ExcelPlas Independent Materials Testing

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Weld Interface - Light Transmission Microscopic Examination (WI-LTME) Using Polarized Light Photomicroscpy (PLP)

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Abstract

Polarized Light Photomicroscopy of HDPE Weld interfaces

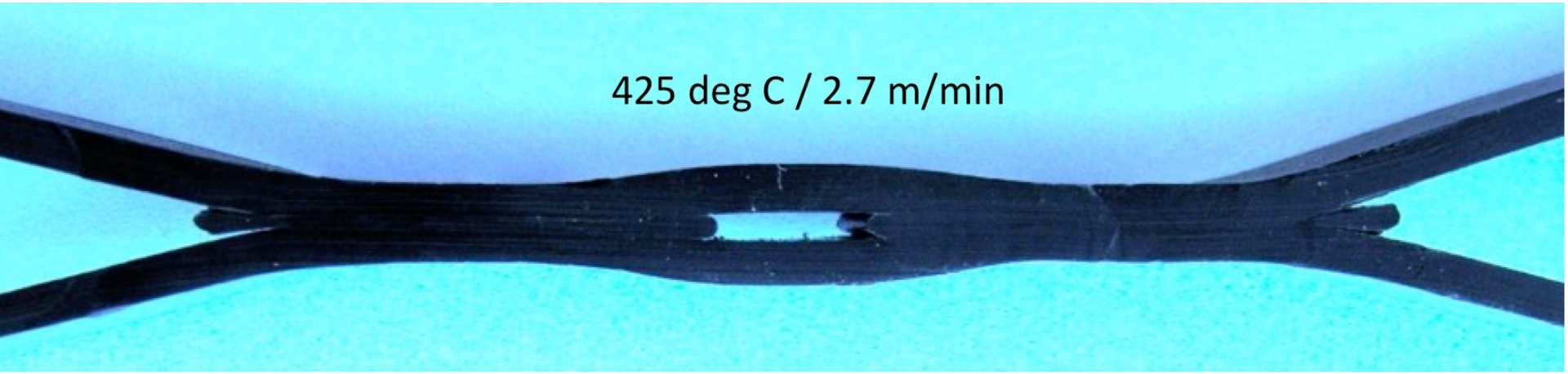
Abstract:

Material flow patterns formed during the HDPE geomembrane welding process were visualized by viewing cross section of the welded zone under polarized light. Polarized Light Photomicroscopy (PLP) allows one to determine if proper interphase mixing and fusion of the material takes place during welding.

Welding pressure and the effective heating on liner surfaces can determine the morphology of the weld zone. Polarized light microscopy studies indicated that the weld is composed of the heat-affected zone (HAZ) consisted of molten zone and the deformed spherulitic zone while columnar crystals were found to occur in the centre of the melt-affected zone (MAZ) due to row nucleation.

In welds made under optimum conditions the welding interface becomes almost indistinguishable from the parent material. In contrast non-optimum welding parameters had a direct impact on microstructure of weld zone which itself is very heterogeneous.

Cross-Section of a "Good" Weld

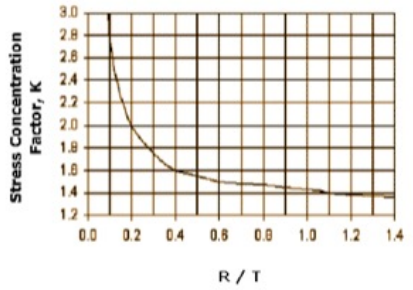


This good double wedge weld is characterized by a gentle sweeping transition with no excessive thickness reduction or profile distortion. The squeeze out beads are uniform, symmetrical and moderately sized.

Cross-Section of a "Poor" Weld

Excessive thickness reduction on weld tracks

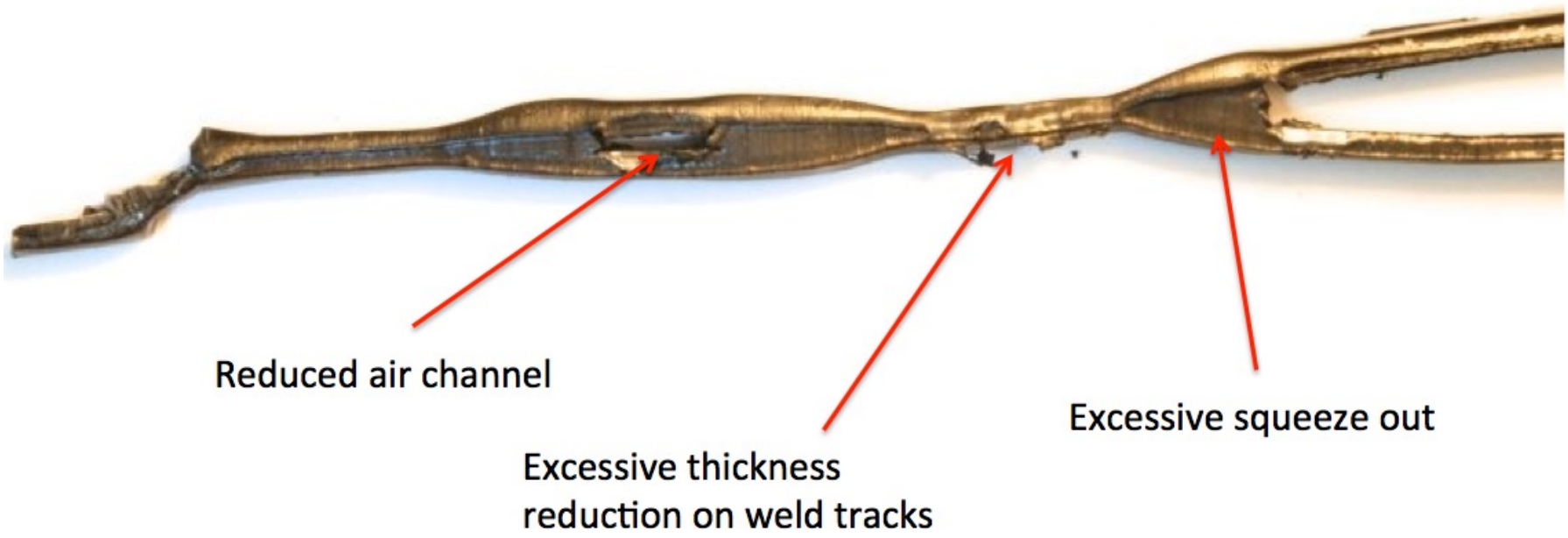
abrupt thick-thin transition ("notch-effect")



