

Model-Based Calibration System for Direct Thermal Printing

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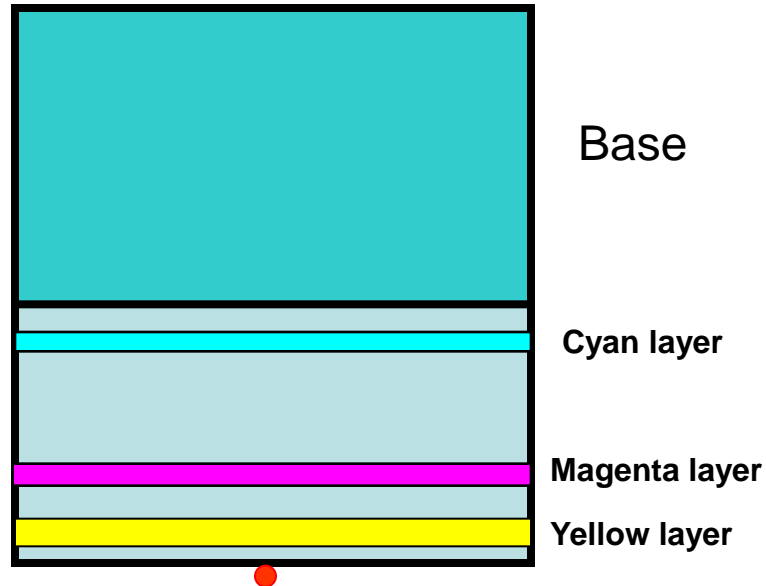
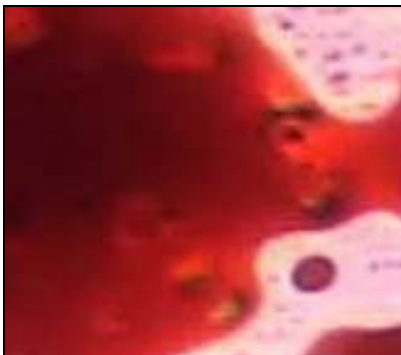
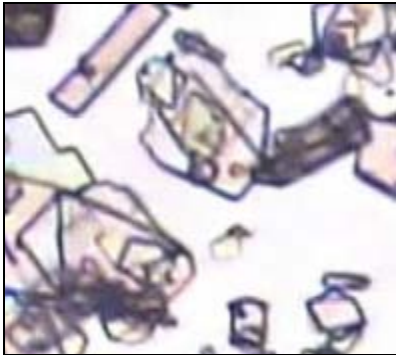


