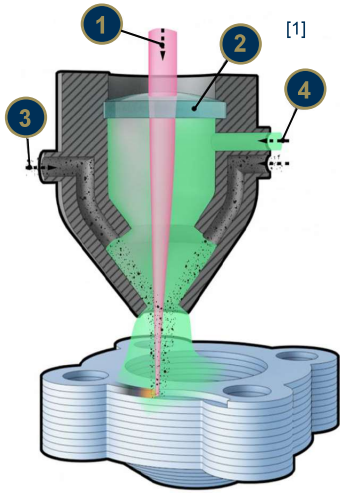
Schlieren: Gas Flow Visualization

Georgia Institute of Technology

Sadhana Kumar, **Ivan Chen**, *Cooper Delgandio, Aarush Gupta, Dr. Zachary Brunson, Dr. Aaron Stebner*

Artificial Intelligence in Manufacturing Pilot Facility

Directed Energy Deposition (DED)



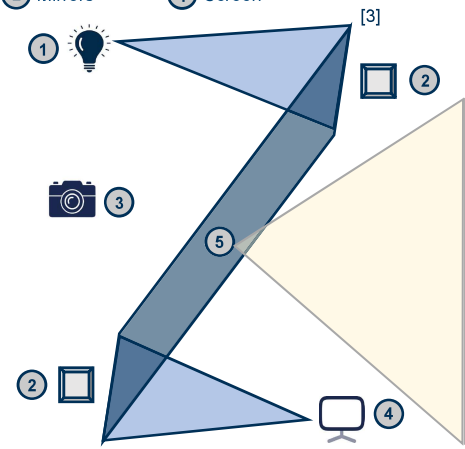
- Powder blown, laser DED method
- Product built layer-by-layer

1. Laser heats up a local region
2. Carrier gas deposits metal powder

1. Laser Beam
2. Focusing Lens
3. Metal Powder
4. Inert Gas (Ar)

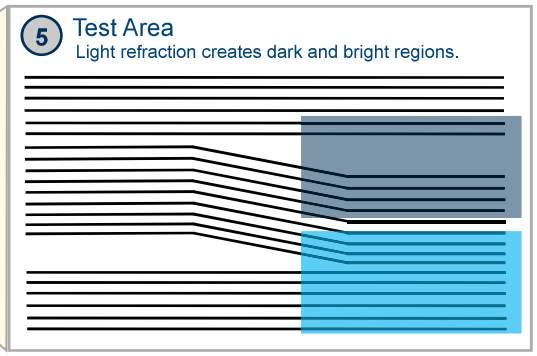
Schlieren: A Way to See the Unseen

1. Light Source
2. Mirrors
3. Camera
4. Screen

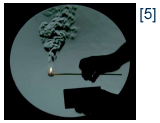


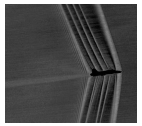
What does it do? [4]

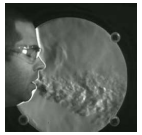
- Visualizes fluctuations in index of refraction
  - Changes in pressure
  - Changes in temperature
  - Changes in density

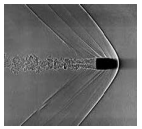


Common Visualization Applications:


[5] Heat dissipation from a system

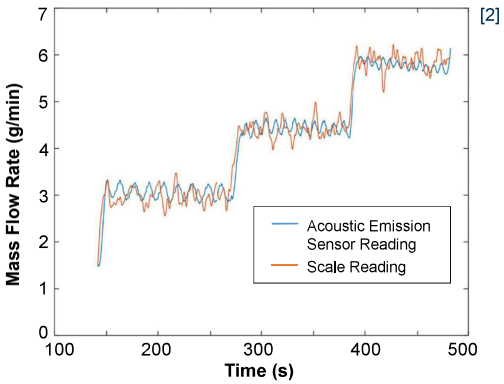

[6] Shock waves from a jet plane


[5] Exhalation and inhalation in humans

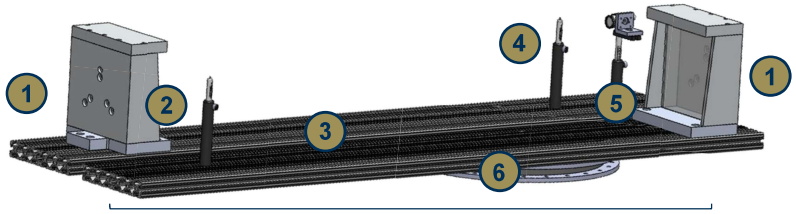

[7] Flow streamlines caused by a fast-moving object

Dealing With Bad Vibrations

- High variability and periodicity in mass flow among nominal DED printers
- Unknown, system agnostic mass flow pattern and source
  - Nozzle, bed, or material instability



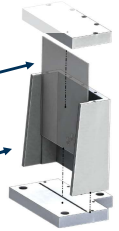
How Do We Fit it in a Metal Printer?



1 Adjustable Mirror Mount

Low refractive index window (~1)
(0.12" museum acrylic)

Powder-safe enclosure



2 Light Source

3 64" Railing

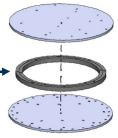
4 Knife Edge

5 Camera

6 Swivel Base

Rotary positioning system

17" swivel bearing



Future Work

- Fabrication
- Setup and testing on Optomec
- Setup and testing on Mazak
  - 3 different nozzles
- Setup and testing on RPMI

RPMI

Optomec

Mazak

THE BEAMTEAM
STEBNER LABS

[1] Adapted from www.manufacturingguide.com/en/laser-engineered-net-shaping-lens-0
[2] Whiting, J., Springer, A., & Sciammarella, F. (2018). AM.
[3] Adapted from www.edmundoptics.com/f/schlieren-systems/11889
[4] Mazumdar, A. (2013) *Principles and Techniques of Schlieren Imaging Systems*. Columbia University.
[5] Taken from Veritasium on YouTube (www.youtube.com/@veritasium)
[6] Taken from https://www.nasa.gov/image-detail/boscof2p4_comp_tb12_1/
[7] Taken from https://shepherd.caltech.edu/T5/Ae104/Ae104b_handout2015.pdf