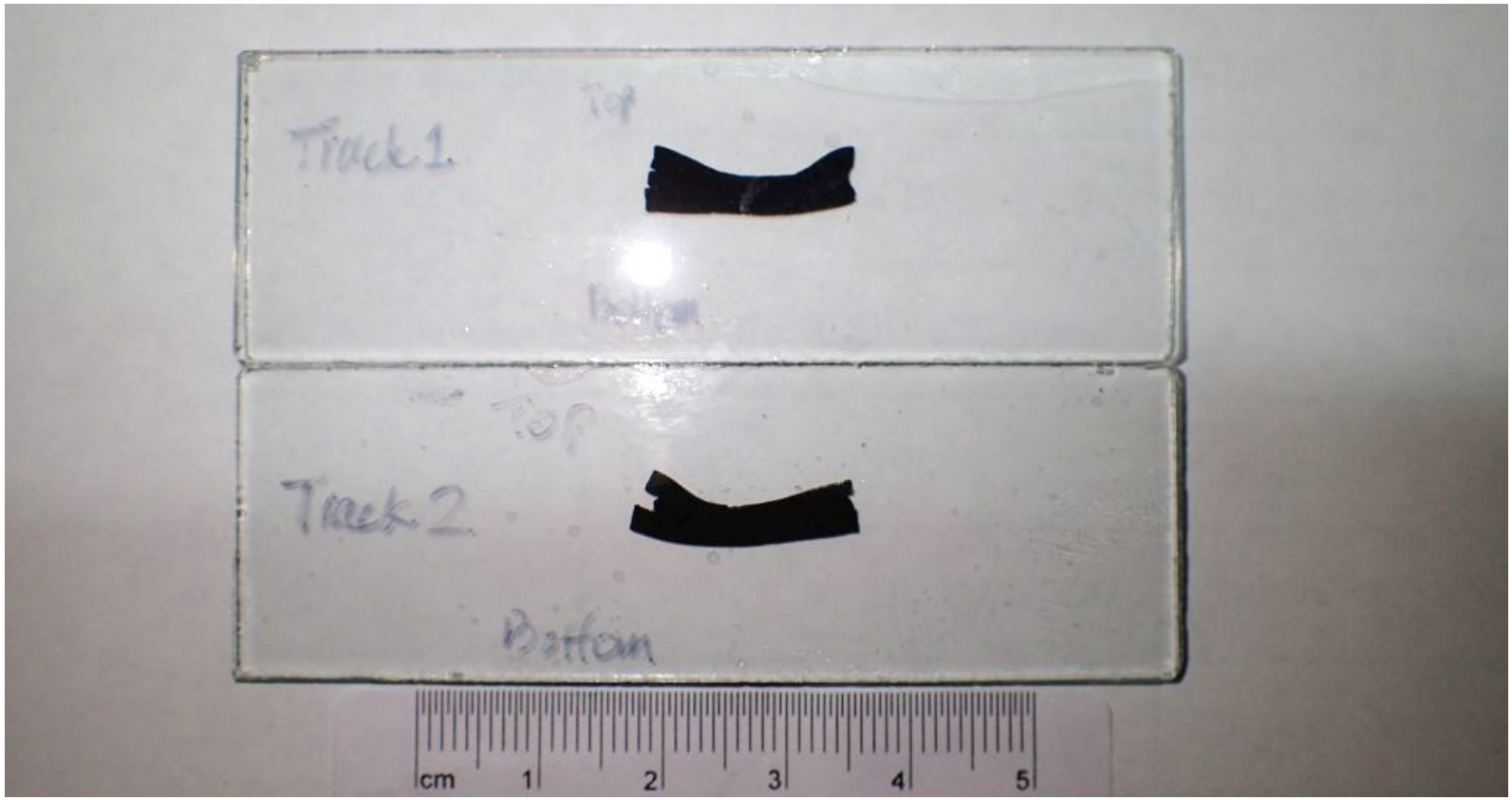
STRESS CONCENTRATION FACTOR , K
(AS A FUNCTION OF RADIUS/THICKNESS)

