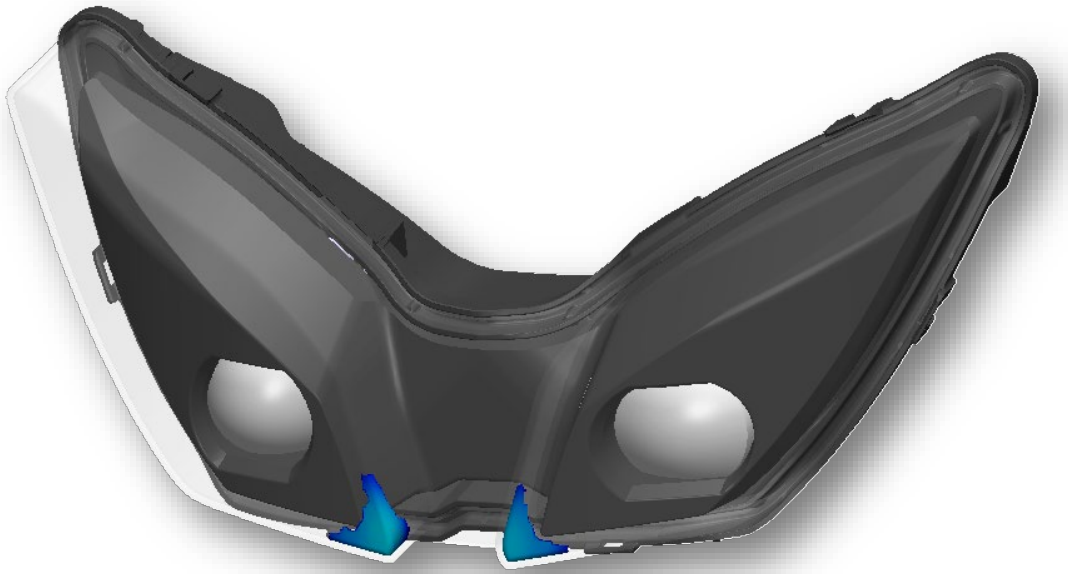
CornerStone
Application Technology Ltd.

CFD Simulation of Headlamp Condensation



Jia-Xiong Li

成 基 應 用 科 技

CornerStone Application Technology

SIEMENS
Ingenuity for life

Outline for Today's Talk

- Motivation
- Literature Review
- Simulation Tool – Simcenter FloEFD
- Simulation Condition
- Result & Discussion

