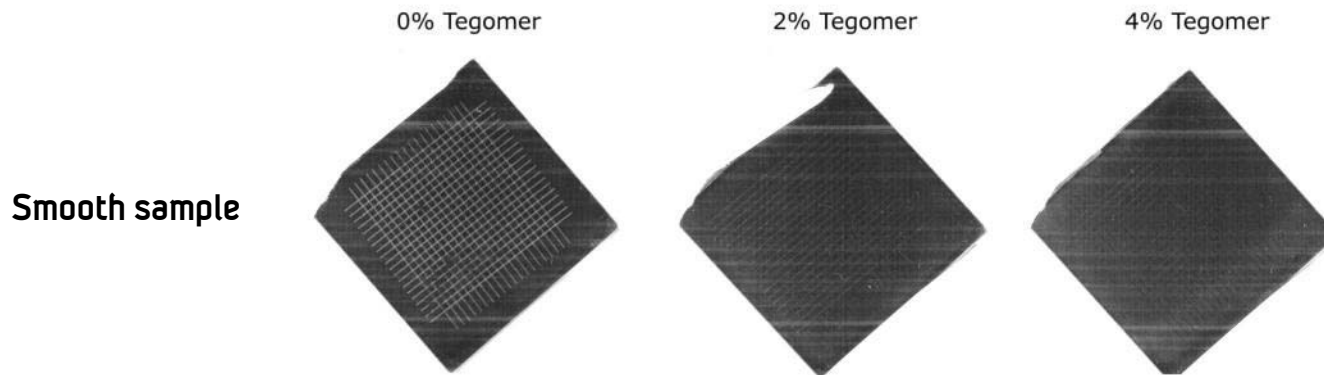


Scratch visibility and colour

- Initially scratches in PP are most visible on dark surfaces due to stress whitening
- Dust and dirt will typically collect in scratches making the scratches more visible also on light surfaces