ExcelPlas Geomembrane Failure Analysis

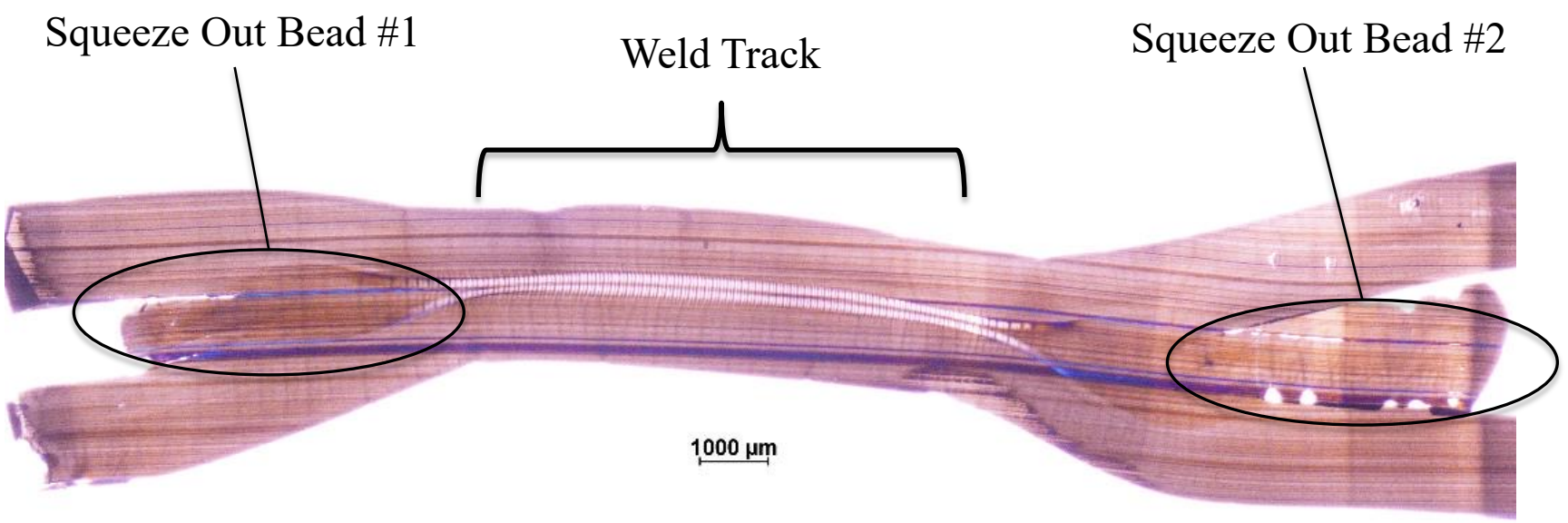
Cross-Section of a "Poor" Weld



Microtomed Weld Slices Between Microscope Slides



PLP of Cross-Sectioned HDPE Weld Track (Bright Field)



PLP of Cross-Sectioned HDPE Weld Track (Dark Field)