Zink™ Direct Thermal Printing

A new way to print in FULL COLOR without ink

Zink™ Coated Media

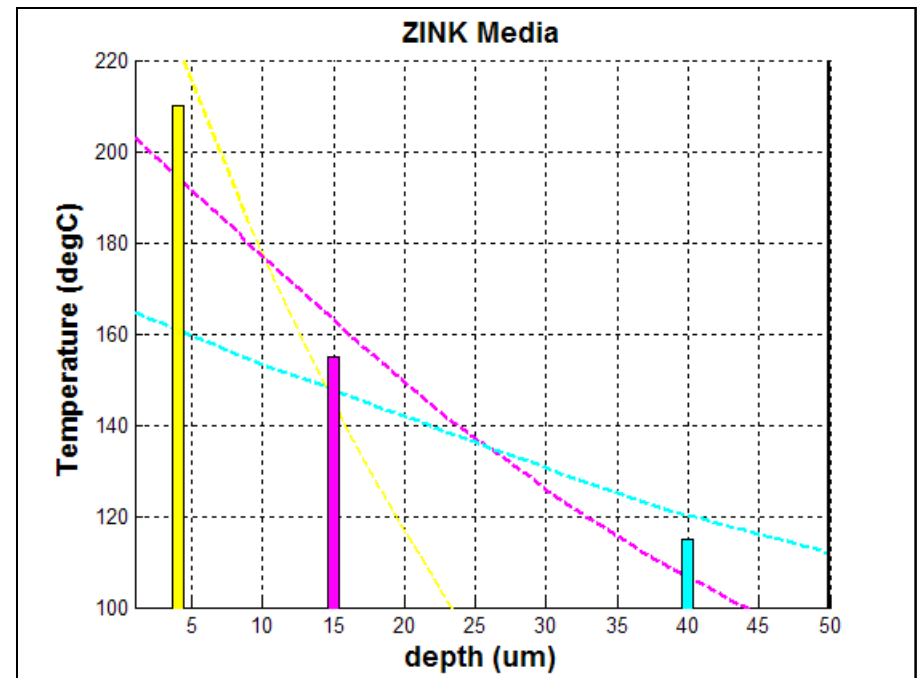
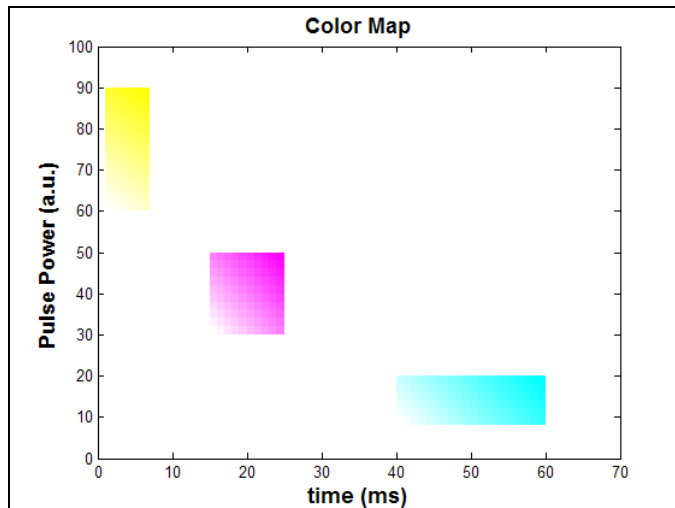
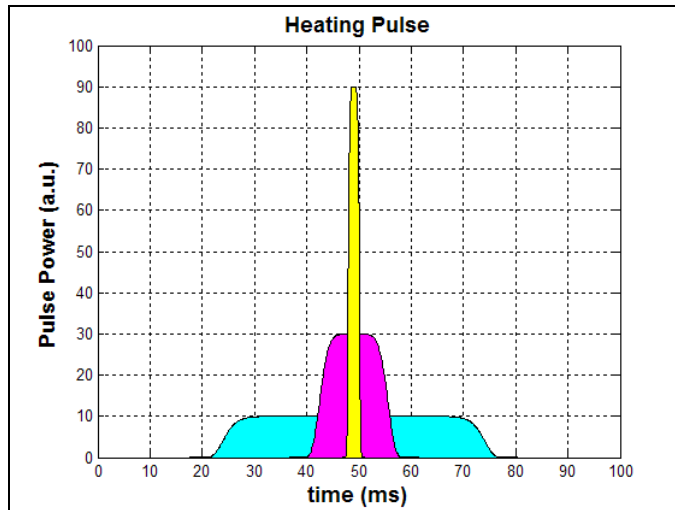
Colorless Dye Crystals embedded in imaging layers



