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covestro

Advancing autonomous driving in any weather

Canatu LiDAR heaters with Covestro Makrofol® and Makrolon®

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Canatu is a carbon nanomaterial developer. We create the most advanced carbon nanotubes for industry-transforming products.

Background

- Aalto University spin-off
- HQ, R&D and production in Finland
- 70+ international team with 15 nationalities

Technology

- Over 150 patents
- Fully automated, roll-to-roll film manufacturing line and semiconductor cleanroom

Commercial development

- Mass production for three automotive OEMs and 1 for semicon
- Over 600,000 sensors delivered, FRR 0
- ISO 9001, ISO 14001, IATF 16949

Business focus

Automotive
High performance transparent conductive films for ADAS heaters and 3D touch sensors.

Semiconductors
The world's thinnest and strongest free-standing CNT membranes for EUV applications.

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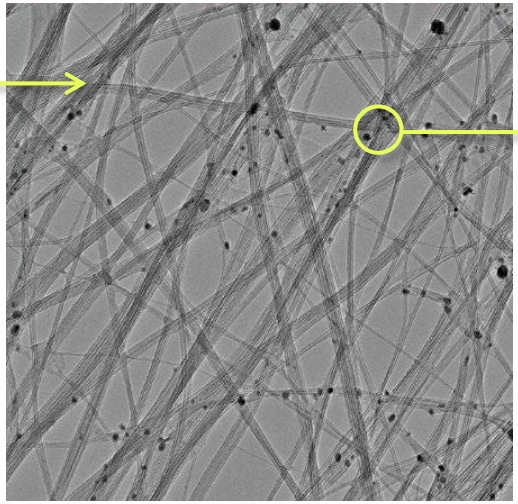
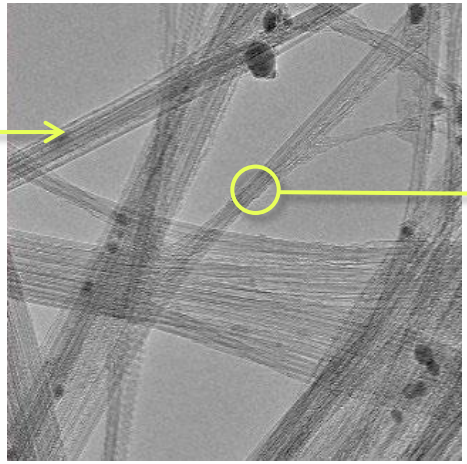
Canatu Carbon Nanotubes (CNT) – Welcome to the nanoscale

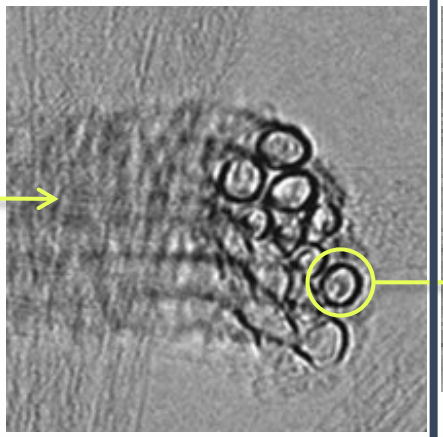
Canatu CNT **film**
0.6 x 0.6 m^2



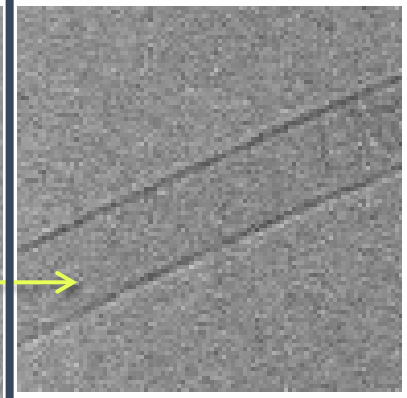
Network of CNT bundles
200 nm



Network **junctions**:
bundles branch and cross
50 nm



Bundle of individual Canatu CNTs
10 nm



Canatu **CNT**
1 nm

Lidar wavelengths
850 - 1 600 nm

Canatu CNT feature size is ~1000 x smaller than lidar wavelengths, making it optically very attractive for lidar applications.

