Application

LASM - Large Area Scan Macroscope

Directed bright-field illumination

Innovative development in glaciology for the investigation of the microstructure of polar ice cores

The large area scan macroscope from **Schäfter+Kirchhoff** was developed for the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven for use at temperatures down to -40°C (and ultimately at -60°C). This novel ice scanner is a vast improvement over traditional methods in terms of quality, reproducibility and speed.

The ice core sections are automatically scanned at high resolution and speed, totally circumventing the highly time-consuming procedure of taking and then matching numerous individual microscope images, by hand at the computer. Also, the sublimation problems affecting the porosity of the ice during prolonged exposure times are also avoided by such high throughputs.

Ice core investigation at 5 µm resolution using a line scan camera with direct bright-field illumination

Measured width:	41 mm	(measured length is unlimited)
Resolution:	5 µm	(8192 pixels horizontally)
Line frequency:	7.2 kHz	
Scan speed:	36 mm/s	
Measurement duration:	2.8 s	(for a length of 100 mm, 41 mm wide)
Sample distance:	50 mm	
Ambient temperature:	-40°C	(ultimately -60°C)

Glacial and polar ice cores encapsulate the history of the world climate. The trapped gases and aerosols in the deep ice cores provide a detailed record of the atmospheric conditions that prevailed up to hundreds of thousands of years ago.

The longest ice core obtained so far was recovered from the Antarctic. With a length of 3260 m, it is capable of reaching 700000 years back in time. Ice core information about past climate change is indispensable for our understanding of the climate changes currently affecting the world.

Ice formation at a glacier surface is a complex process that is influenced by precipitation, wind strength and the presence of dust and other particles. Over the eons, the fresh snow became compressed into a hard veneer of ice with reduced porosity to gases. The continuous absorption of aerosols and gases, through the variably porous surface over a period of 100 to 100000 years, provides a retrospective snap-shot of atmospheric conditions – only shifted in time. These ice core investigations and analyses provide major new insights about the formation of ice and the variations in the encapsulated gases. The glaciologists of the Alfred Wegener Institute for Polar and Marine Research use these novel findings to reconstruct the past and to seek its relevance for the future.

For more information contact:

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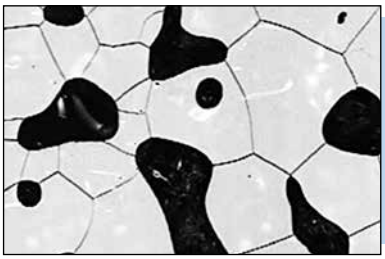
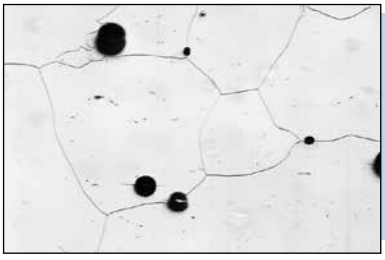
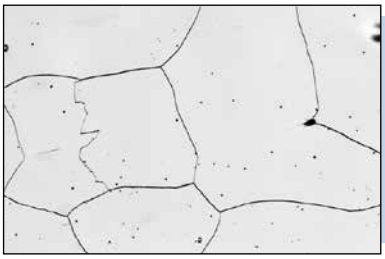


Scan of an ice core from a depth of 60 m under Antarctica. The light granular structure and dark gas bubbles are clearly discernable.



Scan of an ice core from 615 m deep. The bubbles of the encapsulated gas are correspondingly smaller and less frequent.



Scan of an ice core from 1035 m deep. The bubbles have been almost completely transformed into gas hydrates.

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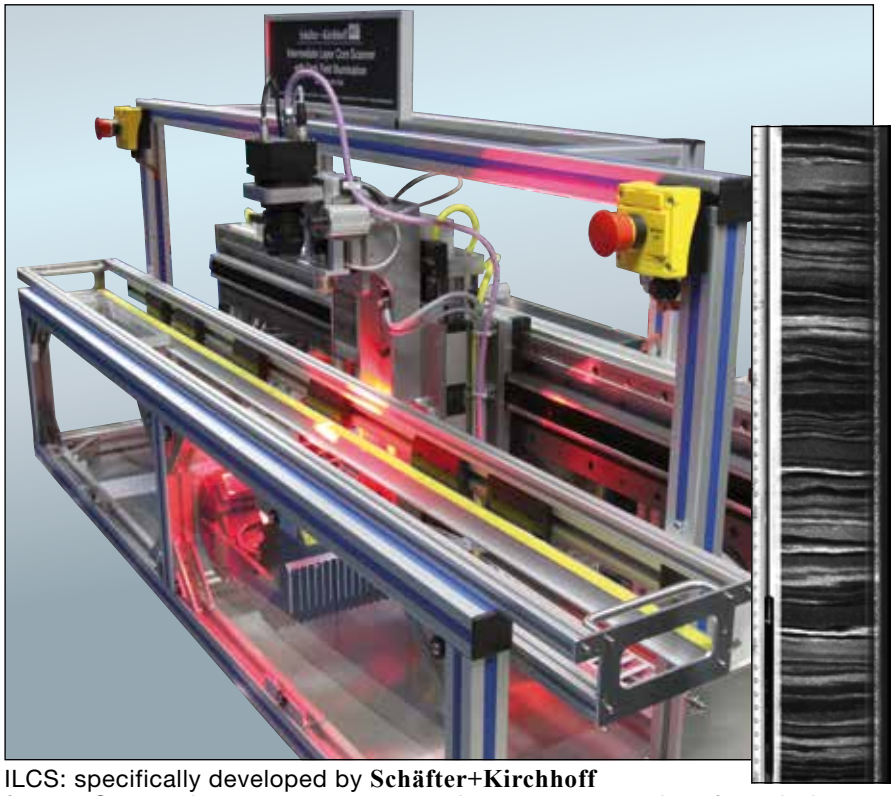
Application