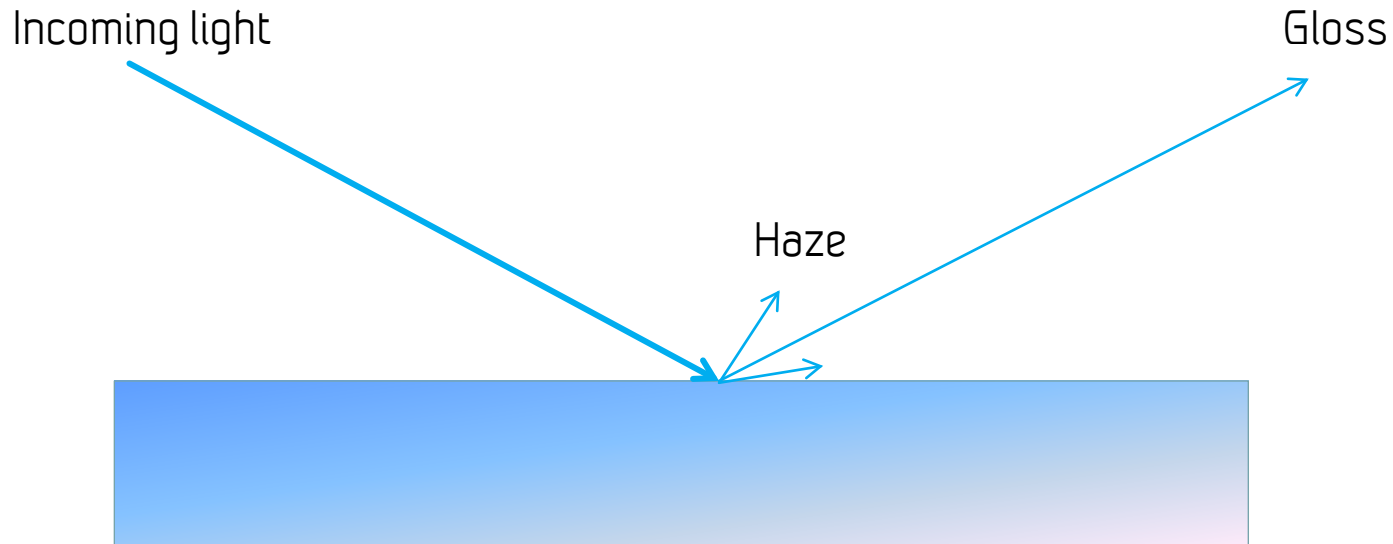
Visual inspection smooth plates

- Requires controlled, repeatable lightning conditions
- Used the office flatbed scanner

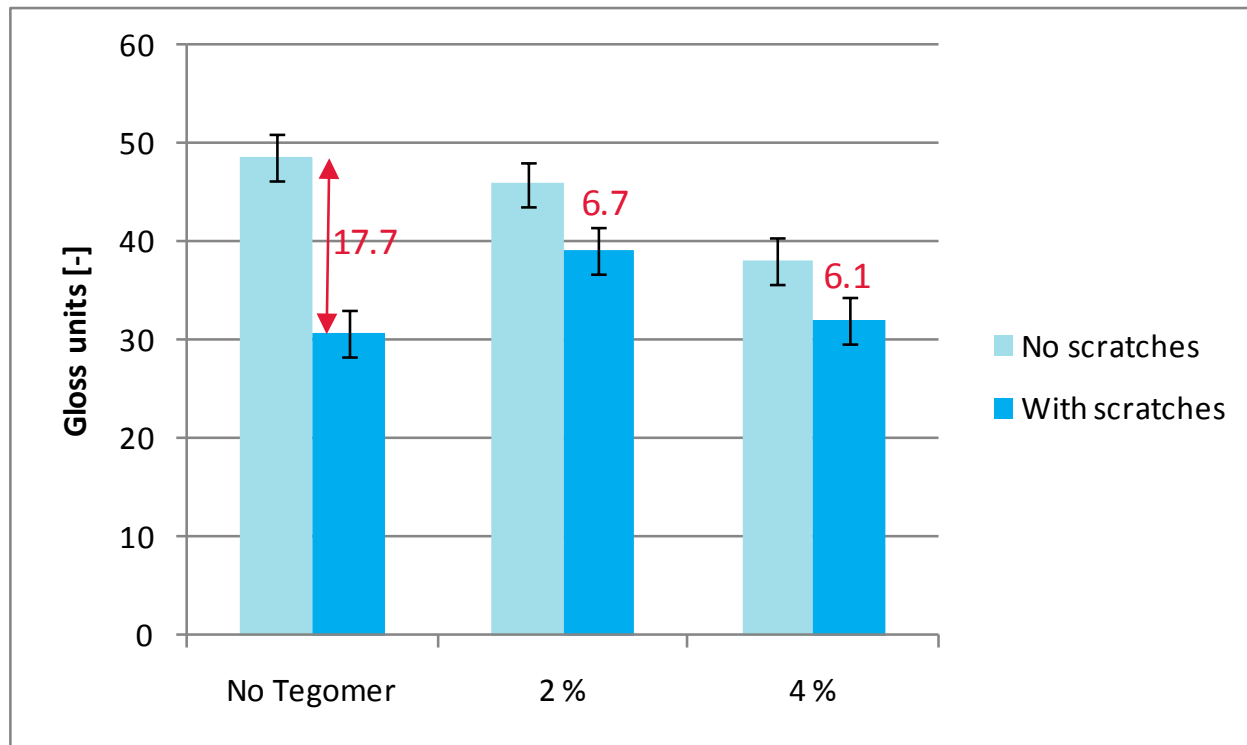


Gloss, brightness and haze

- Surface gloss is the proportion of incident light that is reflected at the specular reflectance angle of the mean of that surface
- Measured according to standard ASTM D523
- Measured in gloss units: 100 is defined as a black polished glass standard
- Haze is stray light
- Brightness is the integral of all reflected light

