An Icing Physics Study by Using Lifetime-based Molecular Tagging Thermometry Technique

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Introduction: Wind and Icing

- Intro: Wind Power
- MTT Technique
- Experiment
- Resolution & Accuracy
- Results
- Conclusions

- Cleanest renewable energy
- 20% by 2030
- Ice accretion
  - Vibrations
  - Reliability
  - Efficiency
  - Safety

Molecular Temperature Thermometry Technique

- Intro: Wind Power
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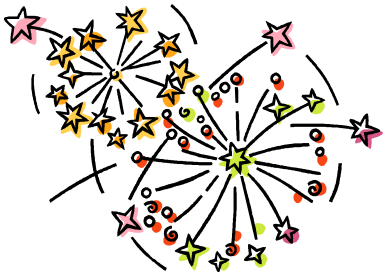
- Laser-induced Fluorescence (LIF)
- Expanding – Multiphase
- Temperature dependent decay



Molecular Temperature Thermometry Technique

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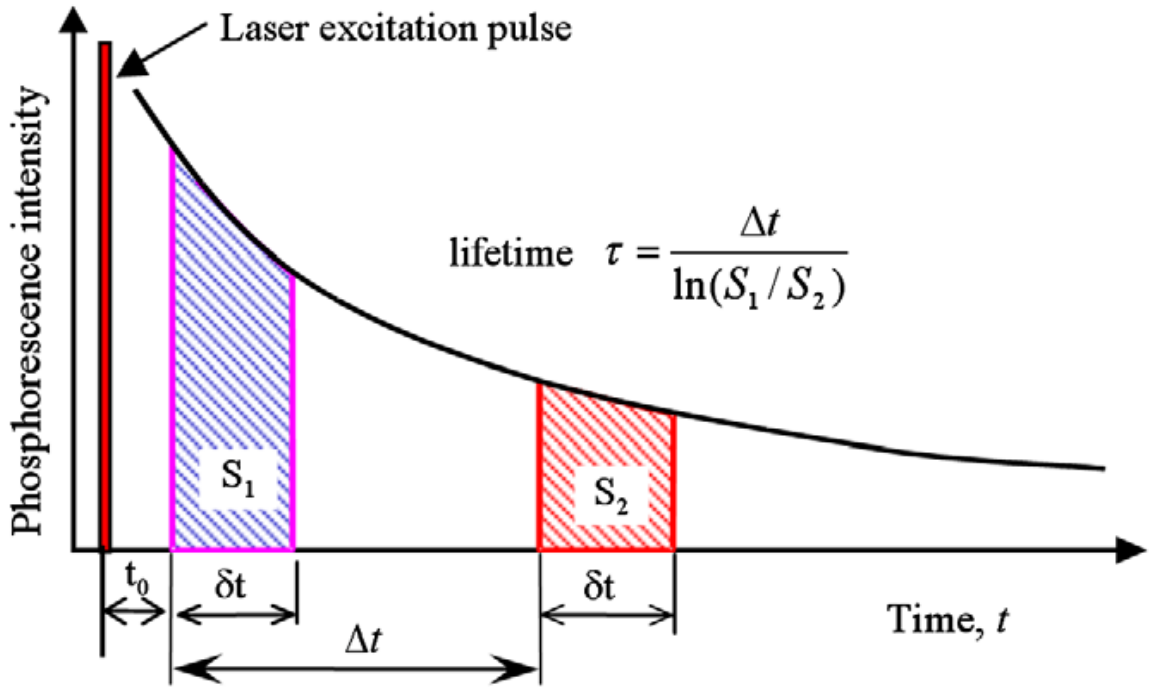