PLP of HDPE Wedge weld

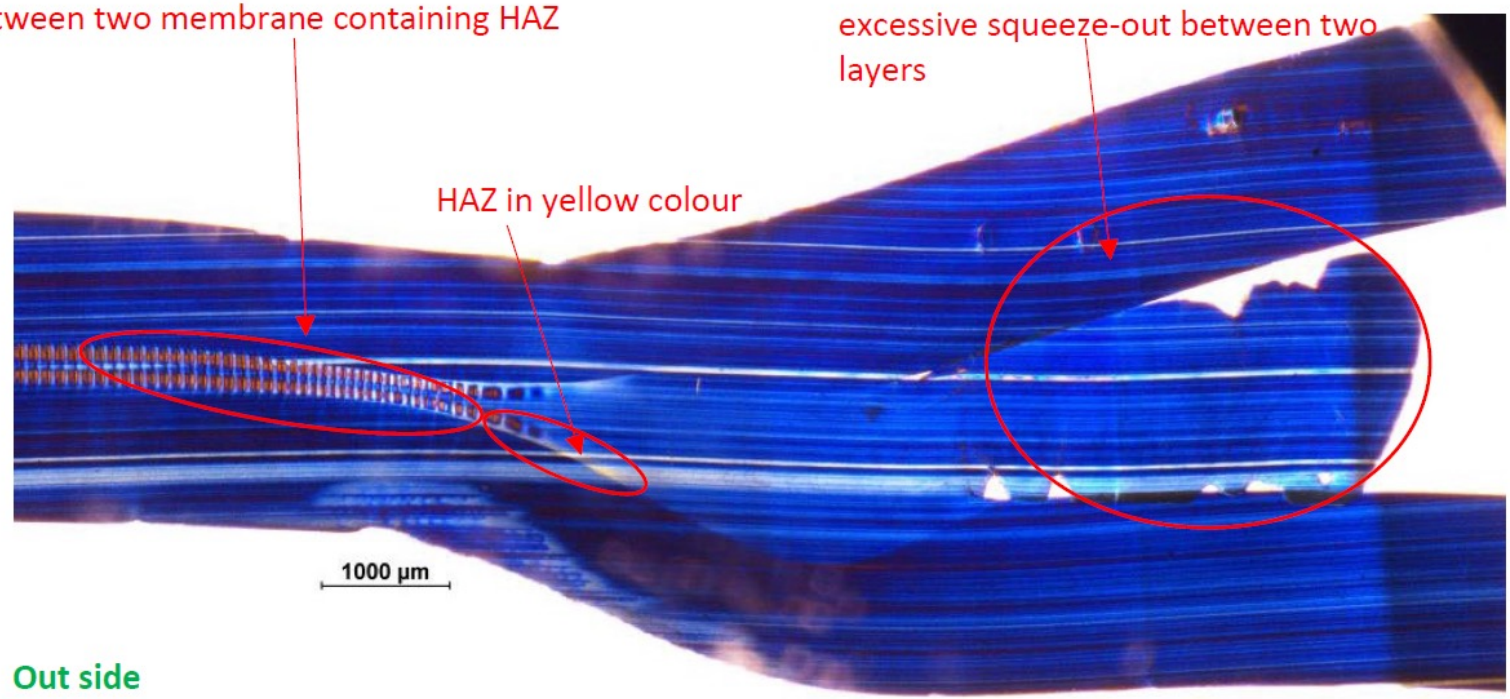


Figure 6.5 EP 1- Affected Weld track 1 under retardation plate – 'Outside area' under polarization under crossed polarizers