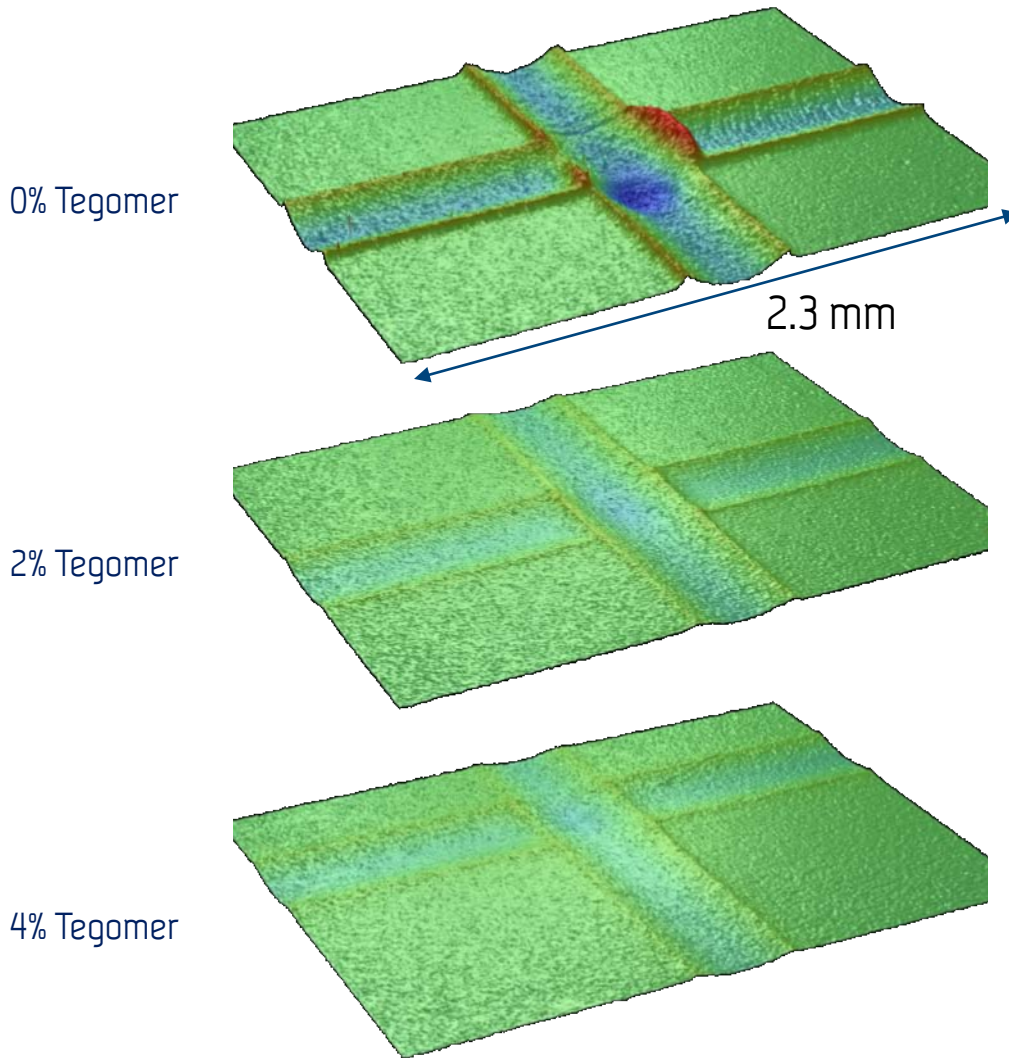


Gloss of smooth samples



- Δ gloss is reduced with the addition of Tegomer 100
- Reduction in initial gloss with the addition of Tegomer 100