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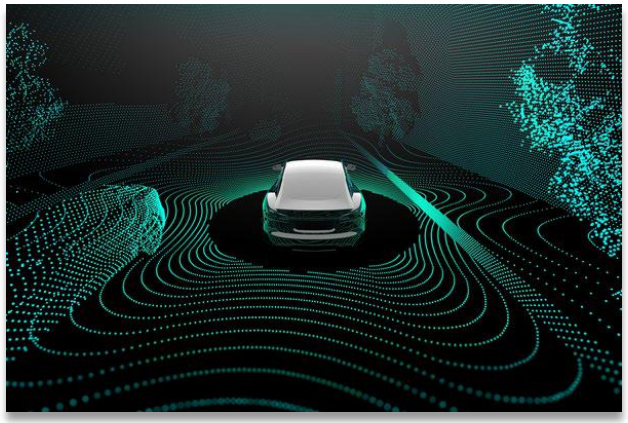
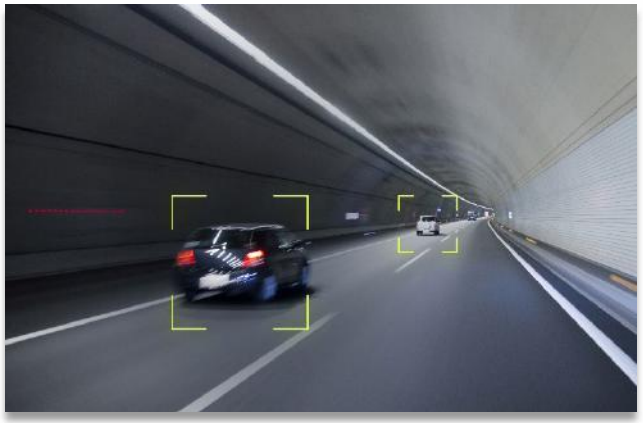
Enabling autonomous driving in any weather with Canatu CNT film heaters



LiDAR

Canatu transparent heaters for LiDAR provide clear field of view for the LiDAR, ensuring accurate 3D mapping of the vehicle's surroundings.



Camera

Wire-free windshield camera heaters provide even and power-efficient heating of the whole surface, enabling accurate object detection without optical distortion.

Headlamp

Unlike halogens, LEDs don't generate heat to deice the headlight. Snow and ice buildups obstruct the light beam and in-lamp integrated sensors. Canatu's wire-free film heaters provide energy-efficient and even heating keeping headlights clear in any weather.

Key benefits for LiDAR

Key benefit	Unique features
 Superior optical performance	• Record high transmittance at LiDAR • Metal-free at FOV, low reflection and haze • High wavefront uniformity
 Even and power-efficient heating	• Record high electrical conductivity • Even heating without optics-degrading thermal gradient • 40% lower power consumption compared to traditional heating solutions with optional temperature monitoring
 Design and integration flexibility	• Customizable to customer needs • Can be implemented on various flexible film substrates • 3D formable with < 1mm bending radius • Integration via film injection molding or in/on-glass lamination

