

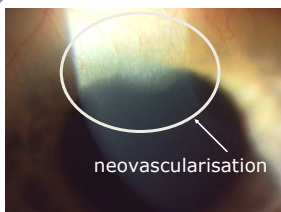
Investigating the mechanical properties of soft contact lenses using nanoindentation

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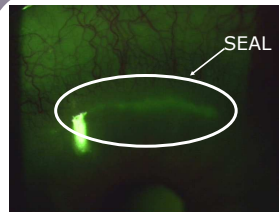
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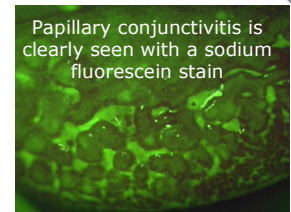
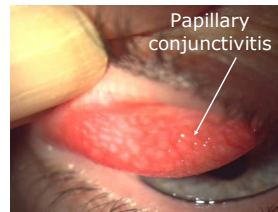
Soft contact lens materials currently fall into two broad categories; **conventional hydrogels (CH)** and **silicone hydrogels (SiH)**. CH rely on water for oxygen transmissibility whereas SiH rely on the silicone groups for oxygen transmissibility. [1,2]



SiH have eliminated hypoxia related problems, such as **neovascularisation**, found with CH lenses. [1]

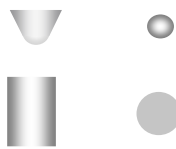


SiH-induced clinical issues, such as superior epithelial arcuate lesions, **SEAL's**, and **papillary conjunctivitis** have become apparent and are attributed to higher mechanical values [2]



Papillary conjunctivitis is clearly seen with a sodium fluorescein stain

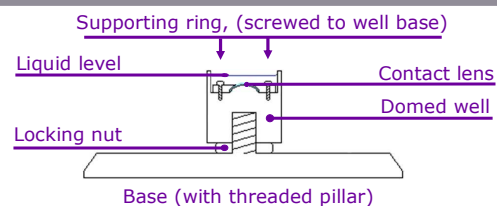
Nanoindentation



10 μm
conospherical

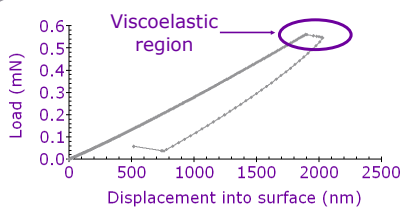


50 μm
flat punch

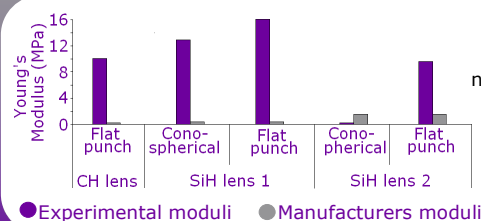


An Agilent Nanoindenter XP, using two different tips, and a custom made liquid cell was used to carry out the experiments.

Results

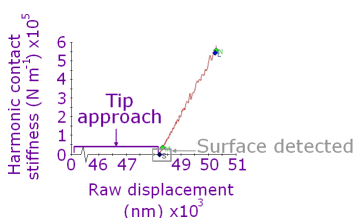


Preliminary results show correctly shaped graphs, with a clear viscoelastic region.

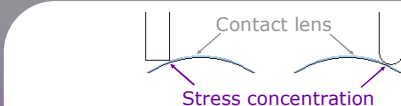
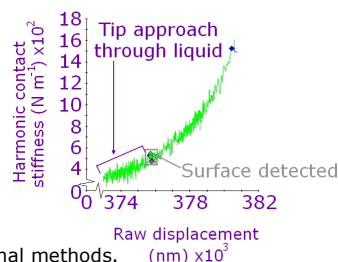


The readings however, are neither repeatable nor consistent with the manufacturers bulk measurements.

Discussion



Surface detection is difficult with conventional methods.



Due to the size of the conospherical tip, it may have travelled straight through the lens. Lenses are not flat; this could cause a stress concentration if the indent is not in line with the centre of the lens.

If the tips penetrate too deeply, due to inaccurate surface detection, the substrate starts affecting the readings.

Further work

To eliminate some of the problems encountered, several new approaches can be implemented for future work:

- The use of a larger, conospherical tip may prove more successful.
- Using a dynamic contact module, designed to measure ultra low loads, may make surface detection less of an issue.
- Finding a suitable standard material, with a modulus closer to that of hydrogels. PhotoStress materials (Vishay Micro-measurements) exhibit similar properties.
- Using flat samples to eliminate problems caused by the domed-nature of contact lenses.
- A new load control method will be utilised to eliminate surface detection issues.

References

- [1] French *et al.* A decade with silicone hydrogels: Part 1, *Optometry Today*, Aug 2008 42-46.
- [2] French *et al.* A decade with silicone hydrogels: Part 2, *Optometry Today*, Sep 2008 38-43