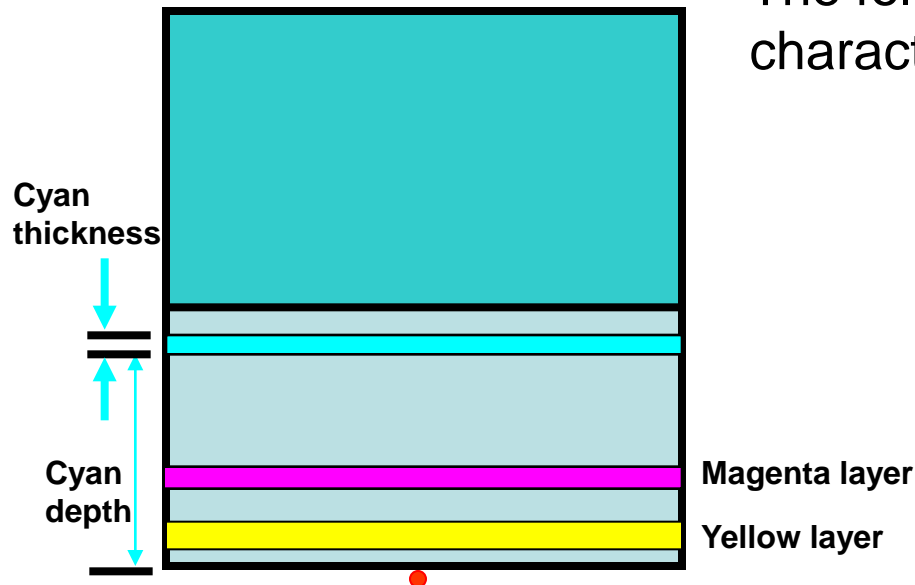
Dye crystals melted and colored at melting temperatures

Zink™ Direct Thermal Printing

How to print in full color with Zink™



Zink™ Media characterization



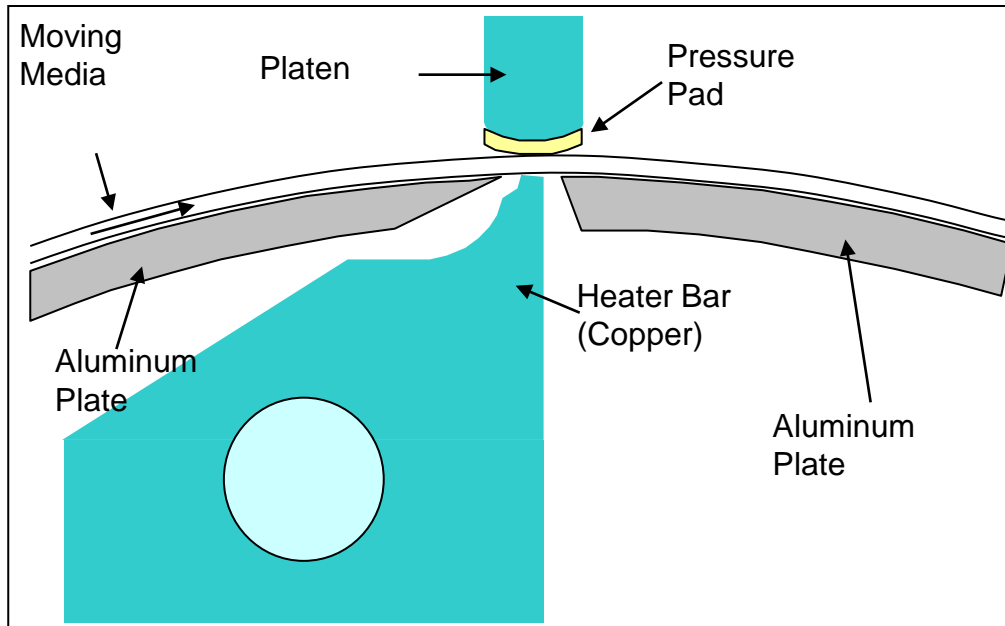
The following properties can fully characterize the media:

1. Thermal properties: C, k
2. Optical Properties: D_{min} , D_{max}
3. Structural properties:
 1. Thickness
 2. Depth
4. Chemical properties
 1. Melting Temperature
 2. Rate of colorization

A model-based calibration system (Golden printer) has been developed to measure these properties (in blue)