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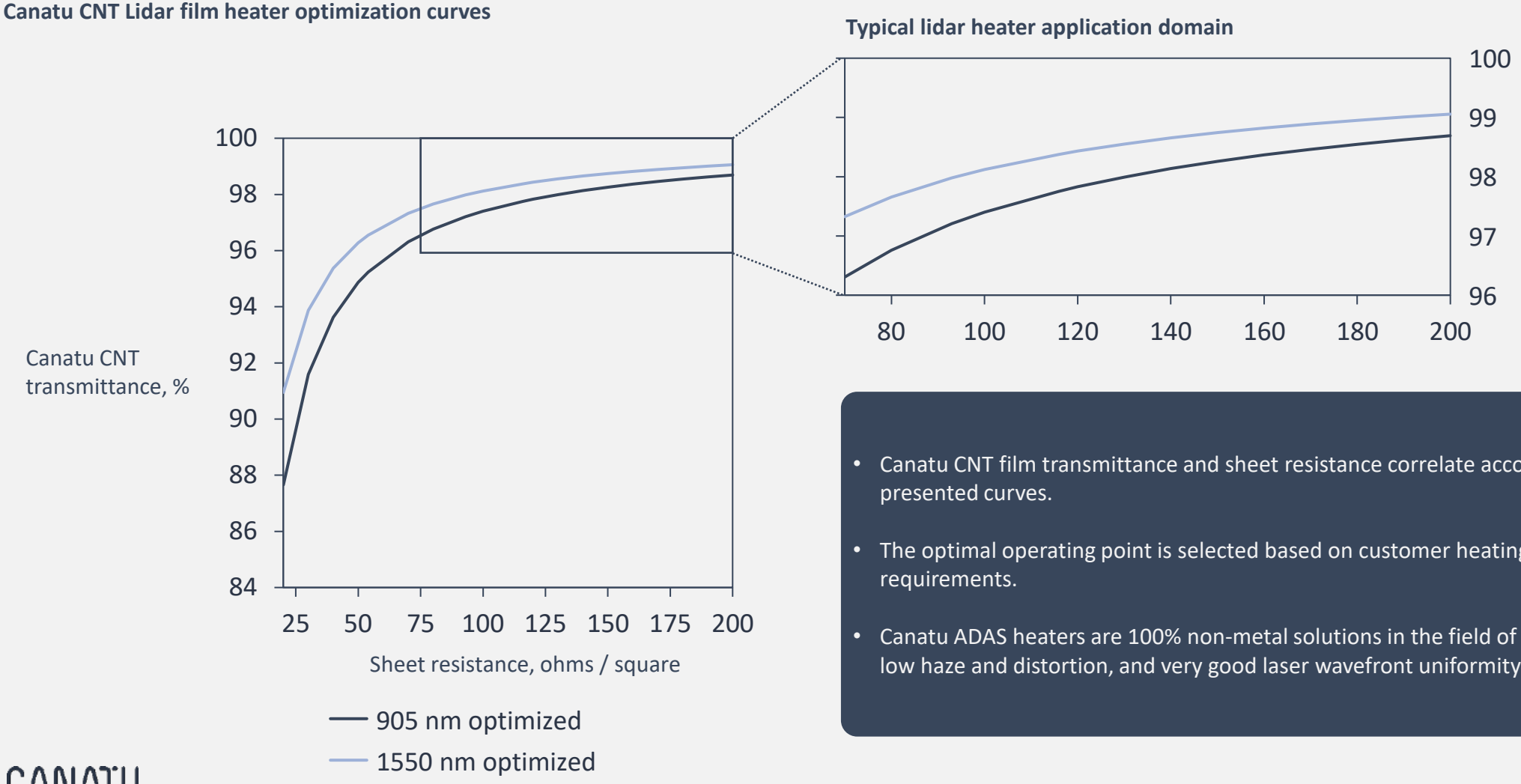
Canatu CNT offers superior optical performance in Lidar applications

Canatu CNT Lidar film heater optimization curves



- Canatu CNT film transmittance and sheet resistance correlate according to the presented curves.
- The optimal operating point is selected based on customer heating and optical requirements.
- Canatu ADAS heaters are 100% non-metal solutions in the field of view resulting in very low haze and distortion, and very good laser wavefront uniformity

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Rapid innovation: Latest developments with Canatu CNT

	Development focus	Results	Key benefits for LiDAR deployments
Canatu CNT performance	• New Canatu CNT synthesis process	• 80% improvement in heating performance with same optical specification	• Faster heating combined with improved lidar performance
Canatu CNT manufacturing	• High performance CNT reactor • Production automation	• 4x increase in Canatu CNT thin film production capacity • Fully automated production line in clean room	• Capacity to meet rapidly increasing lidar demand • High level of process consistency for high precision lidar heaters
Thin film portfolio	• Expansion of validated thin-film portfolio to support customer needs	• **Covestro Makrofol® PC incl. LiDAR specific variants** • Variety of PETs from industry leaders	• Functional freedom to build Canatu CNT lidar heaters on broad set of thin films
Integration with PC and glass lenses	• Verified reference designs for film-insert-molded and glass-laminated lidar lenses	• Verified reference designs for film-insert-molded and glass-laminated lidar lenses	• Design freedom to integrate Canatu CNT heater flexibly with PC and glass lidar lenses and covers