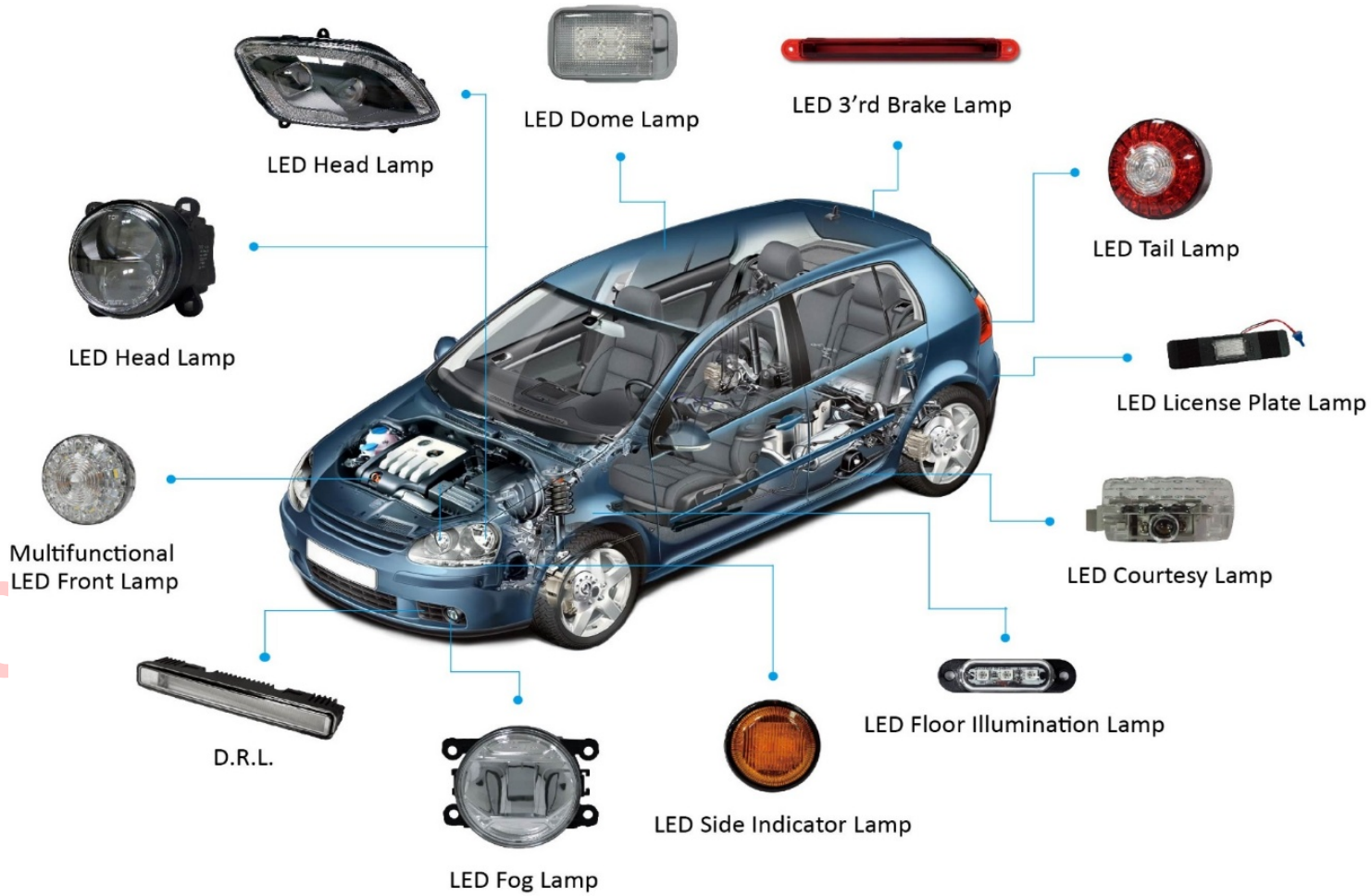
Acknowledgement

JTST TOP ®

IATF 16949：2016

ISO 9001：2015

ISO 14001：2015



LED Automotive Lighting / MANUFACTURER / - Since 1982 -

Motivation

Swimming goggle

Windscreen

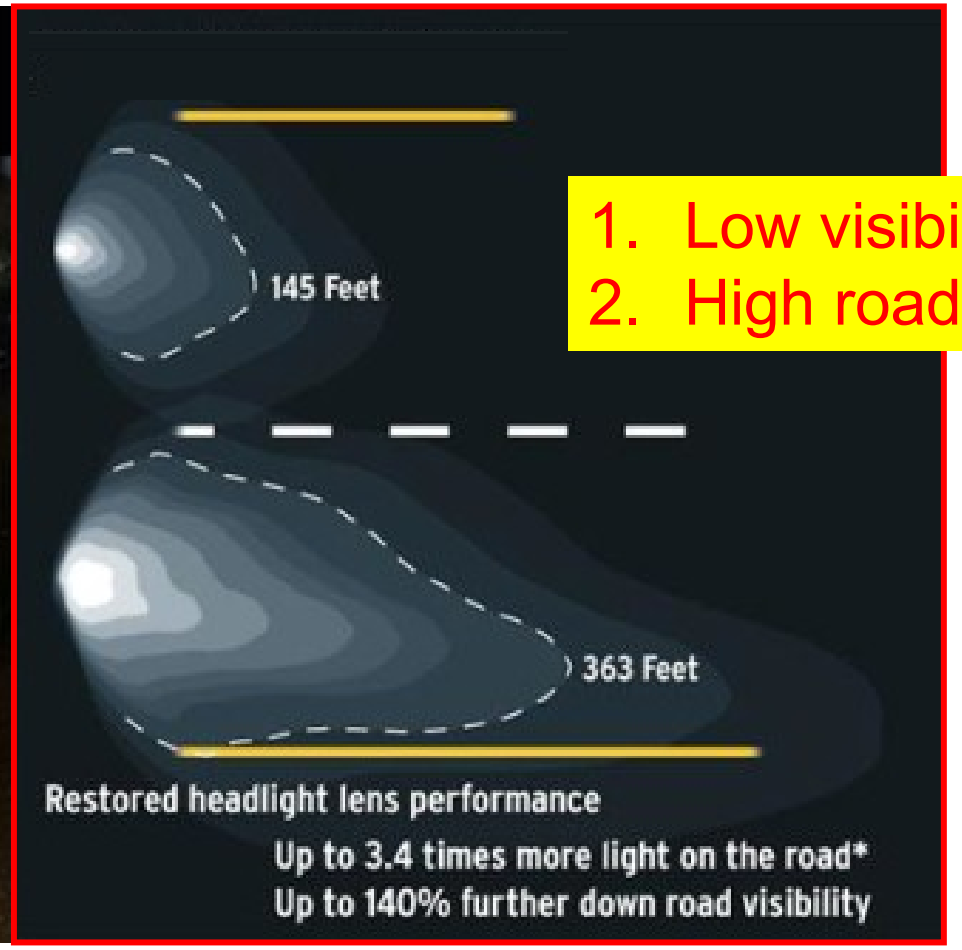
Mirror

Camera Lens

GoPro Lens

Headlamp

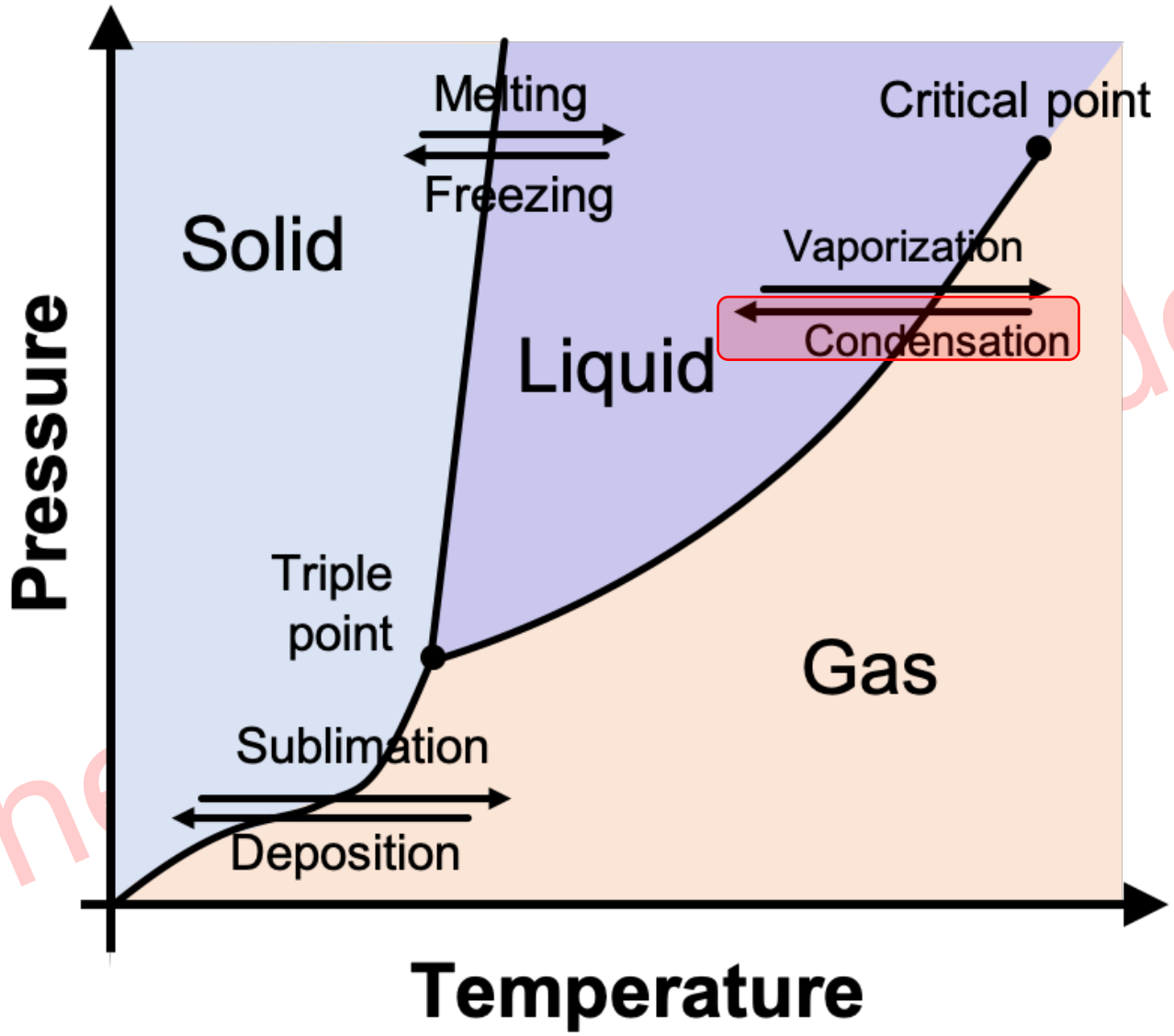
Motivation



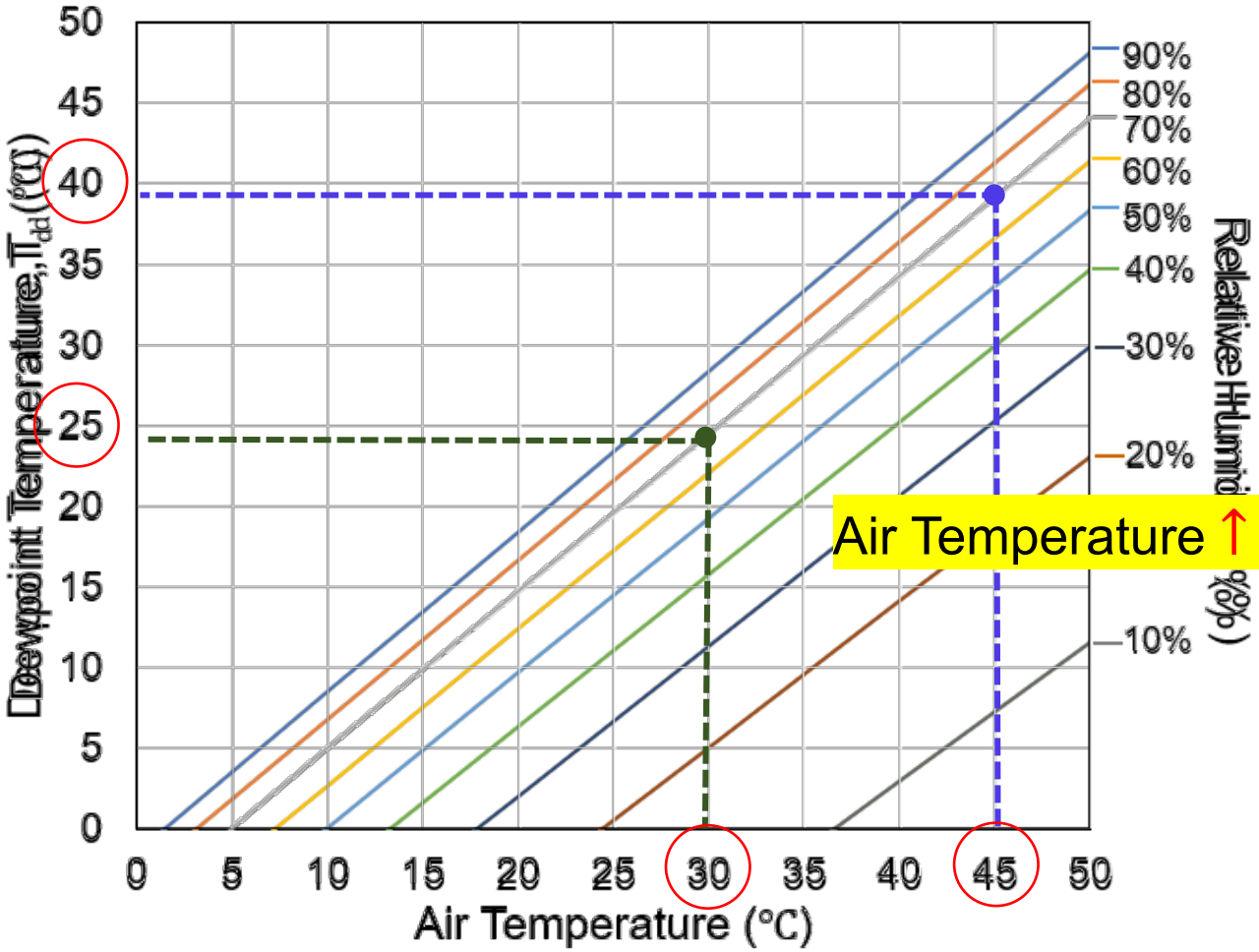
1. Low visibility
2. High road risk

Image from *https://www.popsautoelectric.com/automotive-headlights/*

Phase Change Diagram



Dew Point