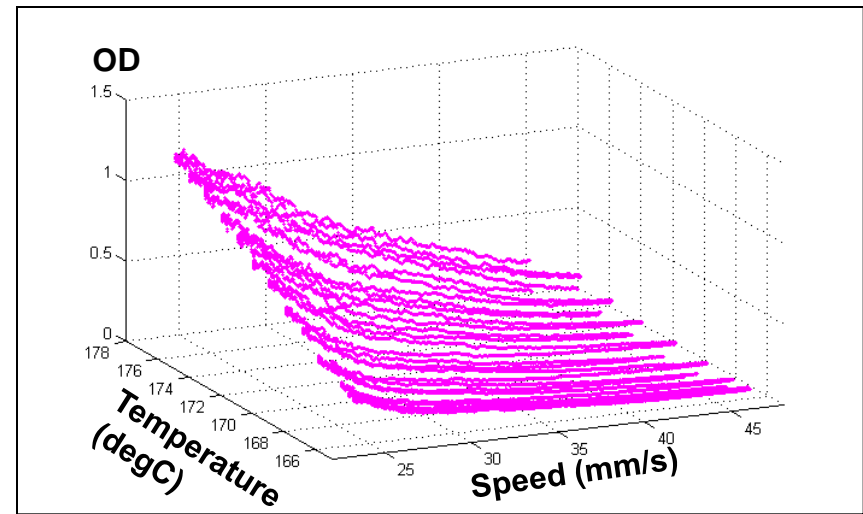
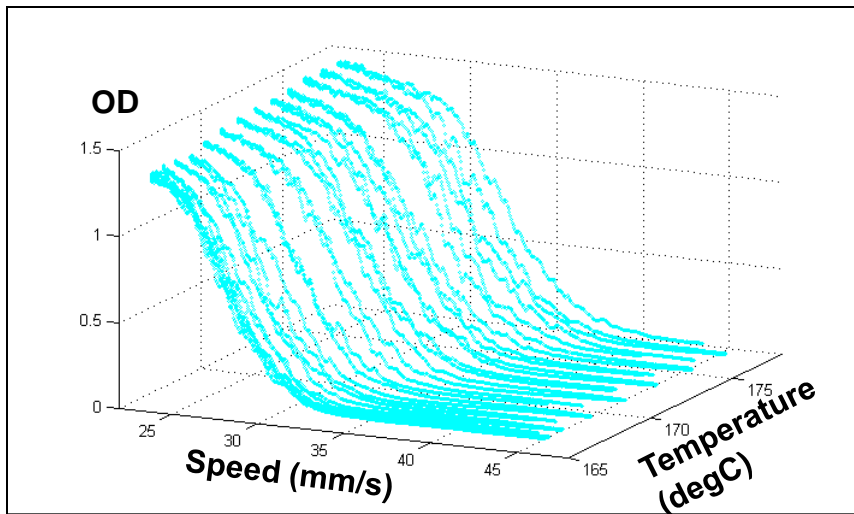
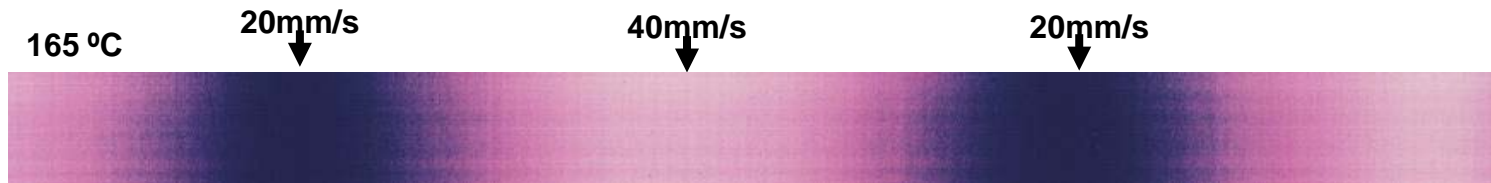
The Calibration System