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Makrofol® and Makrolon® enabling Canatu CNT technology

Canatu + Covestro: Solution providers for heated LiDAR cover lenses

Solutions overview

Sensor transparent films:

- Makrofol® DE (transparent clear)
  Makrofol® ST (sensor transparent black)

Coated films:

- Canatu CNT on Makrofol® can be tailored to meet a variety of customer's electrical, optical and design requirements

LiDAR cover materials:

- Makrolon® AG ST, AX ST, Ai ST
  (sensor transparent PC in various colors)
- High consistency batch to batch
- High impact resistance strength
- Made for "laser clear" molding
- Proven for polysiloxane and polyurethane hard coatings for weathering and scratch protection

Covestro Showcase K'2019

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Covestro – Engineering Plastics

Materials	• Clean production • Color competence • Close specification	We have the materials
Metrology	• New in-house laser metrology • New evaluation methods • Clean room facilities	We have the data
AD Service	• Molding and coating competence • First choice application development platform • Focus on enabling technologies for ADAS	We have the know-how

COVESTRO = Your Innovation Partner

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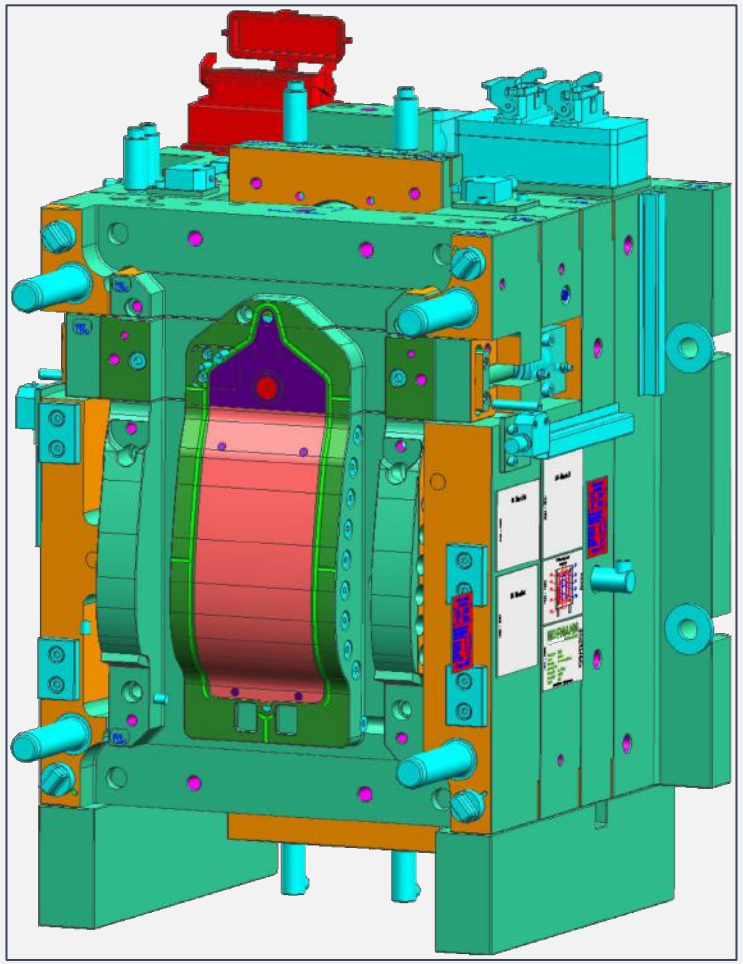
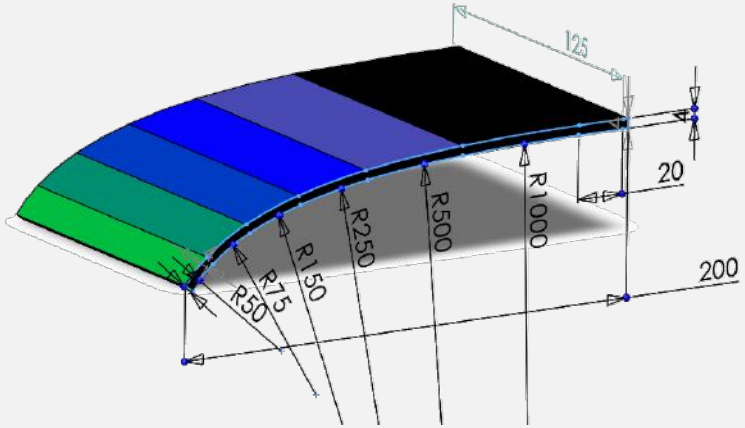
Enabling LiDAR – Design of the sensor test cover