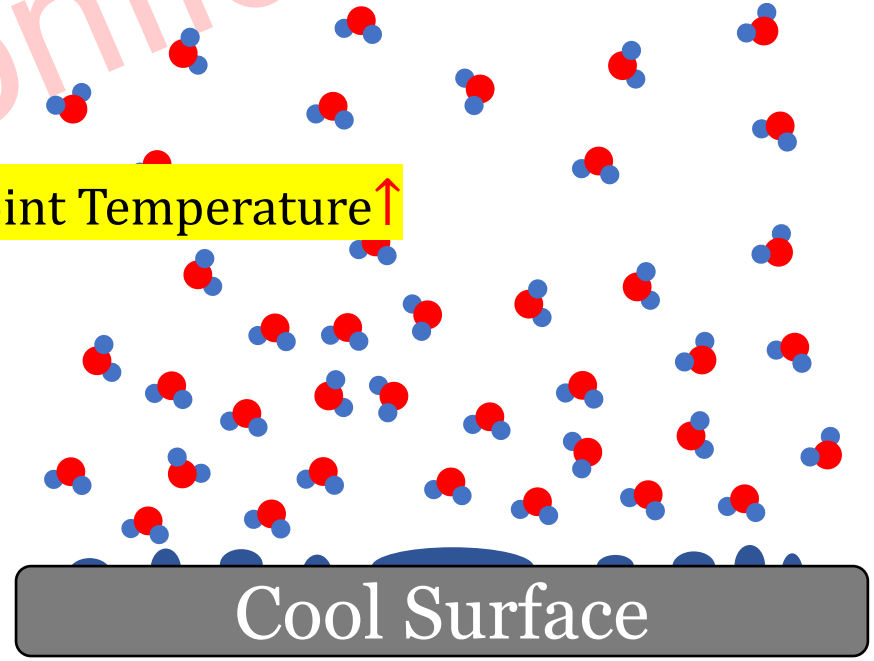


$$T_d = \frac{br(T,RH)}{a - r(T,RH)}$$

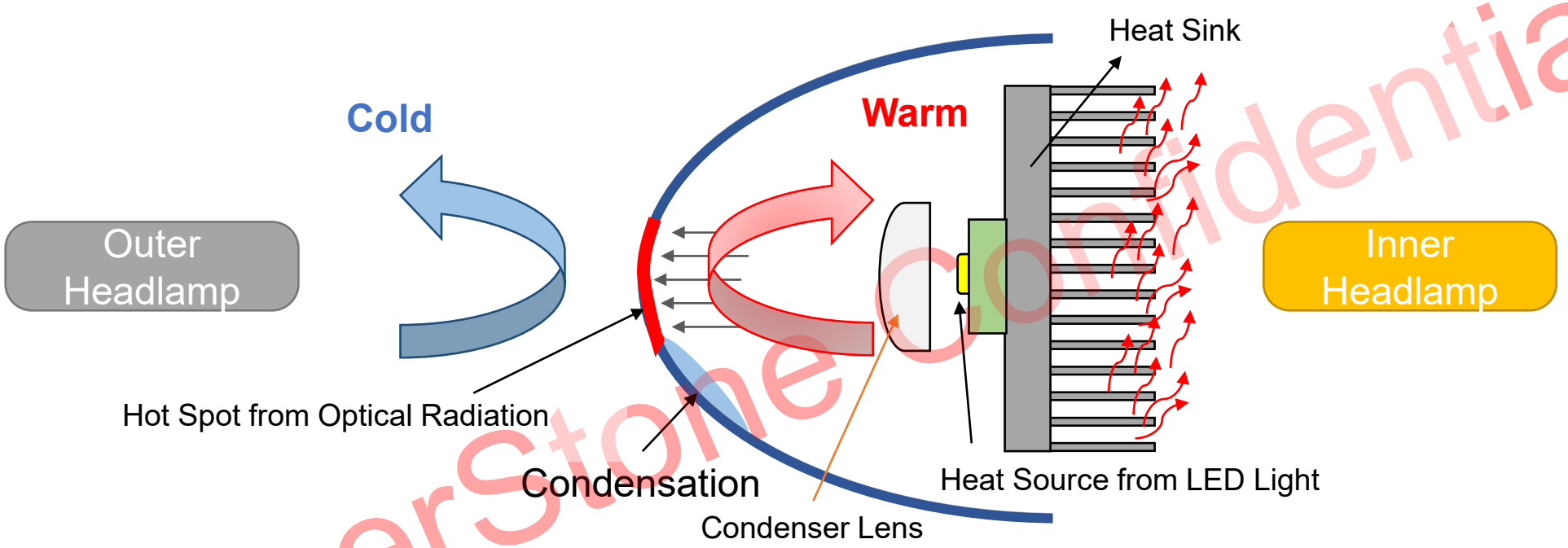
Td: Dew point temperature

1. Relative Humidity
2. Ambient Temperature
3. Surface Temperature

Air Temperature ↑，Dew Point Temperature↑



Literature Review



Literature Review

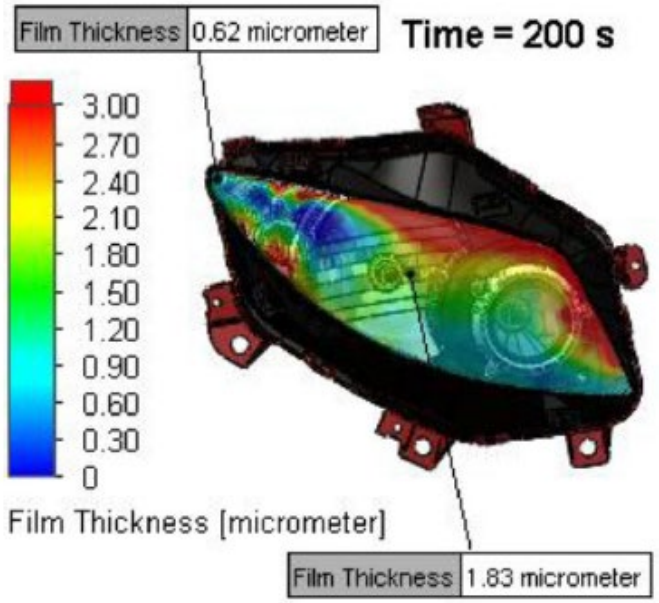
Ambient Temperature : -10 ºC

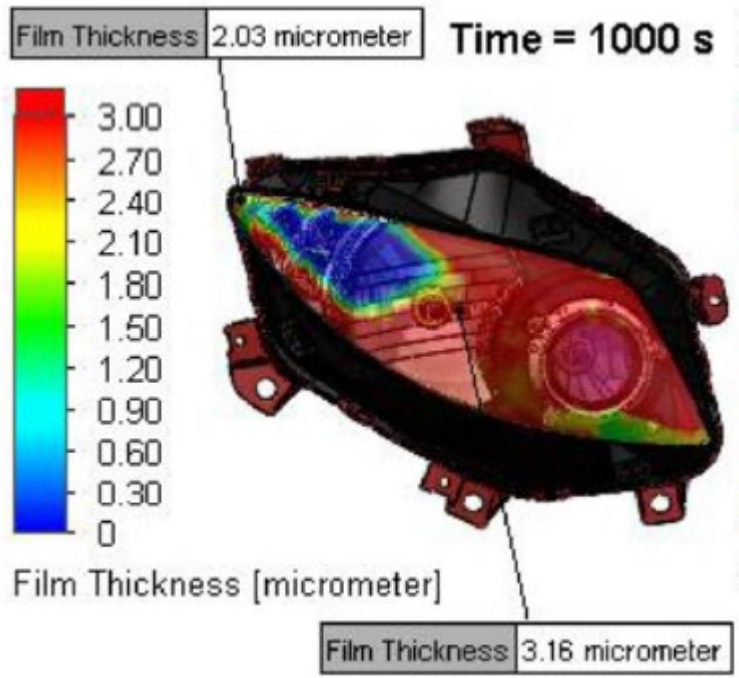
Headlamp's interior Temperature : 25 ºC

Atmosphere : 1 atm

Relative Humidity : 95 %

LED Light : Turn Off





Mentor Graphics Corp, *SAE International.* (2018)