Golden Printer

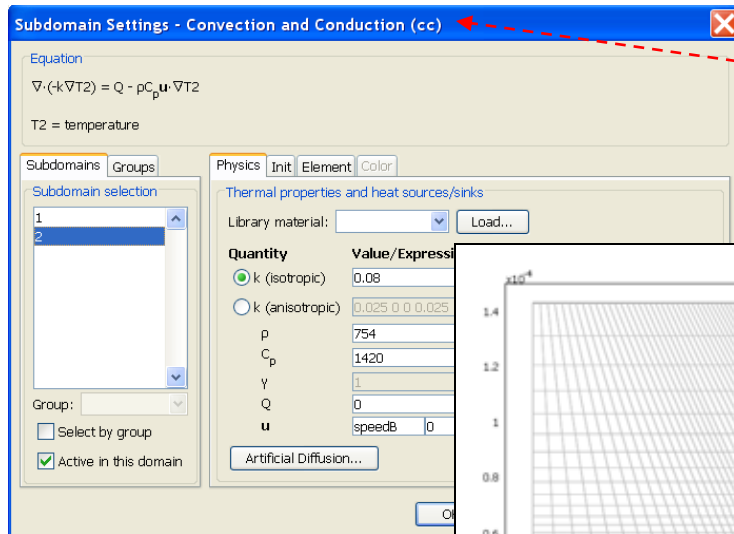


1. A copper bar is pre-heated to a known temperature, and cooled down at about 0.5degC/s
2. A platen pushes the media against the surface of the heater bar at a known force;
3. The speed of media is varied sinusoidally

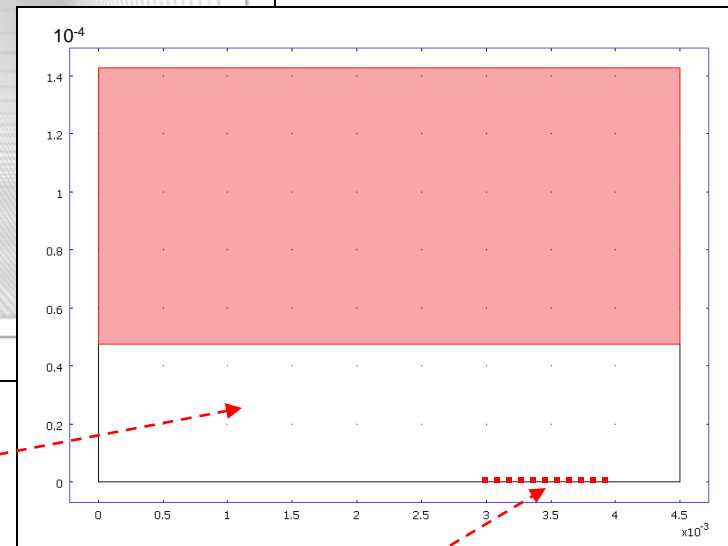
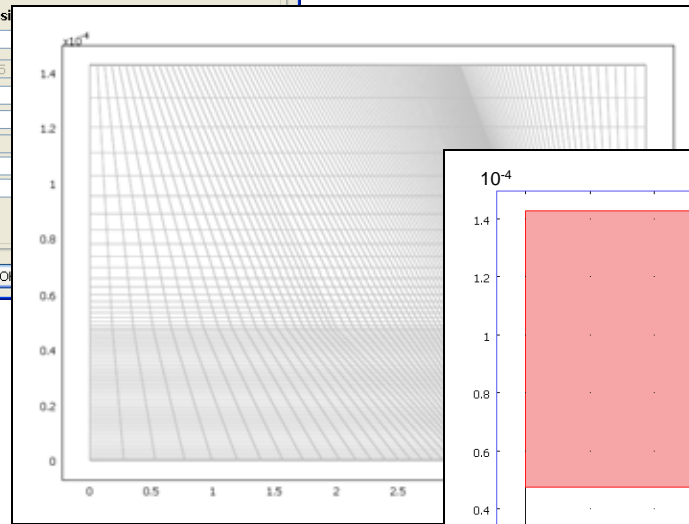
Typical measurement results of the golden printer