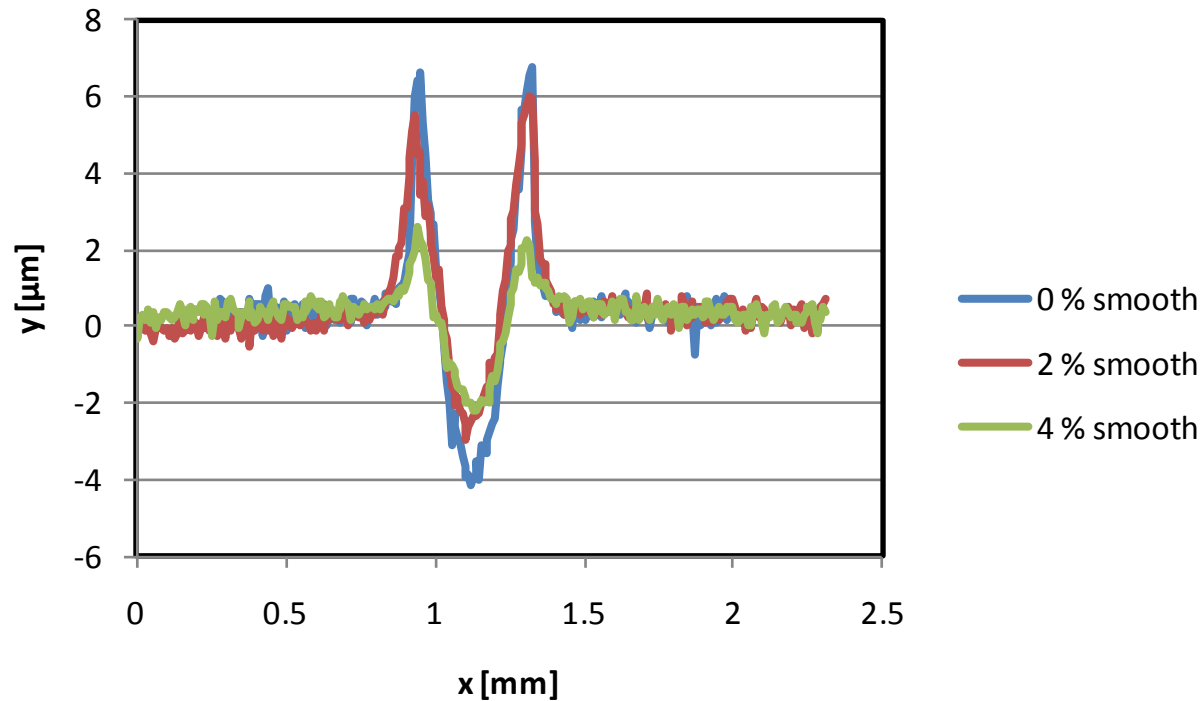
Topography



+ 20 μm = dark red
- 20 μm = dark blue

Measured using white light interferometer
on plates sputtered with 30 nm of gold.