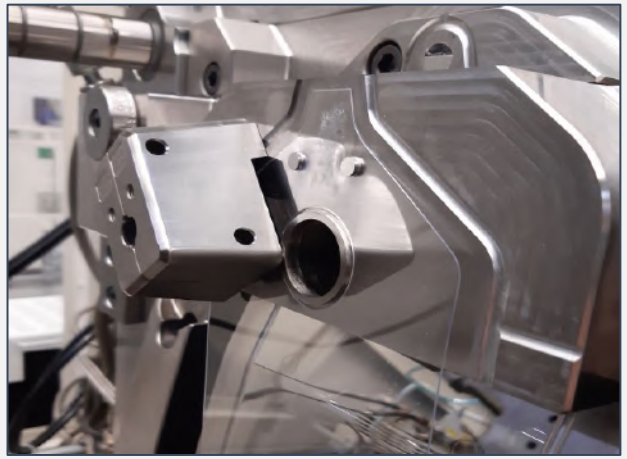


Injection molding tool Covestro, Leverkusen

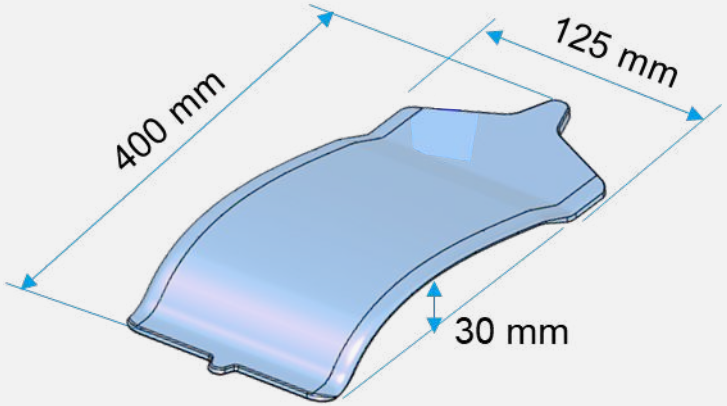


Segments with defined inner & outer radius

Molded part with connector



Circuitry connector possible



Final part dimension

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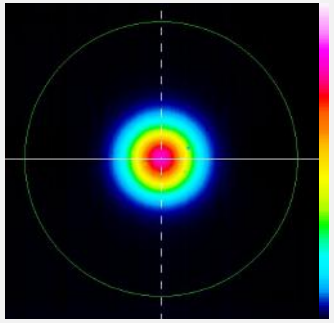
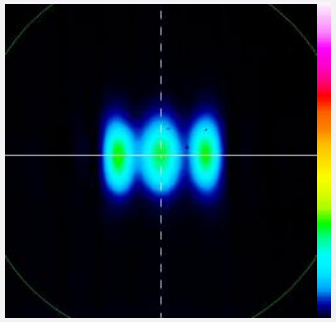
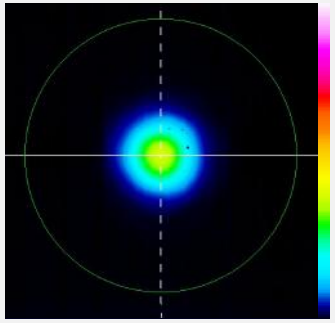
Enabling LiDAR – Heater benchmarking test