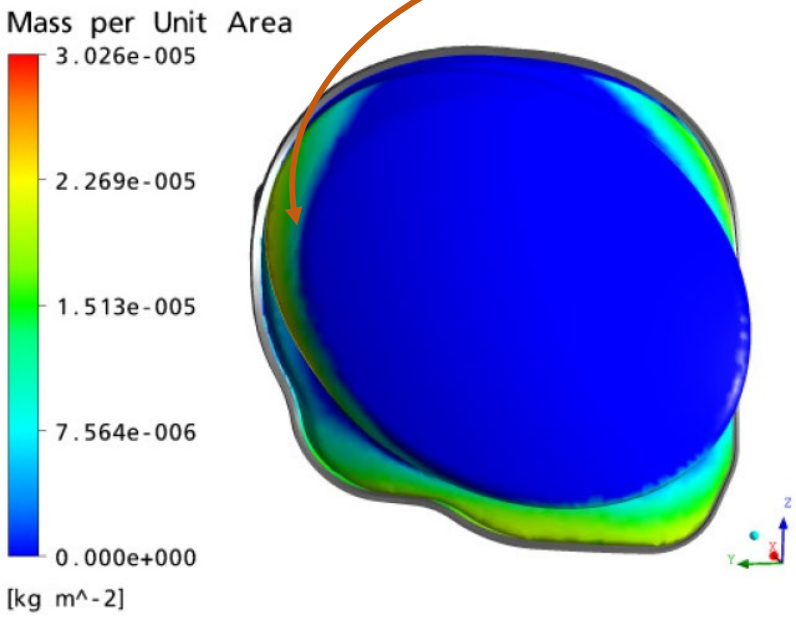
Literature Review

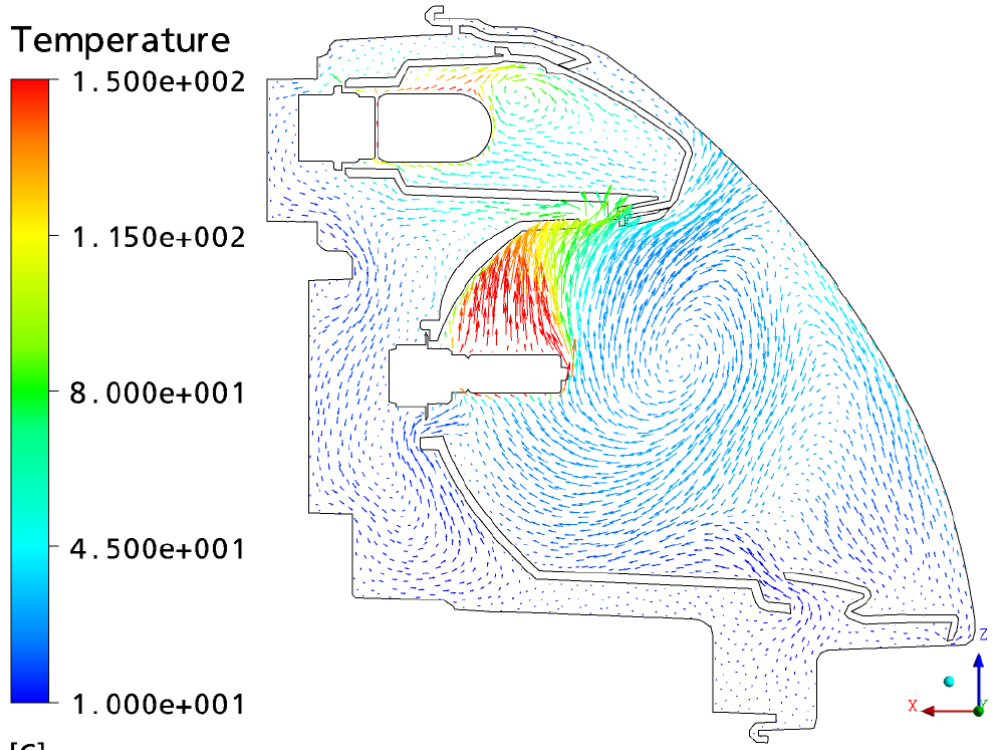
Ambient Temperature : 6 ºC

Atmosphere : 1 atm

Relative Humidity : 95 %

LED Light : Turn On





Alberto *et al.*, *Physics.* (2011)

Literature Review

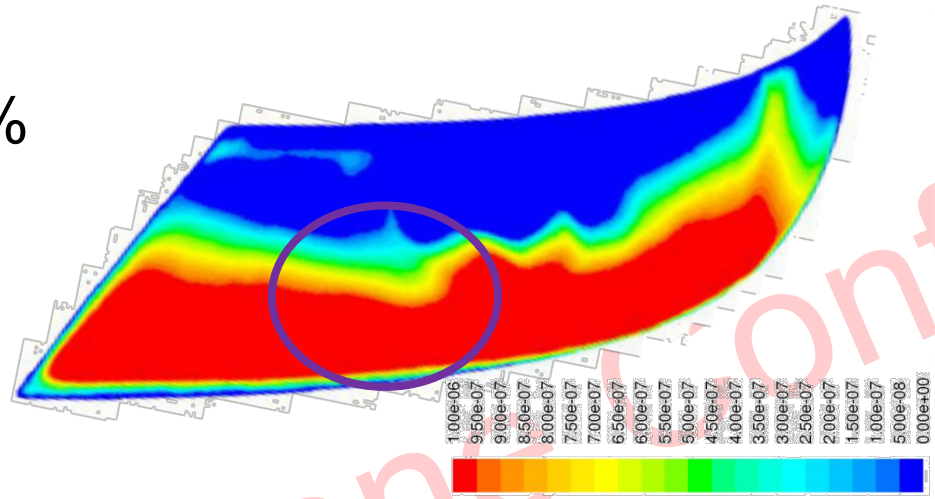
Ambient Temperature : 5 ºC

Atmosphere : 1 atm

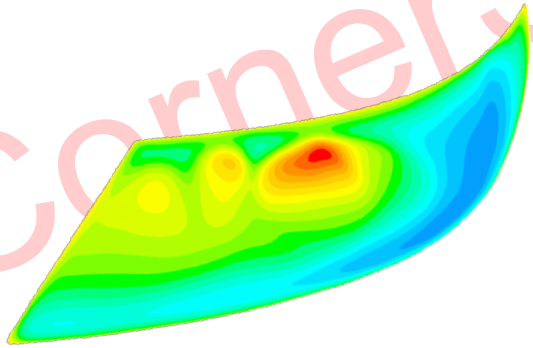
Relative Humidity : 90 %

LED Light : Turn On

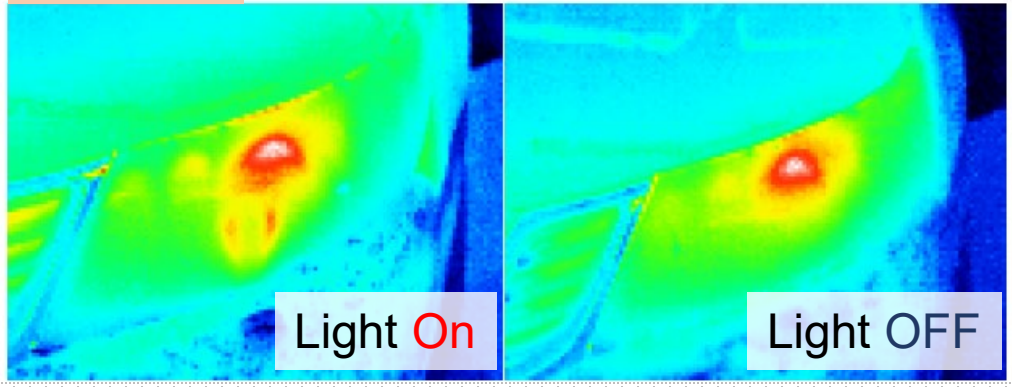
Water film thickness on the lens



Temperature contour on lens



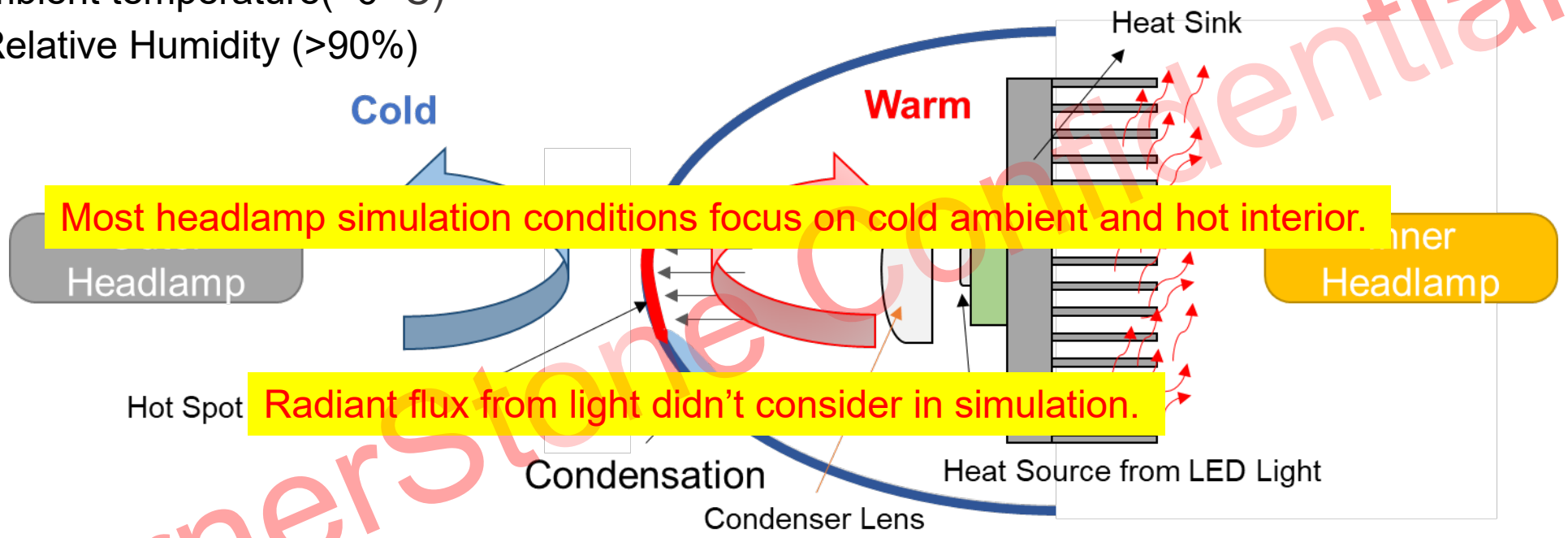
IR Image



Johan, *Thesis.* (2011)