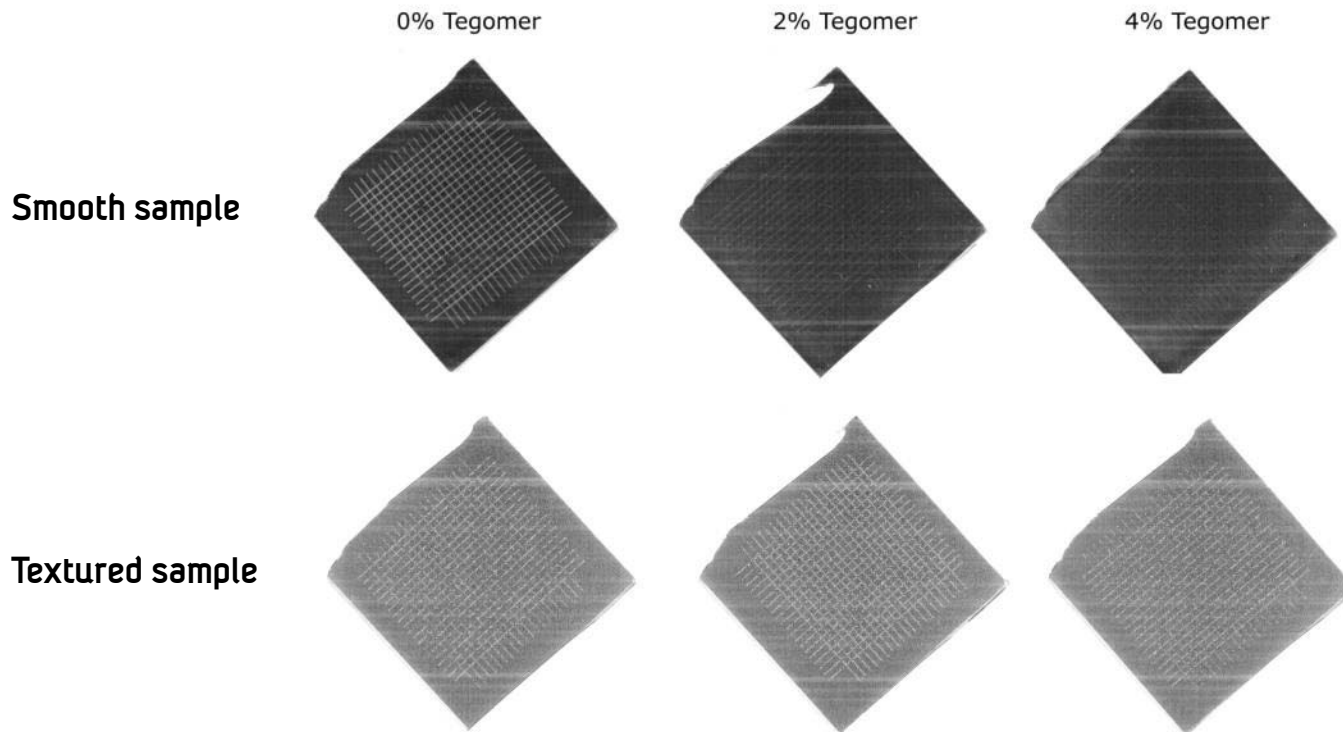
Characterization of smooth scratched samples: Cross section of scratches



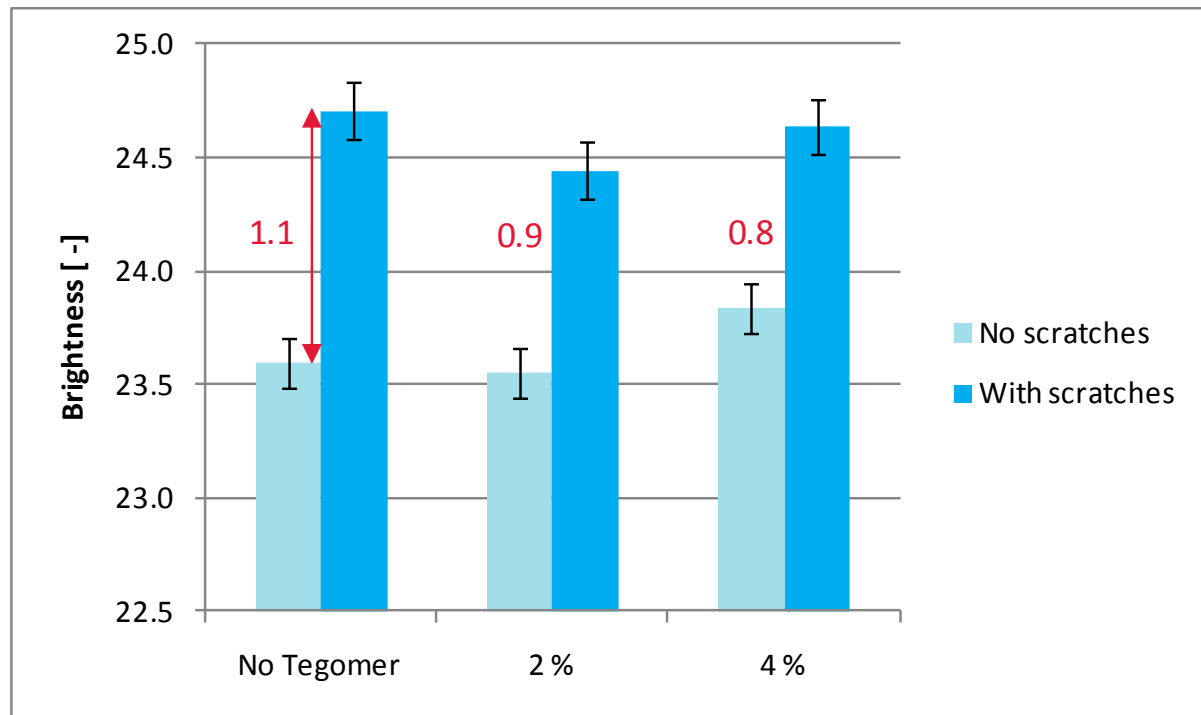
- Scratch depth is significantly reduced when adding Tegomer
- Lip height is significantly reduced when adding Tegomer