$$S = AI_iC\varepsilon\Phi_p(1 - e^{-\delta t/\tau})e^{-t_0/\tau} \quad (1)$$

$$R = {}^{S_2}/_{S_1} = e^{-\Delta t/\tau} \quad (2)$$

Experimental Setup

- Intro: Wind Power
- MTT Technique
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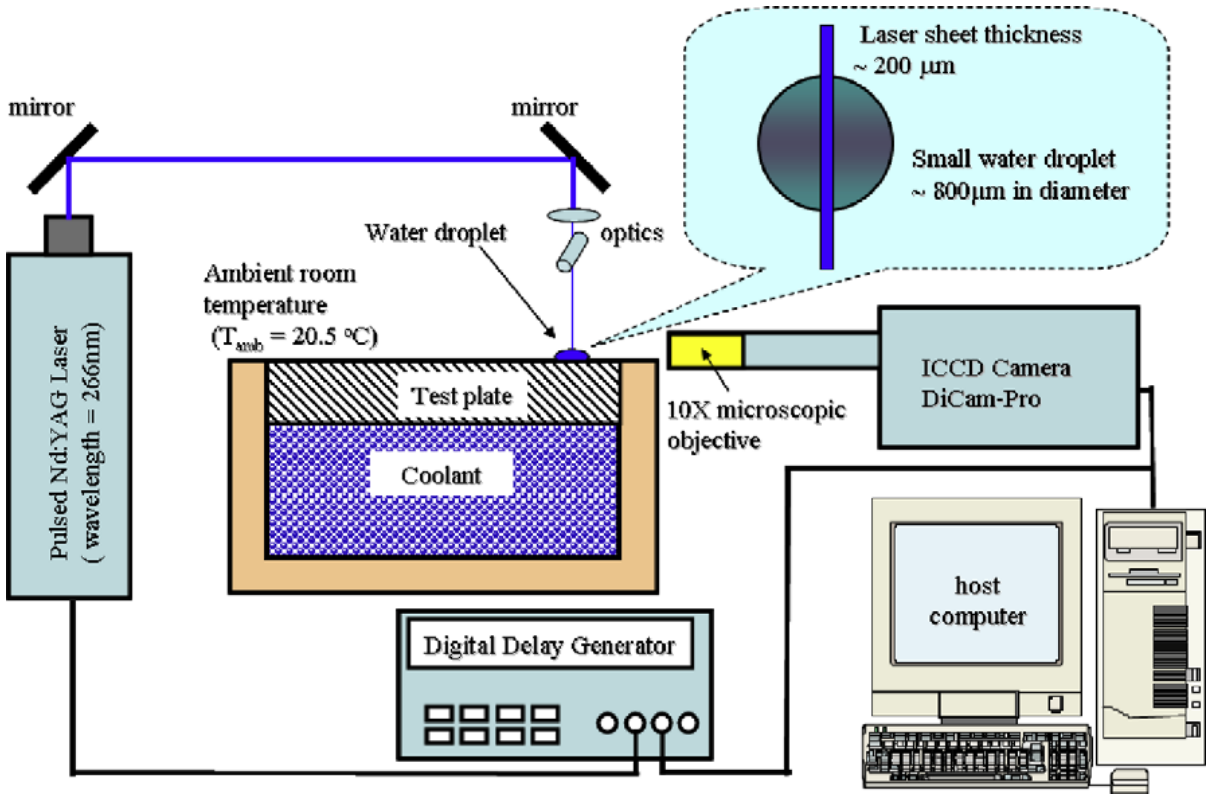

Spatial Resolution and Accuracy

- Intro: Wind Power
- MTT Technique
- Experiment
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- Spatially-averaged Temperature
- Accuracy:
  - Image noise
  - Identification of second region
- Estimate of accuracy:

$$\frac{\sigma_\tau}{\tau} = \frac{1}{\ln(S_1/S_2)}\sqrt{\left(\frac{\sigma_{S_1}}{S_1}\right)^2 + \left(\frac{\sigma_{S_2}}{S_2}\right)^2} \qquad (3)$$

Spatial Resolution and Accuracy

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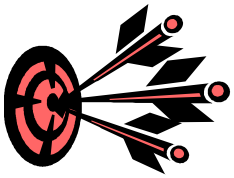
- 6% instantaneous error
  - Estimated 1.6°C
- Average over neighbors
  - Reduce by $1/\sqrt{N}$
- 21x21 pixel
  - Less than 0.3°C



Measurement Results and Discussion

- Intro: Wind Power
- MTT Technique
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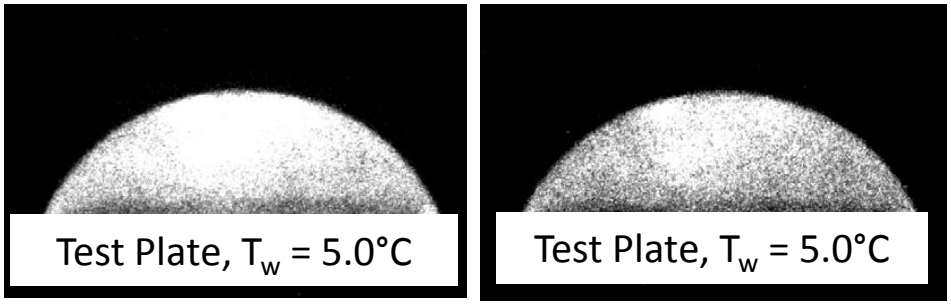
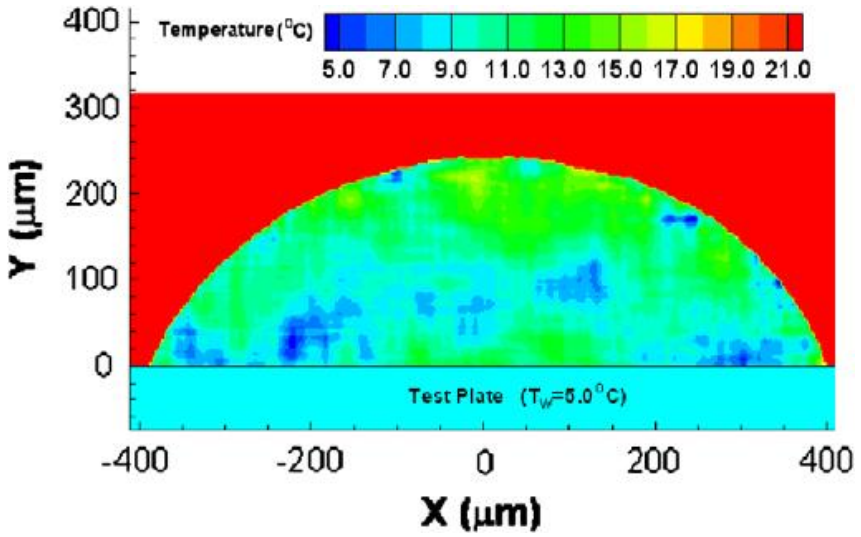
- Results
- Conclusions