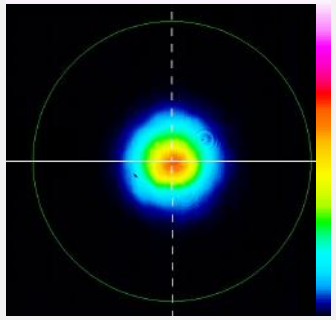
Input laser power



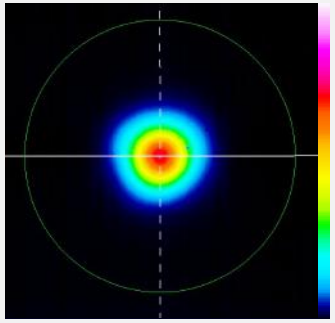
Transmitted power
w/ wire heater



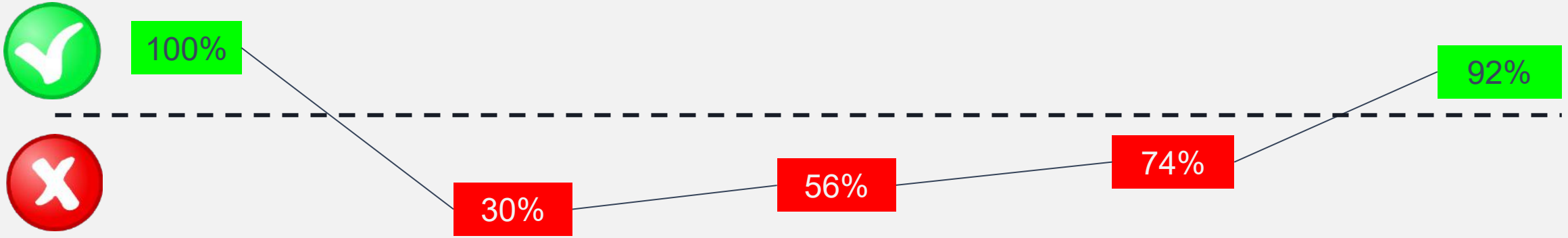
Transmitted power
w/ silver ink heater



Transmitted power
w/ metal mesh



Transmitted power
w/ Canatu CNT



(* 6% gain through LR + AR coating included)