Visual inspection textured plates

- Requires controlled, repeatable lightning conditions
- Used the office flatbed scanner

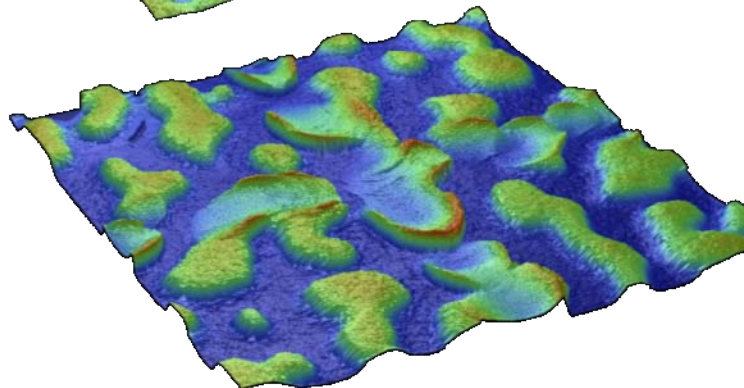
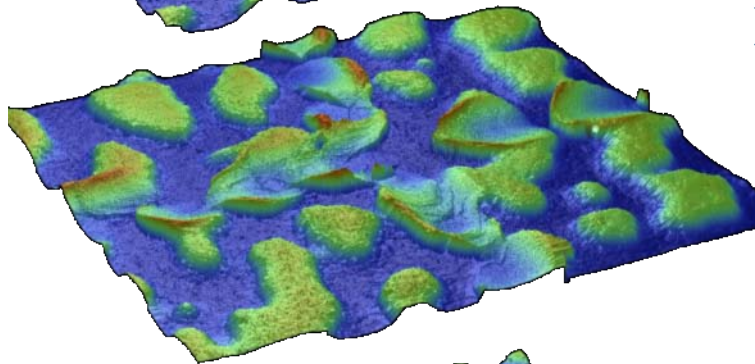
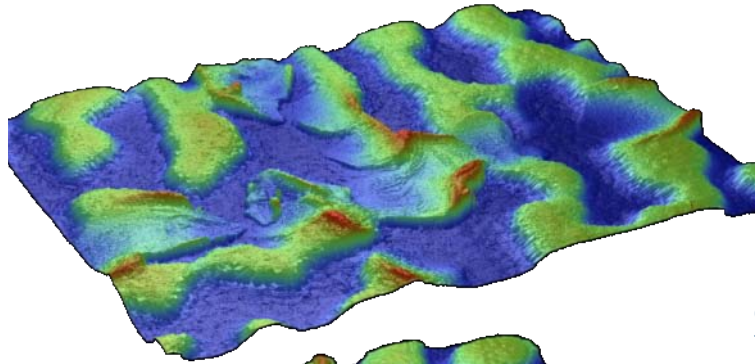