Literature Review

Cold ambient temperature(<6 ºC)
High Relative Humidity (>90%)



Simulation Condition

Ambient Temperature : 26 ℃ (Room Temperature)

Atmosphere : 1 atm

Relative Humidity : 80 %

Physical time: 1800 s

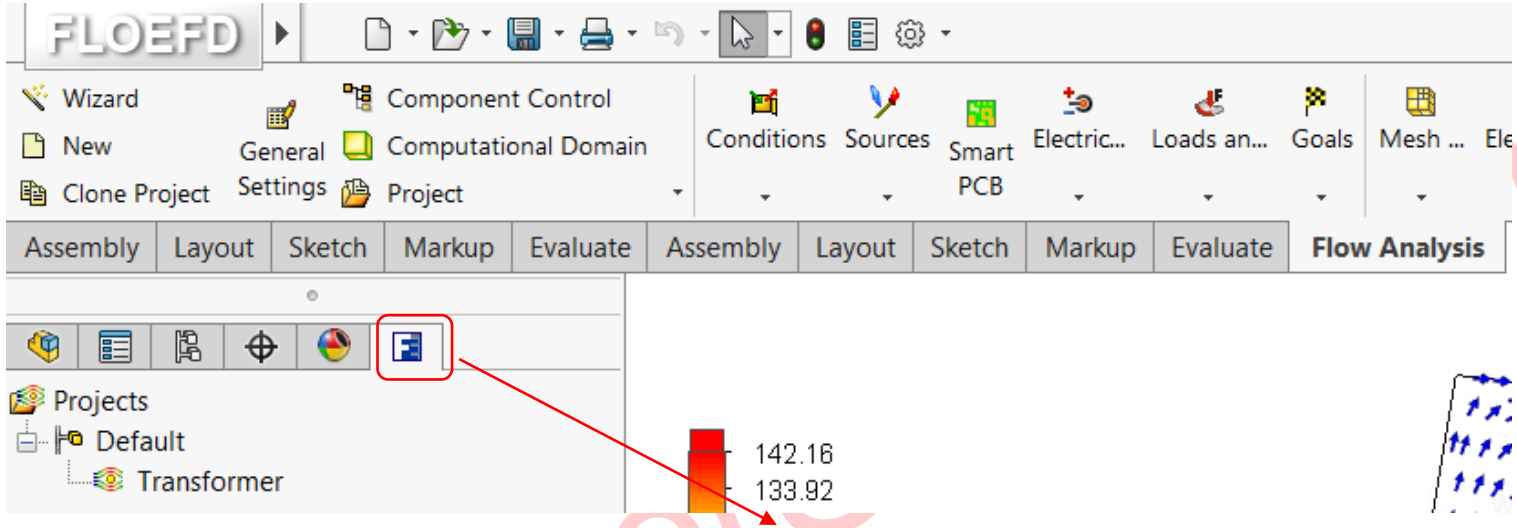
LED Light : Turn On (Consider optical radiation on lens)

CFD Tool : Simcenter FloEFD

Easy Verification

Simulation Tool – Simcenter FloEFD

No more switching between solutions from Geometry to CFD



Use your MCAD directly in FloEFD

PLM Software SIEMENS NX

SolidWorks

creo™ A PTC Product

CATIA

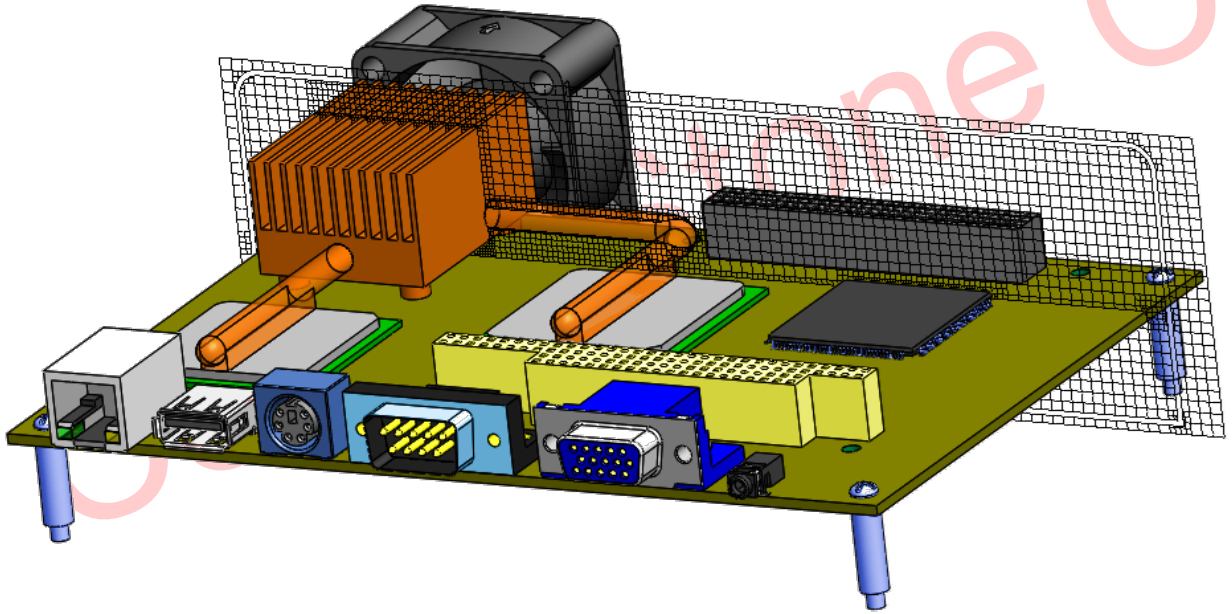
Solid Edge

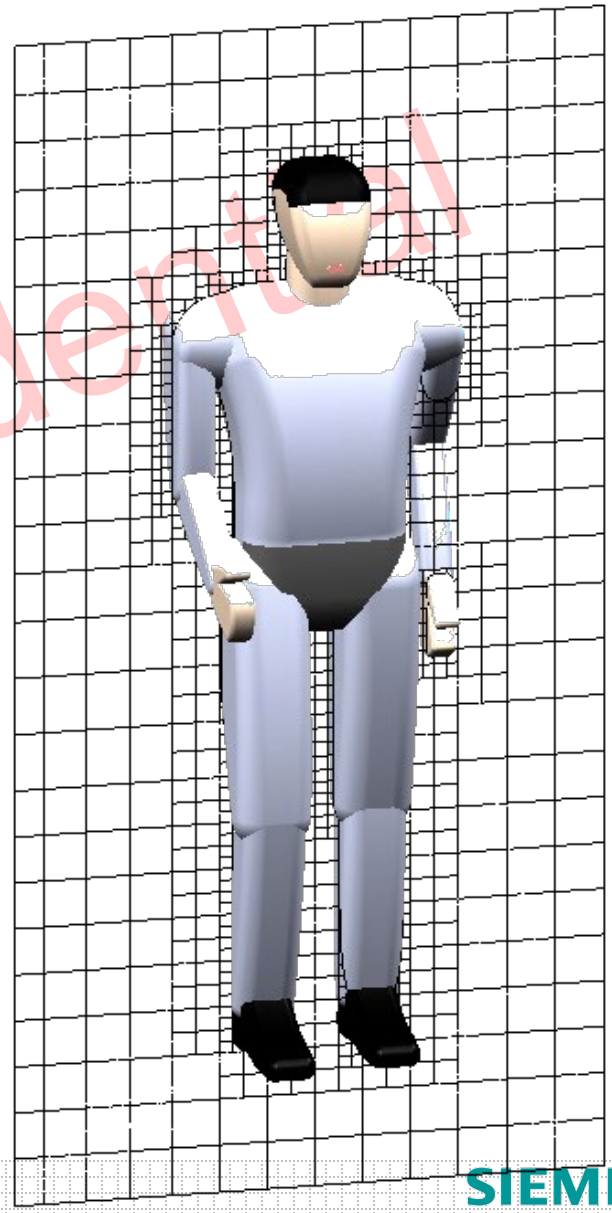
Autodesk Inventor Suite

Simulation Tool – Simcenter FloEFD

Smart Cartesian Meshing Technology

- ✓ Unique SmartCell technology featuring multi control volume cells
- ✓ Automatically refines in regions based on geometry or flow conditions
- ✓ No need to be a CFD meshing expert to use FloEFD