ILCS – Intermediate Layer Core Scanner
Stratigraphy scanner using dark-field illumination

Innovative development in glaciology for the visualization of the laminar structure of polar ice cores

The ILCS Scanner was developed by **Schäfter+Kirchhoff** for expeditions in to the polar regions and all of the mechanical, electronic and optical components were designed for use at temperatures down to -40°C.
The ILCS Scanner is used to image the laminar structure of up to 1.7 m long ice core sections.



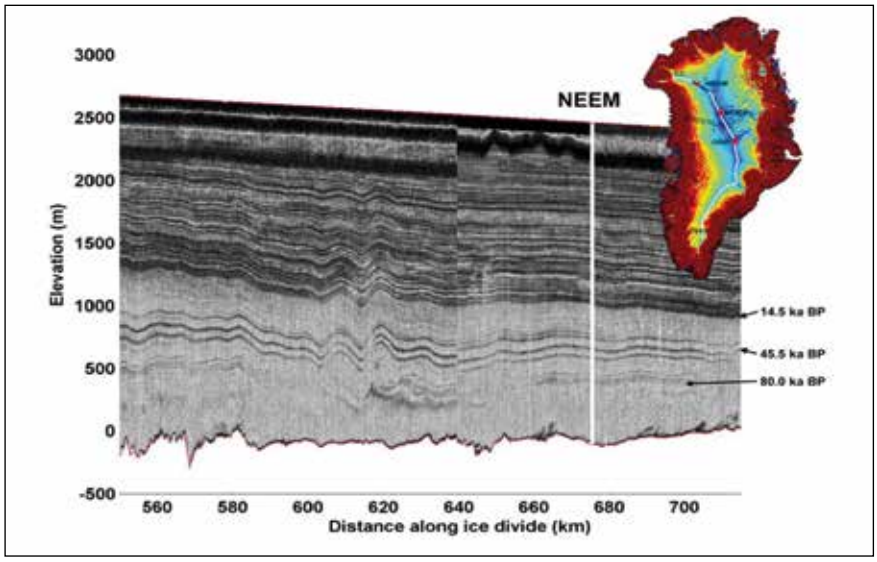
ILCS: specifically developed by **Schäfter+Kirchhoff** for -40°C operating temperatures

Inset: a 40 cm portion of a typical scan

The annual variations in precipitation and deposition of dust and other particles on the icey surface of a glacier result in a characteristic laminar structure that is very informative, revealing climatic variations useful in dating the trapped ice core particles and air bubbles.

Also revealed in the ice are distant global changes, such as the deposited ash from volcanic eruptions from the other side of the world, which serve as a temporal reference when comparing ice core patterns from ice collected at various global locations. This allows the absolute dating of major and minor geologically important events.

For stratigraphic visualization, the optical inspection of the laminar variations proceeds by contiguously scanning manageable chunks of ice core until the many kilometers of a typical ice core have all been documented. The ice cores are sectioned according to a predefined strategy in order to reveal their laminar structure (see below) and are planed flat before scanning. The dark-field illumination depicts the particles and gas bubbles as lighter areas and the clearer ice appears dark.



NEEM – The North Greenland Eemian Ice Drilling Project

The collection of ice cores from the Greenland ice sheet, under the auspices of the (NEEM) North Greenland Eemian Ice Drilling project, was successfully completed in July 2010, after 3 years, when the drill-head hit the underlying bedrock. The ice cores from depths of up to 2.5 km provide a record of the past climate covering more than 120 000 years – back to the Eem warm period when the earth was 3–5°C warmer than today. The sea level was also higher than nowadays, lying about 5 m above current levels.
The large area scan macroscope (see page 52) was also developed by **Schäfter+Kirchhoff** for the direct analysis of an ice core in polar conditions, where the ice is collected and stored.

ILCS – Intermediate Layer Core Scanner

Documentation of the visual stratigraphy of polar ice cores using a line scan camera sensor with dark-field illumination

Operating temperature:	-40°C
Resolution:	0.05 mm
Imaging width:	105 mm
Imaging length:	1250 mm single pass, 1700 mm double pass
Max scan speed:	22.7 mm/s
Scan rate:	48.5 s for a core of 1100 mm
Illumination:	2 x line LEDs (dark-field)

Ice core sectioning strategy as defined by the NEEM Project:

A: Microstructural investigations
B-D: Various visual stratigraphic analyses
E: Gas analysis
F: Archive