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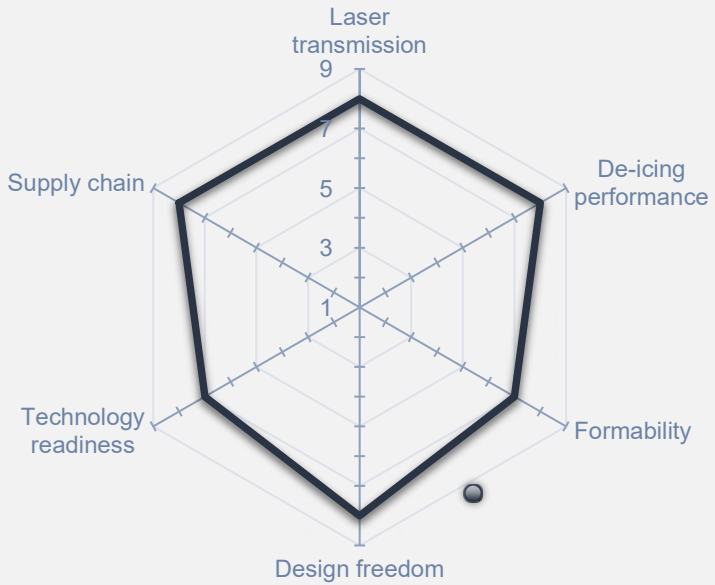
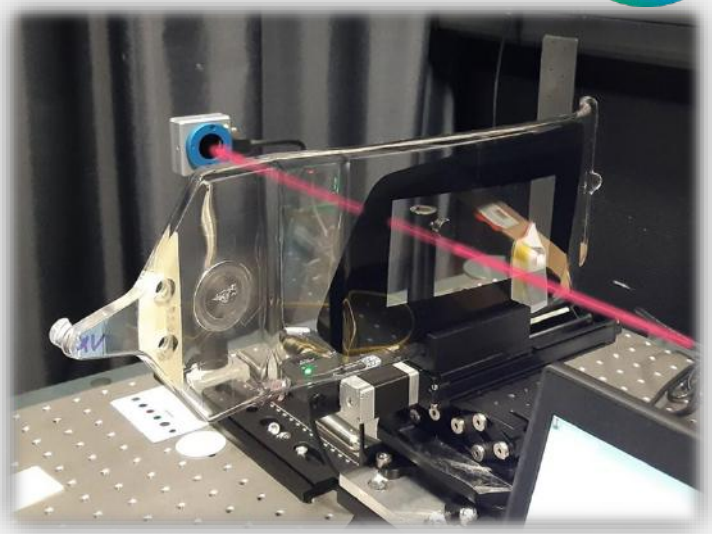
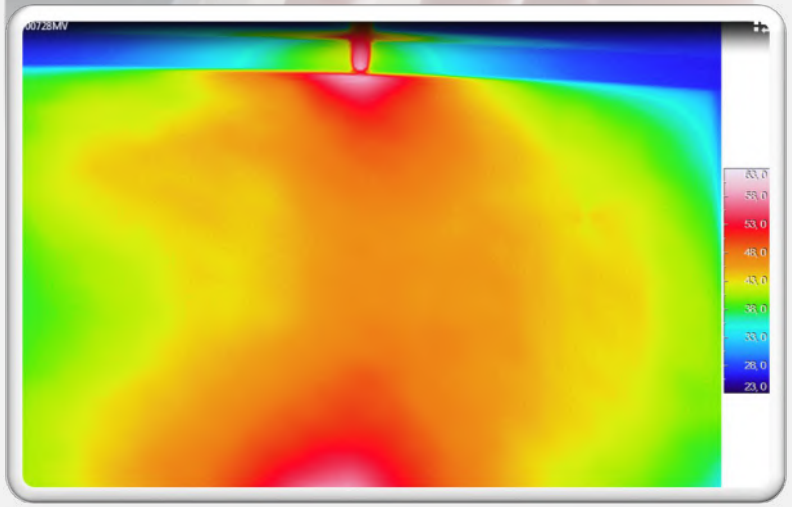
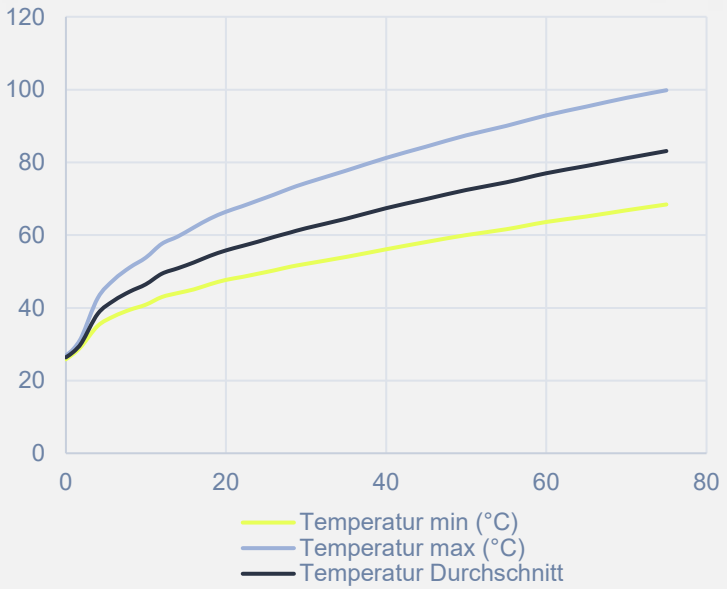
Canatu CNT passes Covestro’s validation program









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Thank you!

Come check out the Canatu + Covestro lidar sensor cover at Canatu booth!

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