PLP of HDPE Wedge weld

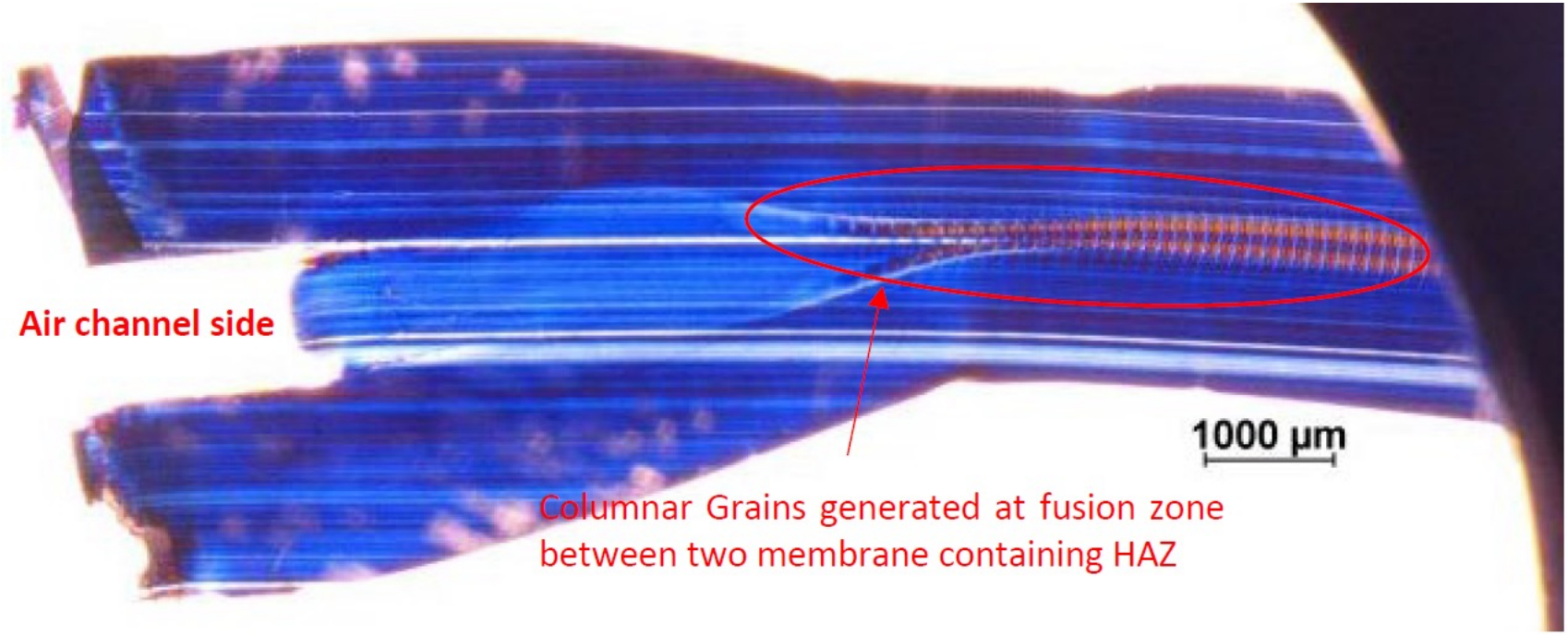