Brightness of textured plates



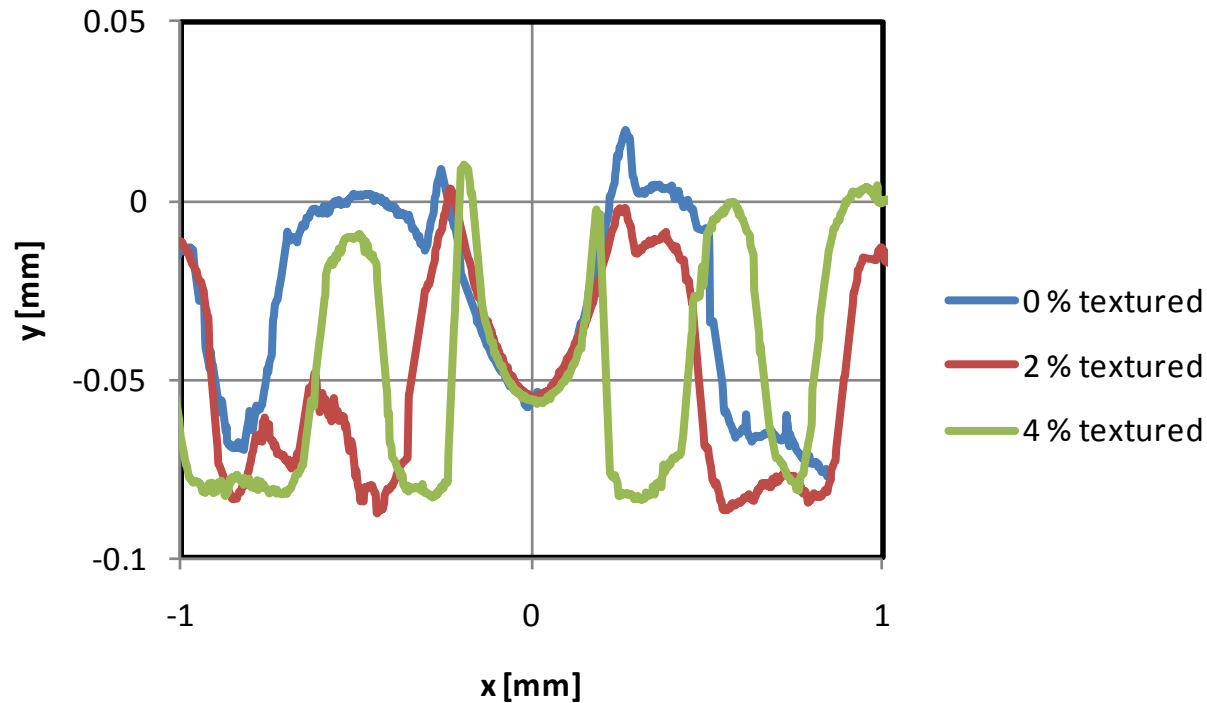
- Δ brightness is reduced with the addition of Tegomer 100
- Parts appear slightly brighter with the addition of Tegomer 100

Topography of scratched textured samples



Scratching needle hits features sideways meaning less effect of reducing friction.