- Typical example





Measurement Results and Discussion

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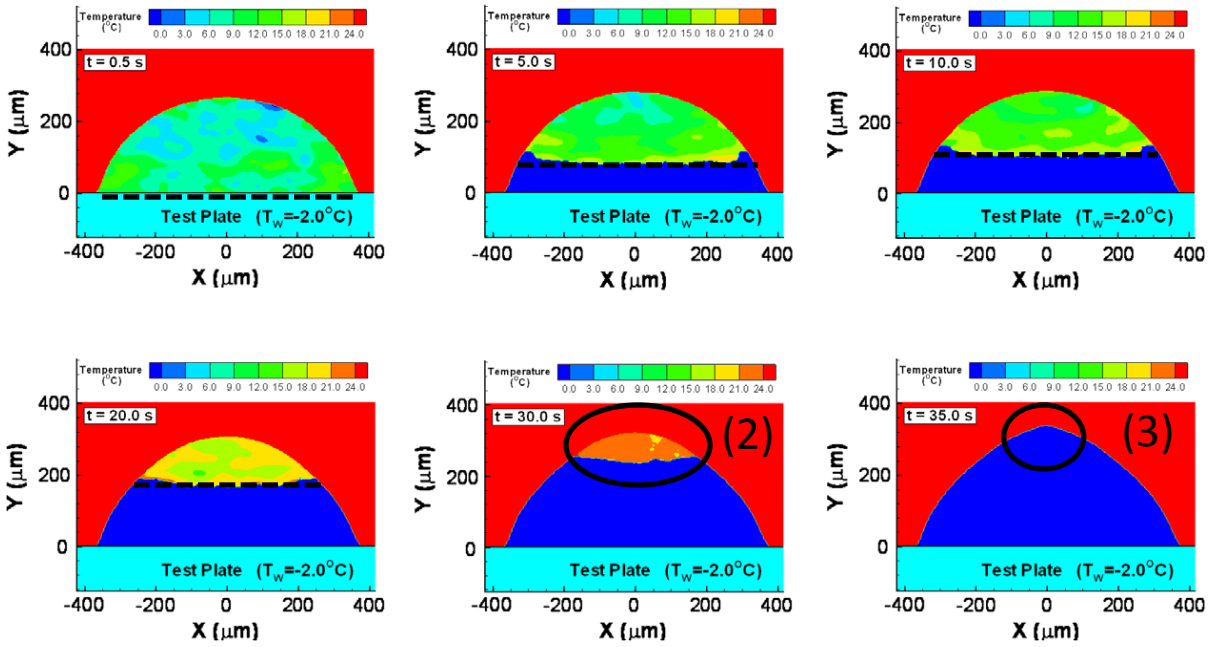

- (1) Steady interface rise ---------
- (2) Temperature *increase*
- (3) Sharpened profile *against* gravity

Conclusions: MTT Viability

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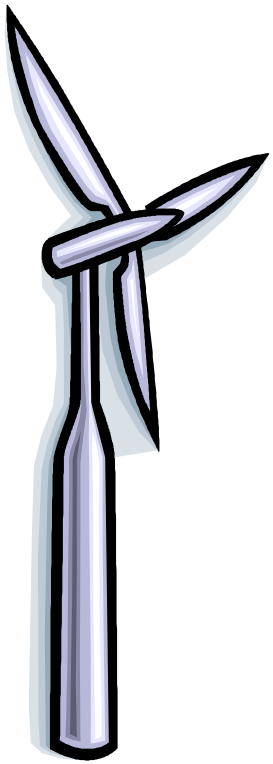
- Developed MTT technique
- Investigated unsteady heat transfer in icing
- Important results:
  - MTT successful
  - Freezing profile
  - Temperature increase
- Improved understanding

Fin.

- Tu t'en vas déjà?

(You're leaving already?)



- Any questions?