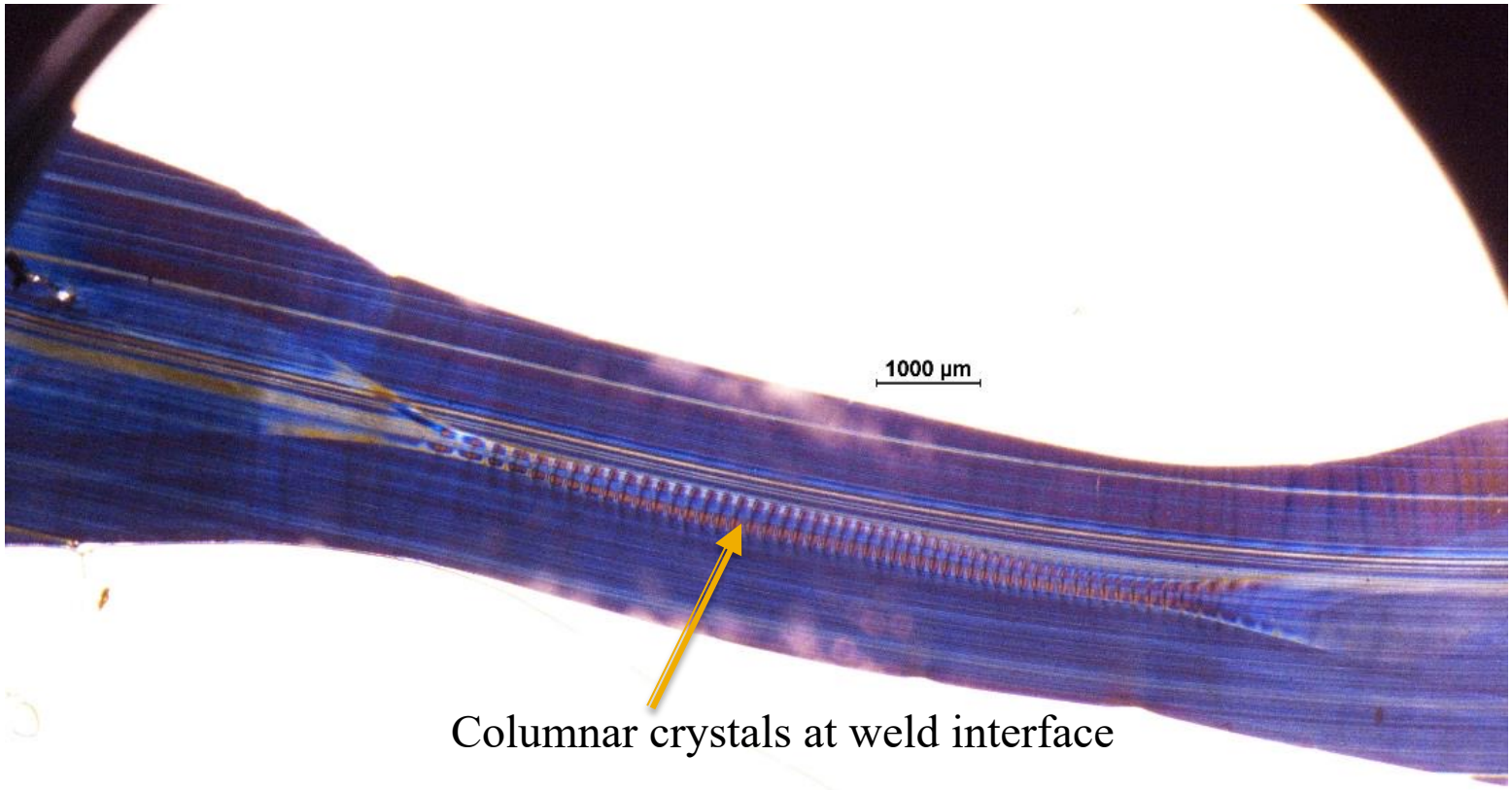
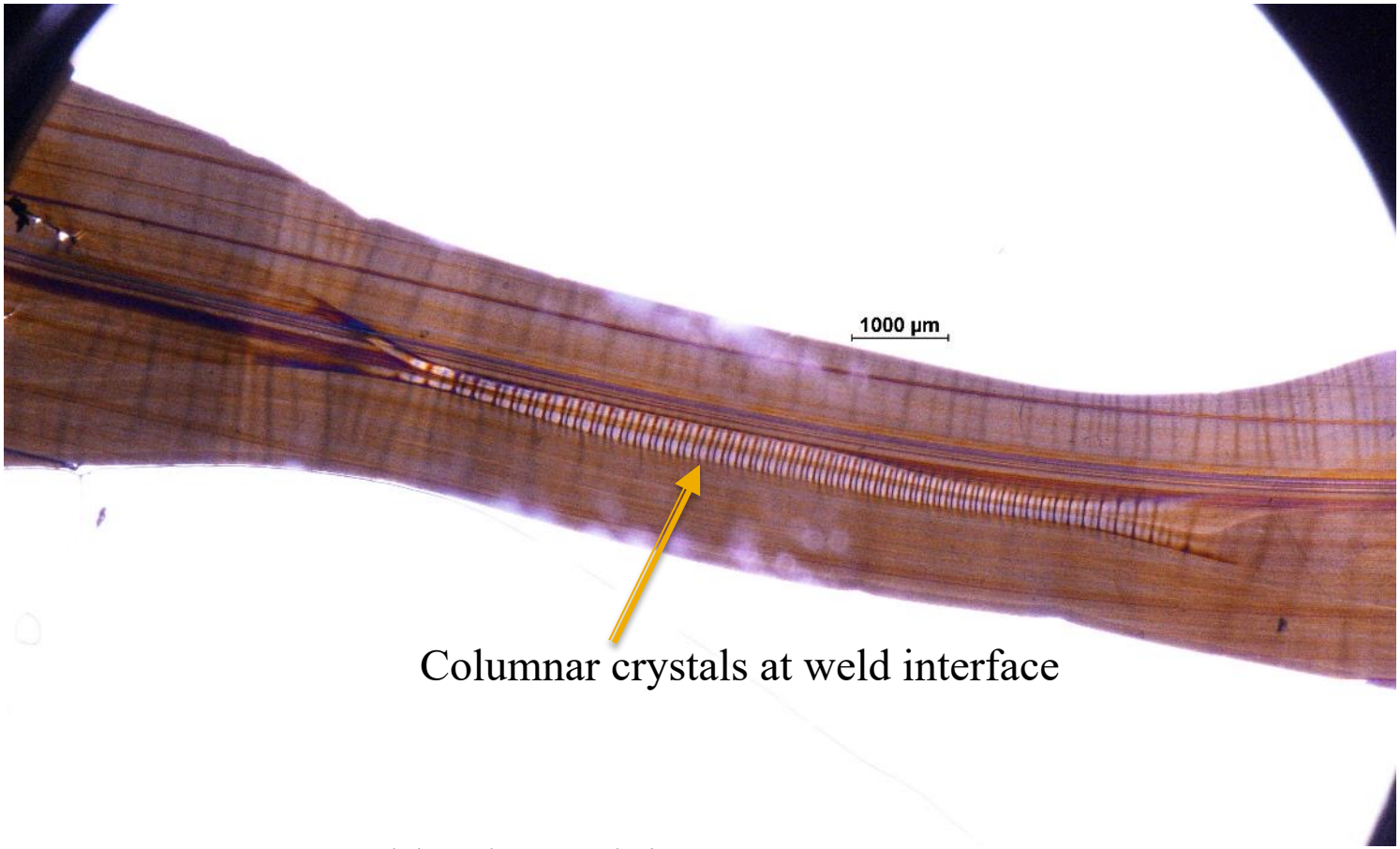