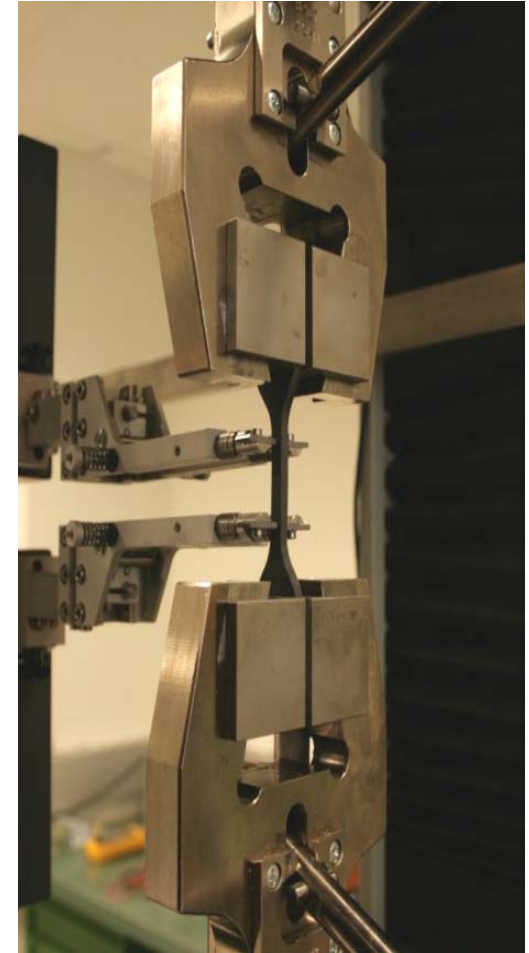
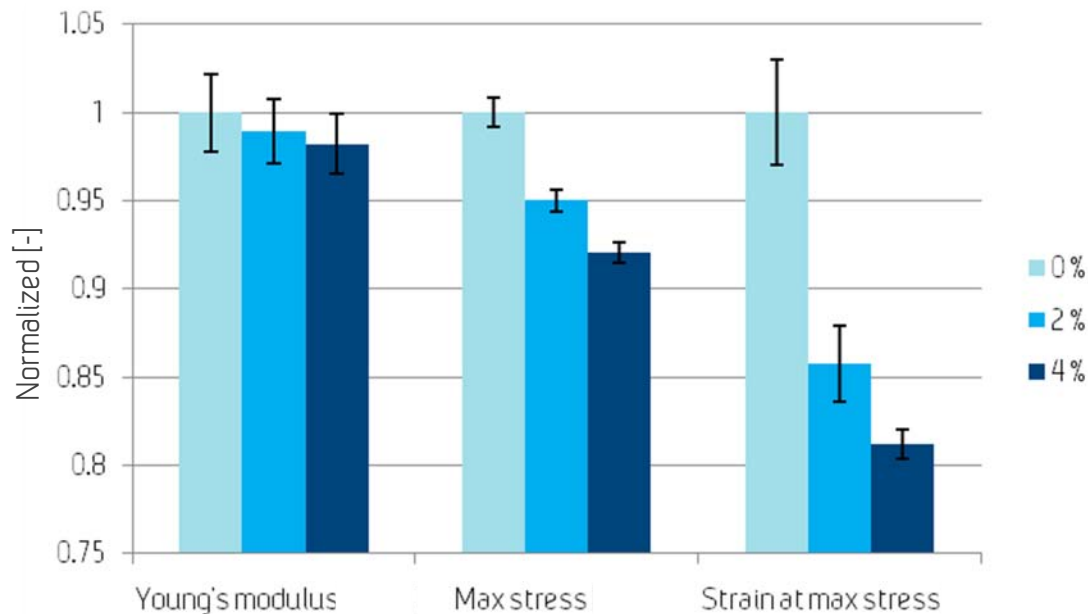
Characterization of textured scratched samples: Cross section of scratches



- Depth of scratch is $\sim 50\mu\text{m}$, 10 times more than on smooth samples
- Still the scratches are less visible by visual inspection
- Only small difference between samples with and without tegomer

Mechanical properties

- Moulded dog-bone samples
- Record the force required to deform the sample
- More additive means less polymer
 - lower modulus
 - lower yield stress



Summary

- Scratching is a highly complex mechanical process
- Strategies to reduce scratching problems
 - Making the surface harder
 - Reducing surface friction
 - Hiding the scratch
- Reducing the surface friction using an anti scratch agent can have a significant improvement on scratch resistance