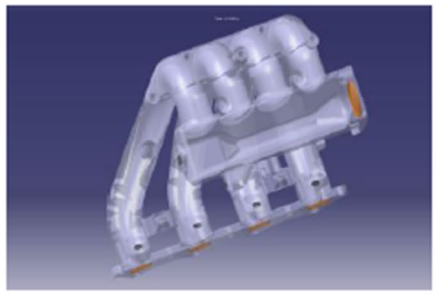




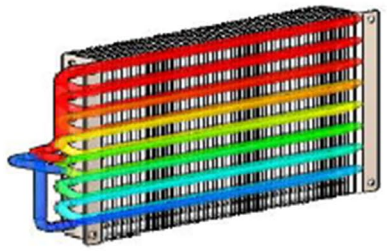
Simulation Tool – Simcenter FloEFD

Physics Range

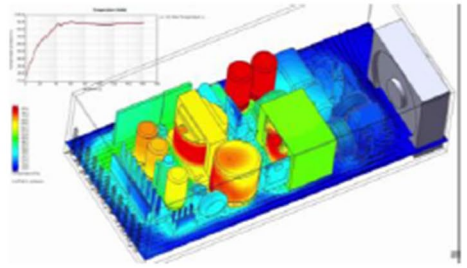
1. Fluid Flow
2. Heat Transfer
3. Real Gas Flows
4. Non-Newtonian Flows
5. Compressible Liquids
6. Free Surface Flows
7. Rotating Flows
8. Radiation & Optical Effects
9. Condensation
10. Steam and Humidity
11. Water Films
12. Sorption of Vapor
13. Surface Icing and De-icing
14. Equilibrium Combustion
15. Cavitation
16. Joule Heating
17. Aerothermal Heating
18. Hypersonic
19. Particle Tracking



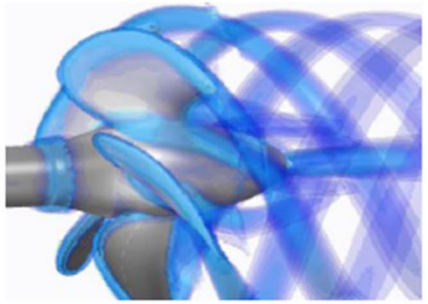
MIXING FLUIDS



REFRIGIRANTS (Real Gas)