Figure 6.7 EP 1- Affected Weld track 1 beneath retardation plate- 'Air channel side' area under polarization under crossed polarizers

PLP of Cross-Sectioned HDPE Weld Track



PLP of Cross-Sectioned HDPE Weld Trackmple 5 (cont.)



PLP of HDPE Wedge Weld

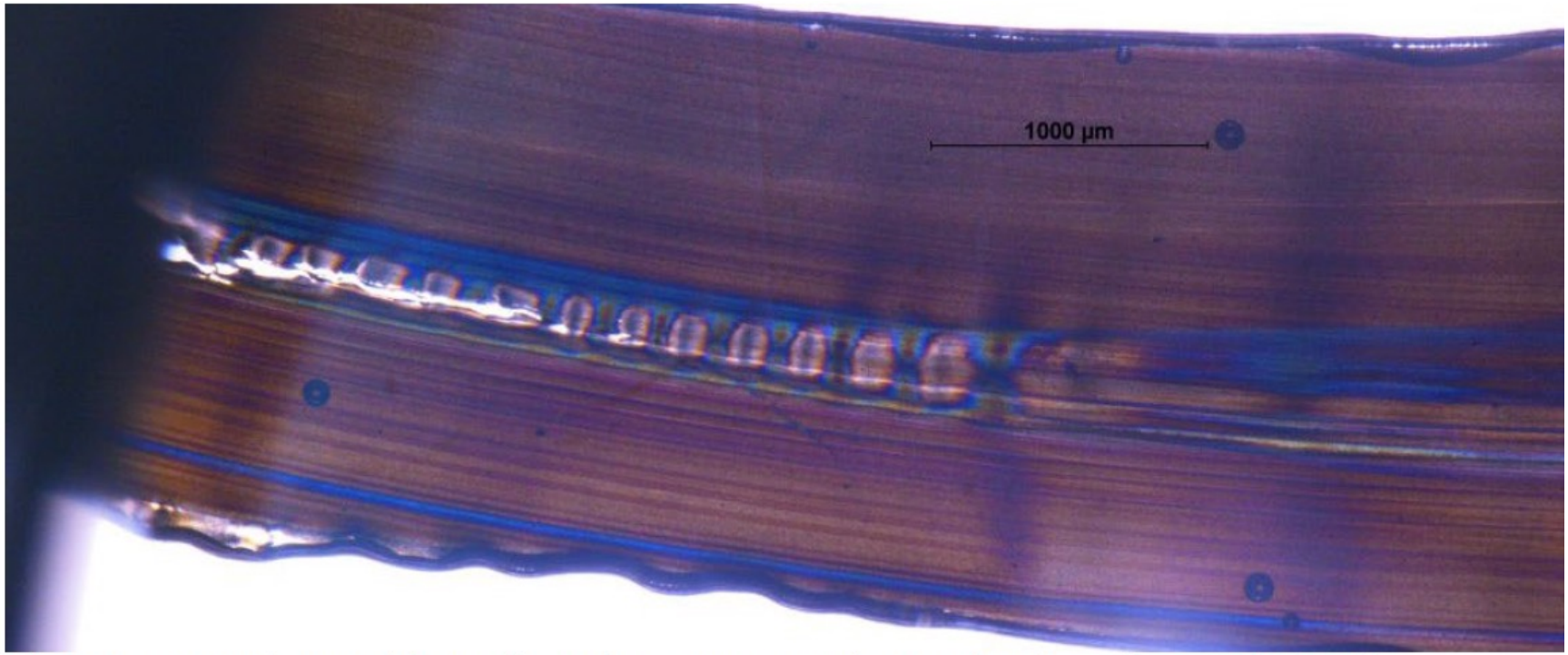
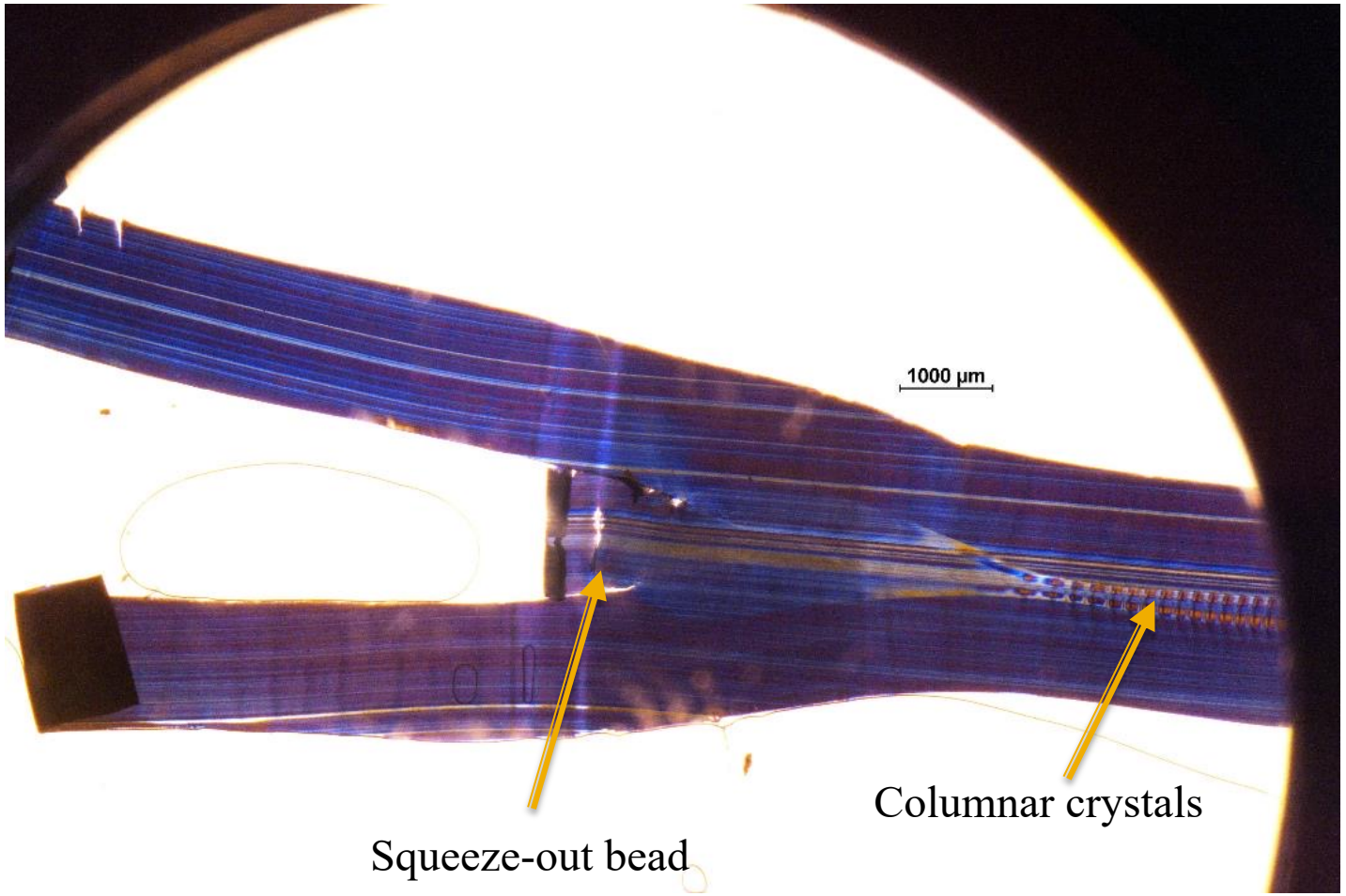


