CANAIU®

DVN Automotive LiDAR Conference

Juha Kokkonen CEO Canatu

CANATU Transforming products for better tomorrows with nano carbon



Our Carbon nanotubes are at the core of everything we do. They offer excellent and reliable conductivity and transparency for highly engineered solutions.

Our expertise in nanotechnology and working with carbon makes us versatile. We enable breakthroughs that have a wide-reaching impact.



Background

- Aalto University spin-off
- ✓ HQ, R&D and production in Finland
- Fully automated, roll-to-roll film manufacturing line and semiconductor cleanroom



Technology

- Over 100 patents across 23 patent families
- √ Award-winning technology

CANATU[®] We collaborate with forerunner companies to enable breakthroughs in innovation



Transparent conductive films Record-high opto-electric CNT performance for automotive interiors and ADAS heaters

Free-standing CNT membranes The world's thinnest and strongest free-standing CNT membranes for semiconductor manufacturing

Commercial development
In mass since 2015 (automotive) with
nearly 1MIL sensors delivered, FRR 0
Mass production of EUV membranes
since 1H 2021

Licensing agreement (heaters) in 2018

Proven in over 100 projects. Multiple OEM awards



CANATU ADAS is an essential safety and driving enjoyment system – based on understanding the environment with advanced sensors



CAMERA

- + Dominant, used for object detection
- + Cost-efficient and versatile
- Easily affected by weather

LIDAR

- + Accurate 3D distance mapping
- + Less sensitive to weather
- Currently bulky, although miniaturization a key focus in the industry
- Currently costly, although cost expected to reduce drastically

RADAR

- + Distance and speed of objects reflecting radio waves
- + Resistant to adverse weather
- Does not detect all objects

CANATUR But fast development creates urgency to deal with roadblocks to ADAS uptake

- Consumer acceptance
- Legal issues & liabilities
- Reliability of the function in harsh weather conditions

this may be the greatest constraint to ADAS update



CANATU Side effects of sub-optimal weather on LiDAR and camera sensors

- LiDAR and camera system performance degrades in adverse weather conditions
- Sensors get blocked by moisture, rain, snow or frost
- Accurate object detection becomes difficult
- LiDAR is unable to create an accurate 3D map of the measured data



CANATUR Traditional wire heaters cause optical distortion and LiDAR beam deflection

- Conventional wire heaters cause wavefront distortion blocking the optical path of the light
- High thermal gradient in cover glass induce additional laser beam deflection decreasing the range of the scan
- Heating wires obstruct the camera sensor field of view causing pixel distortion leading to distortion on the image



CANATU Overcoming the limitations with Canatu film heaters

- Based on Canatu CNT film, featuring record-high transparency and conductivity, ultra-low haze and no reflection
- Wire-free, enabling maximum transmittance at LiDAR optical path
- Thin-film heater, offers even heating across the entire surface because the whole surface is conductive
- 3D formable enabling easy integration in LiDAR sensors embedded in the front bumper, emblem or other special parts.





CANATU[®] ADAS sensor types have unique characteristics that impact ADAS heater designs

Camera	Lidar	Radar
 Relatively broad range of wavelengths covering the visible light spectrum (and infrared cameras extending to non-visible infrared spectrum) Inbound light from the environment as signal source: sensor needs to be able to handle a very broad range of light conditions and signal sources Very complex signal analysis task: Machine learning based object recognition Sensitive to signal path degration, e.g., haze, distortions, uneven spectral transmission Optical: high-level of transmittance in visible light spectrum, minimal haze and distortions Heater typically integrated into glass due to sensitivity to signal path integrity 	 Specific wavelengths, 905 nm and 1550 nm Signal source accurately controlled by the user, does not rely on externally emitted signals: works well in all lighting conditions Well-defined and limited analysis scope: create a distance map of the field of view Sensitive to wavefront degration in the signal path Optical: high-level of transmittance in specific infrared wavelengths. Wavefront uniformity essential Heater typically integrated into structural elements or glass. 	 Specific and narrow frequency band around 77 GHz Signal source accurately controlled by the user Well-defined and limited analysis scope: create a distance and velocity map of the field of view RF: high-level of transmittance in specific radio frequency. Neutral polarization characteristic important Heater typically integrated into structural elements.
Visible: 400-700 nm Infrared: 800 – 1400 nm $4 10^{22} 10^{20}$ γ rays 1 1 1 $10^{-16} 10^{-14} 10^{-12}$	905 nm, 1550 nm 10 ¹⁸ 10 ¹⁶ 10 ¹⁴ 10 ¹² 10 ¹⁰ 10 ⁸ 10 ⁵ X rays UV IR Microwave FM AM Radio waves 10 ⁻¹⁰ 10 ⁻⁸ 110 ⁻⁶ 10 ⁻⁴ 10 ⁻² 10 ⁰ 10 ²	$\begin{array}{cccc} & 77 \text{ GHz, 3,9 mm} \\ 10^4 & 10^2 & 10^0 & v \text{ (Hz)} \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & & \\ &$
11/19/21	Increasing V	$Wavelength (\lambda) \rightarrow Corr}$

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CANATU LiDAR heater

- Wire-free at LiDAR optical path
- High transmittance at LiDAR wavelength
 - CNB is wavelength independent, measured by spectrometer
- High uniformity at LiDAR optical path
 - CNB does not contribute on transmitted wavefront slope (RMS), measured by interferometer





CNB heater power on







38urad@60C 24V

CANATU Meeting the industry standards for reliability

- An automotive-accredited 3rd party lab has validated that Canatu heaters fulfil the high industry standards in reliability.
- To simulate accelerated aging, samples are kept in 85°C temperature at 85% humidity.



CANATU Canatu ADAS heaters – complete portfolio for current and future ADAS solutions

Canatu Camera Heaters



Phase: Mass development with lead customers

Benefits

- **Optical performance:** High and uniform transmittance at visible and infrared wavelengths, low haze and disturtion, low reflection, color neutral
- Heating performance: Efficient and even heating
- **Design flexiblity:** Multiple on-glass and in-glass integration options
- Temperature monitoring allowing dynamic power control: Real-time temperature tracking to optimize power consumption
- Reliability: Automotive-grade reliability

Canatu Lidar heaters



Phase: Concept development with lead customers

Benefits

- **Optical performance:** Uniform transmittance at Lidar wave lengths, high level of wavefront uniformity on CNB film
- Heating performance: Efficient even heating
- **Design flexibility:** High level of design freedom with 3D formable solutions
- **Temperature monitoring allowing dynamic power control:** Real-time temperature tracking to optimize power consumption
- Reliability: Automotive grade reliability

Canatu Radar heaters

Phase: Concept study with lead customers

Benefits

- RF performance: Low RF signal attenuation with specifically designed CNB heaters
- Heating performance: Solid heating performance
- **Design flexiblity:** Highlevel of design freedom with 3D formable heater solutions
- **Temperature monitoring allowing dynamic power control:** Real-time temperature tracking to optimize power consumption
- **Reliability:** Automotive grade reliability

Canatu film heaters Enabling any-weather safe autonomous driving

EVEN HEATING Thin-film heater, offers even heating across the entire surface and keeps the whole surface clear from moisture, snow and ice.

LOW DISTORTION Entirely wire-free, enabling maximum transmittance at LiDAR optical path, and accurate 3D map of the measured data.

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3D FORMABLE Can be fabricated in any 3D shape enabling easy integration and full field of view in 360° LiDAR & fish-eye camera sensors.

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Nano solutions for massive impact













CANAIU®

Autonomous driving in any weather

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