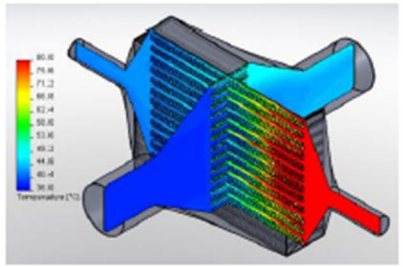


ELECTRONICS COOLING

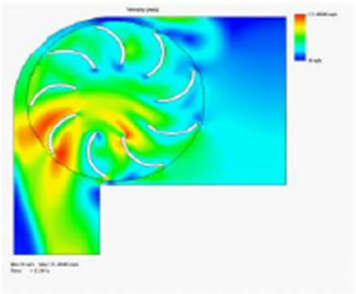


CAVITATION

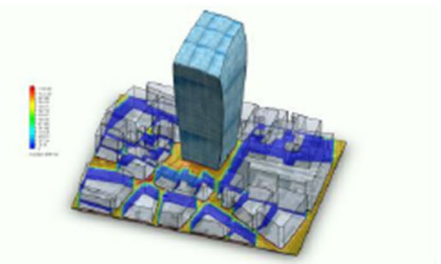
CONDENSATION



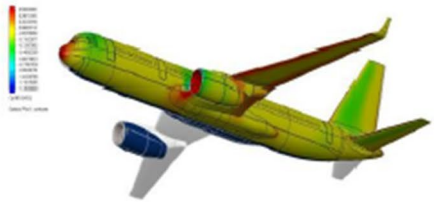
HEAT EXCHANGER



ROTATING EQUIPMENT

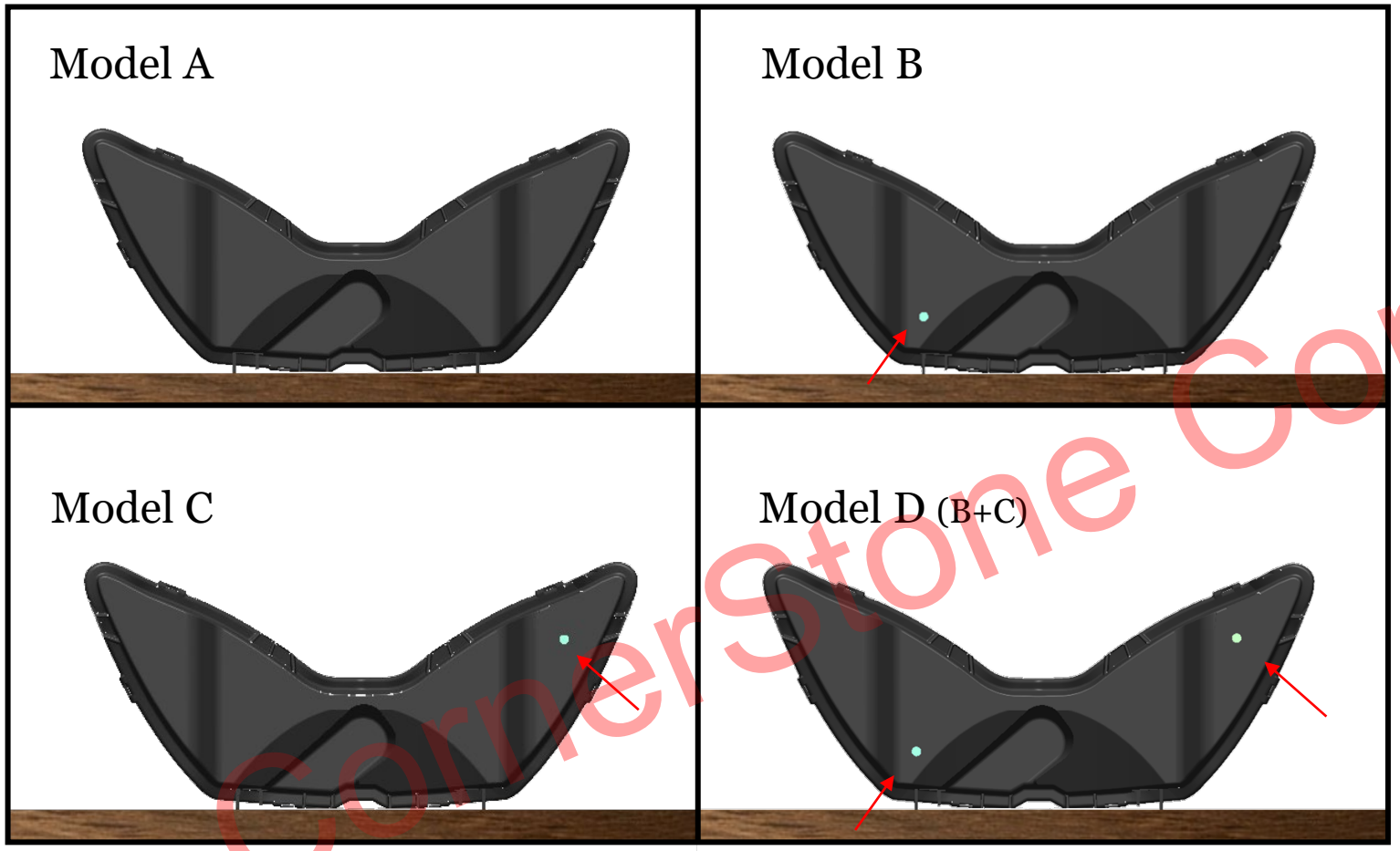


RADIATION



AERODYNAMICS

Simulation Models

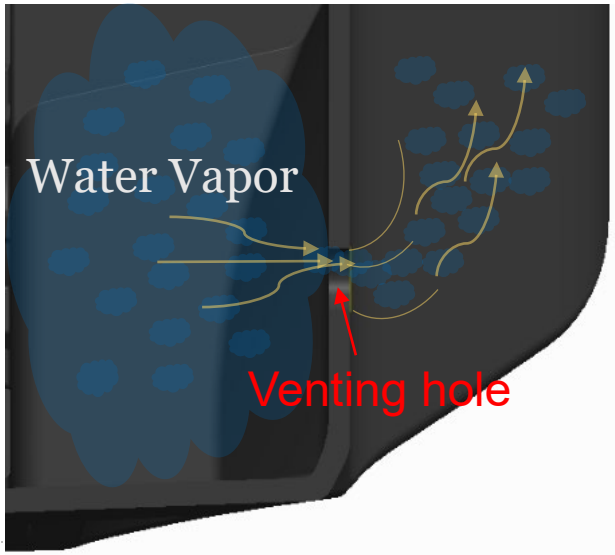


Vent-Membrane Property

Gas permeability coefficient: 1.14×10^{-9} $m^3m/m^2/s/Pa$

Vapor diffusion coefficient: 2.41×10^{-7} m^2/s

Thickness: 0.16 mm



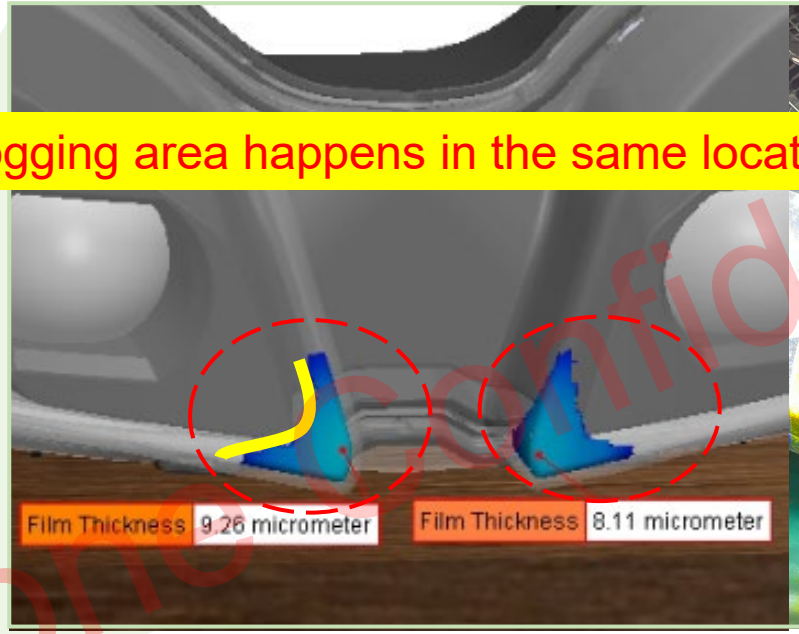
Result & Discussion

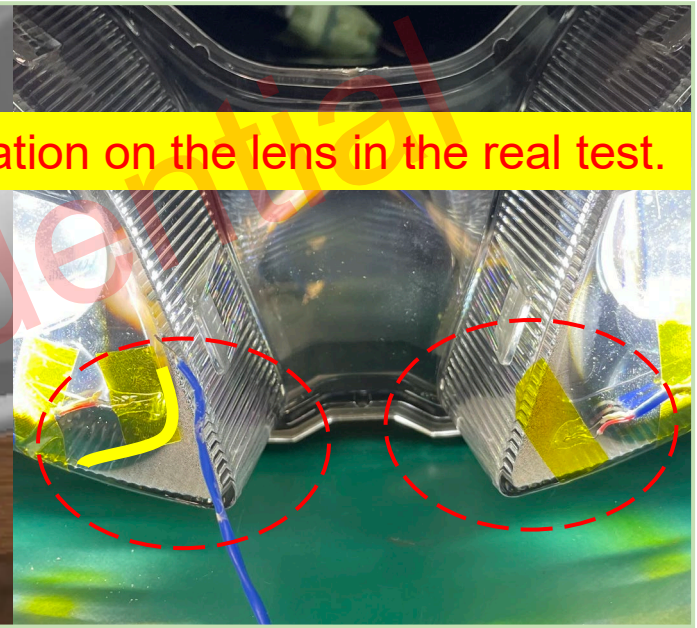
Model A

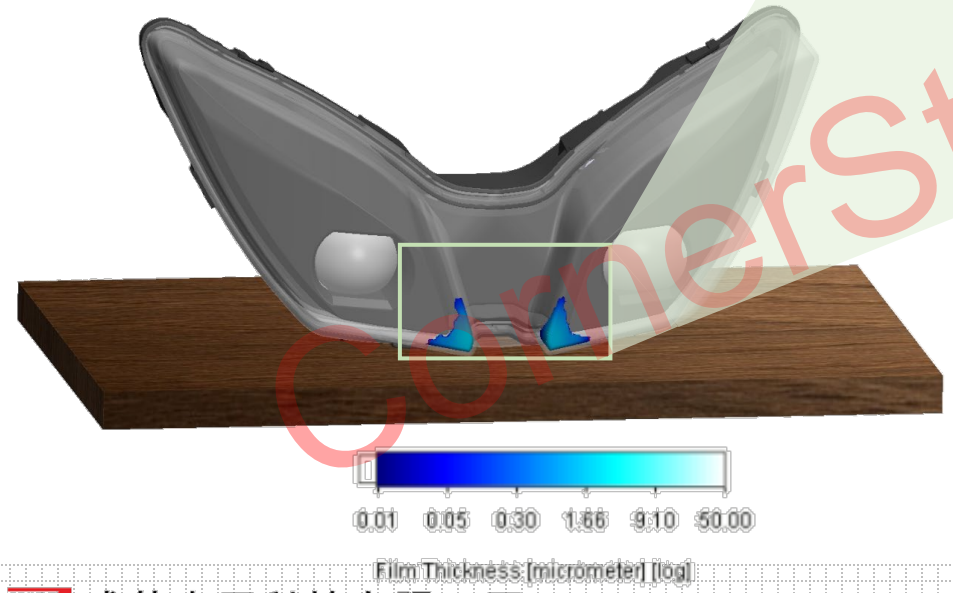
Simulation

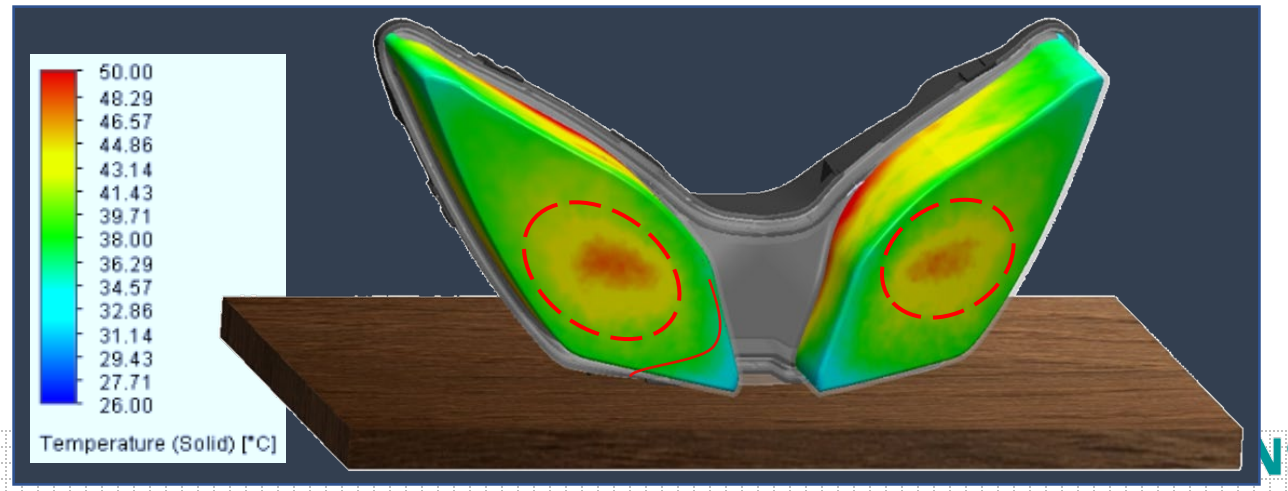
Test Image

The simulated fogging area happens in the same location on the lens in the real test.