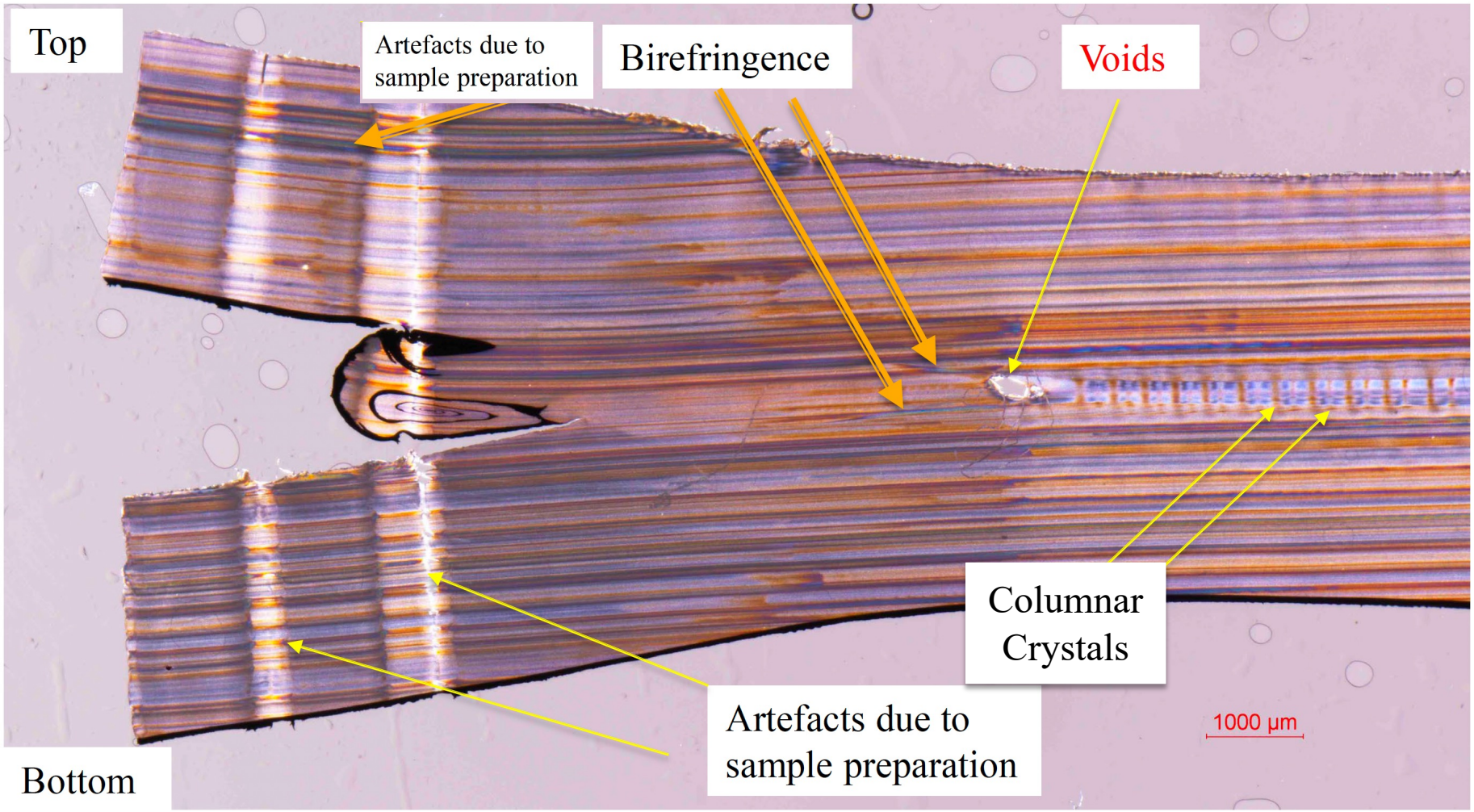
Figure 6.17 Random weld sample under a stereoscopic examination- plane-polarized image

PLP of HDPE Wedge Weld



PLP of HDPE Wedge Weld

PLP of HDPE Wedge Weld



Conclusions - 1

- The appearance of the weld's morphological features depend on the welding parameters used. In the columnar region, elongated spherulites oriented along the flow direction form since the molten material is pushed laterally to form the squeeze out beads. The deformed crystals indicate that crystallization has taken place under a shear stress. Hence the crystals at the weld interface possess a stress-induced crystal structure because they were formed under the influence of a flow stress.

- A plane or region of highly coloured rainbow patterns (known as Birefringence) indicates a plane of higher stress. High residual stress areas can occur for example if the weld zone is too cool or if it is formed too quickly and the partially molten material crystalizes while being pushed out laterally (i.e. sideways) by the nip rollers. Regions of high birefringence signal an adverse condition in the weld since fracture can initiate in these zones due to them acting as stress concentrations.

Conclusions - 2

- The columnar crystals are seen across the weld interface are most important for weld strength. These crystals are transversely striated structures that form while under a shear field. It is optimum if these crystals are small and regular because larger crystals are more likely to have defects and hence exhibit more brittle behaviour. Since geomembrane weld generally cool more slowly than the parent sheet the weld interface shows visible columnar crystals or grains whereas the polyhedral spherulites in the parent sheet as too small to resolve.

- Note since we are microtoming very thin slices (< 10 micron) small tears, thin spots and creases can occur from time to time and these are labelled as artefacts and can be ignored. The thin microtomed slices are mounted between glass slides with a mounting oil (to reduce refractive index differences) therefore there can be black circles appearing on the image and they can be ignored.