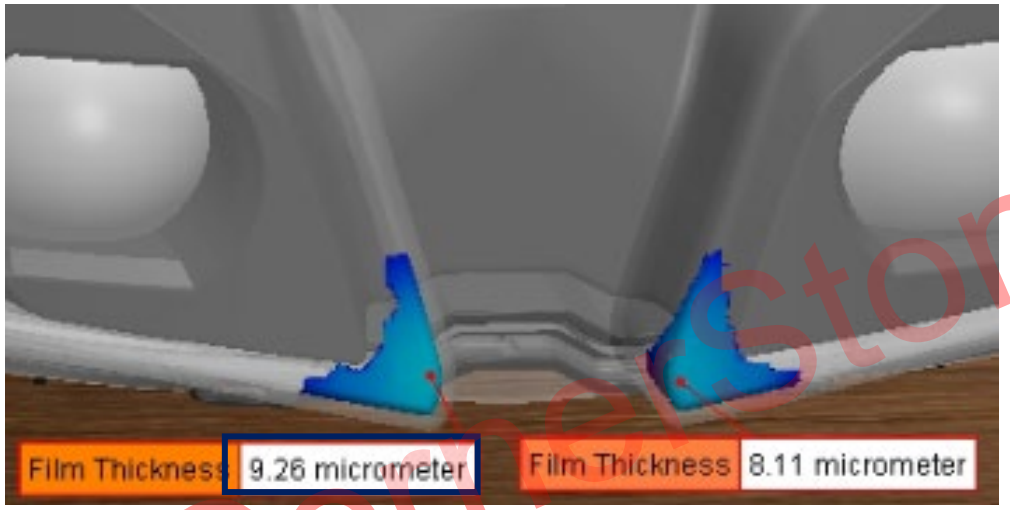


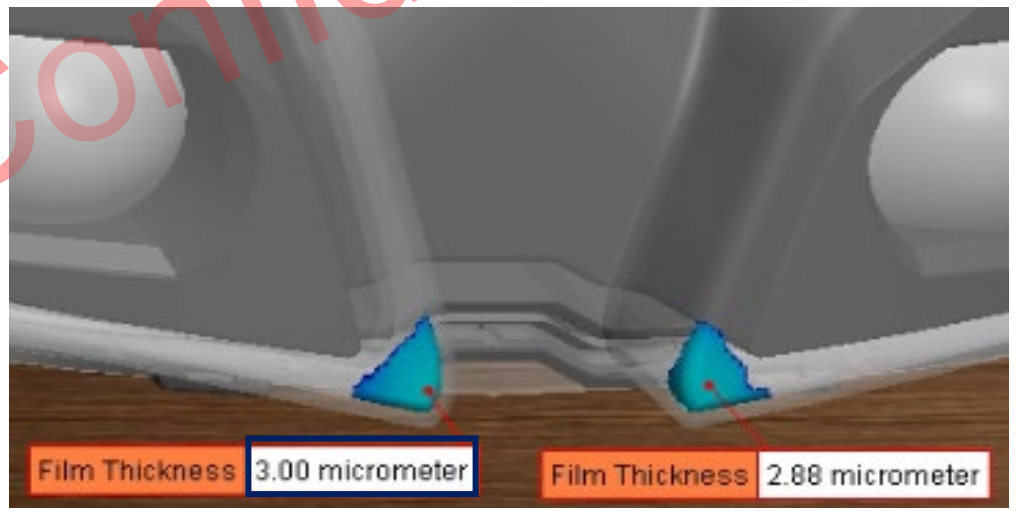


Result & Discussion

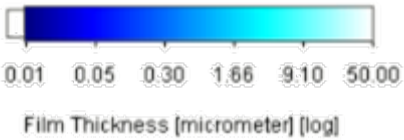
Model A

Model B





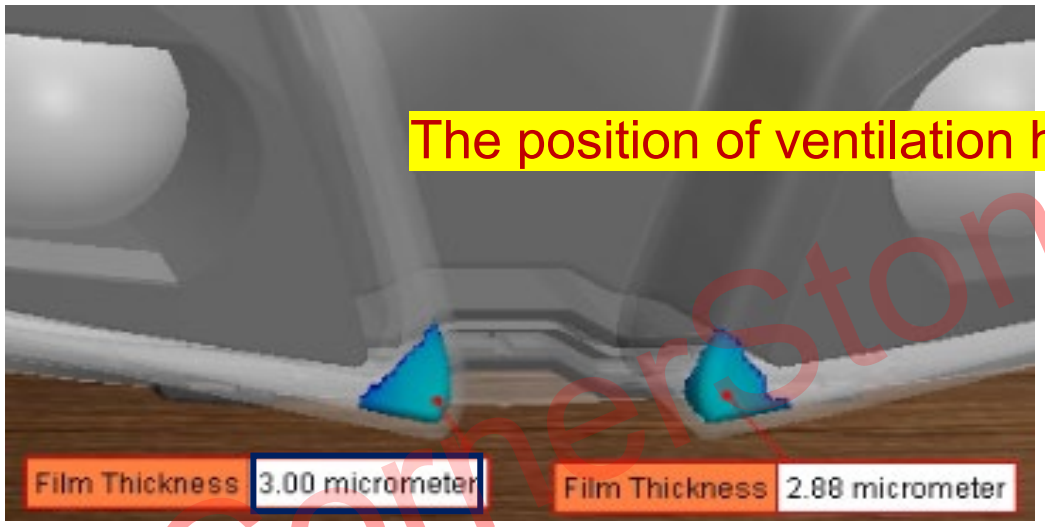
Model B Maximum thickness from 9.26μm to 3μm. 67%↓



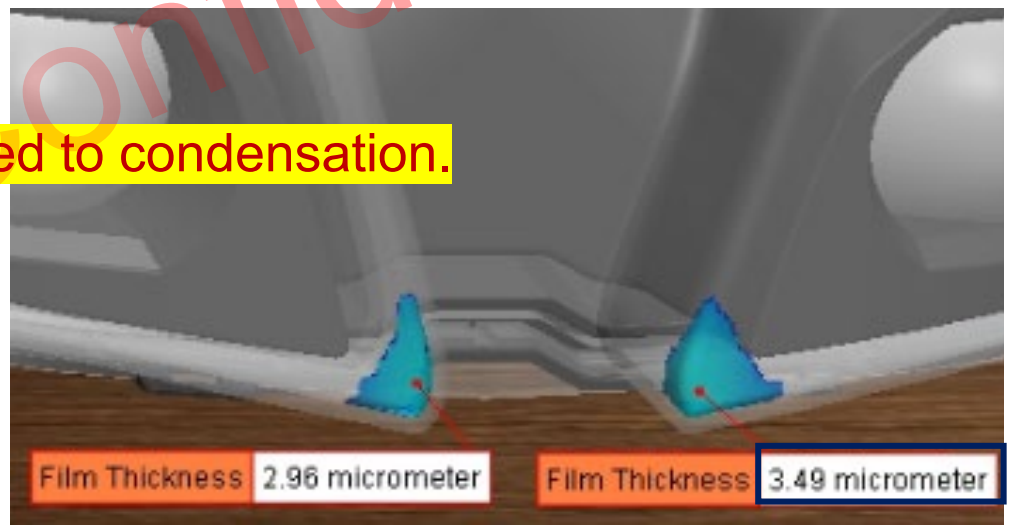
Result & Discussion

Model B

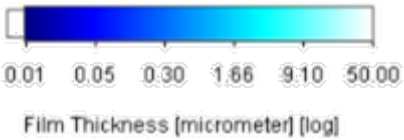
Model C



The position of ventilation hole is related to condensation.

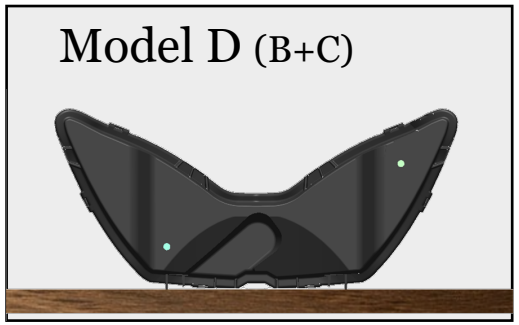


Model C Maximum thickness from 3μm to 3.49μm. 16%↑



Result & Discussion

Model D (B+C)



No fogging happens on lens.

Result & Discussion

a. The position and number of holes significantly affect condensation.

a. Simcenter FloEFD simulate a precise prediction for fogging phenomena.

b. Simcenter FloEFD can help to accelerate the time from design to production.

c. Simcenter FloEFD can easily cost down and save the money.

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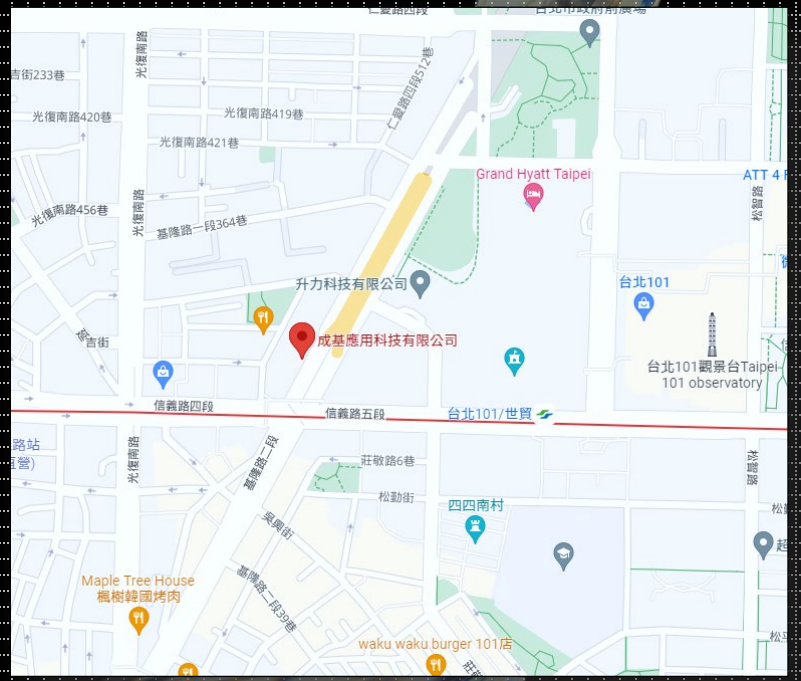

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