Comsol Model of the media



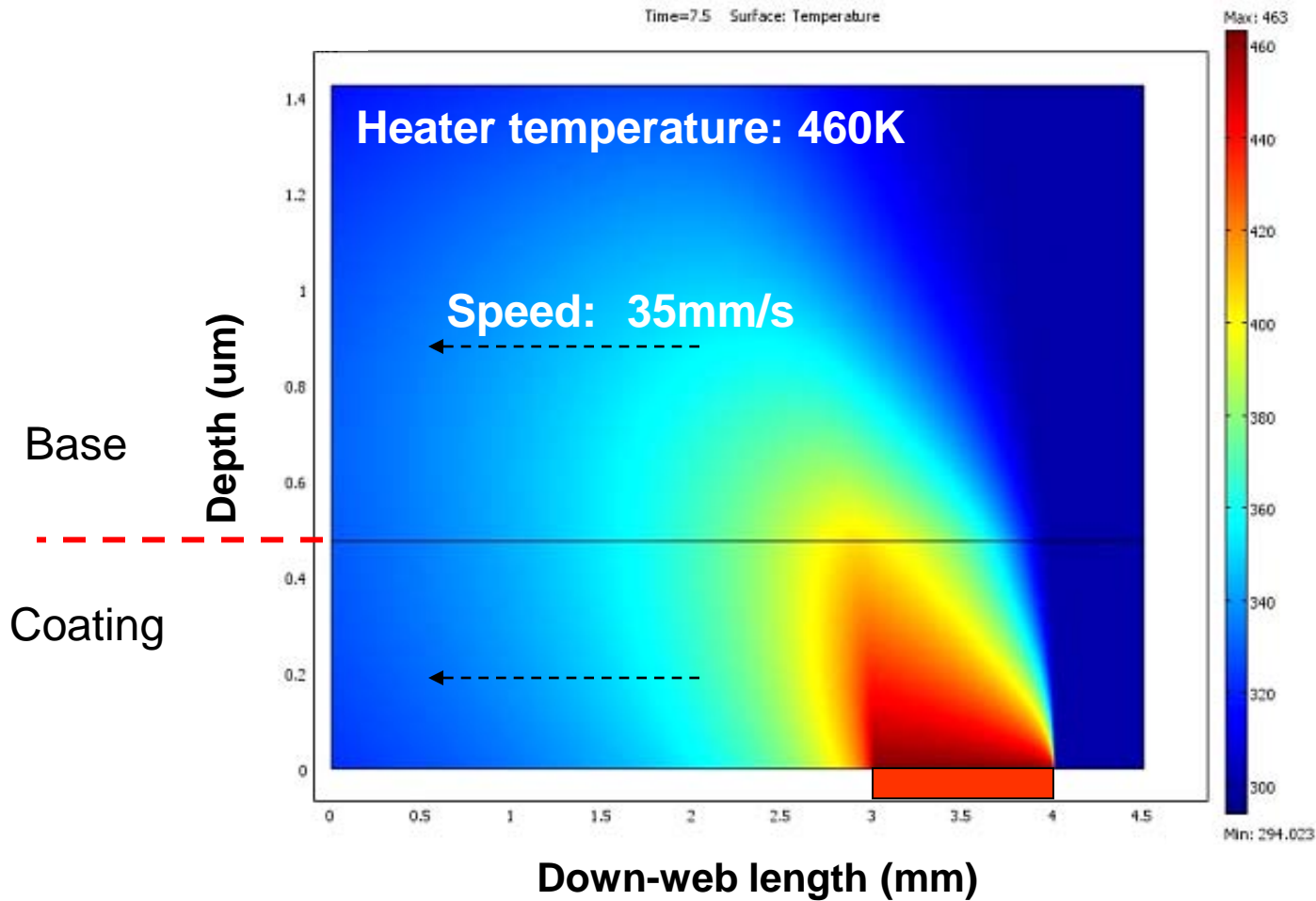
The convection & conduction mode is used for the Comsol model



The media is modeled as a uniform material

The heater: constant temperature boundary condition

Model of the media: temperature distribution



Arrhenius Model of the colorization process

For N uncolored molecules,

$$\frac{dN}{dt} = -R(t) \cdot N \quad R \text{ is the rate of the colorization.}$$

The colorization process can be accurately represented by the Arrhenius equation:

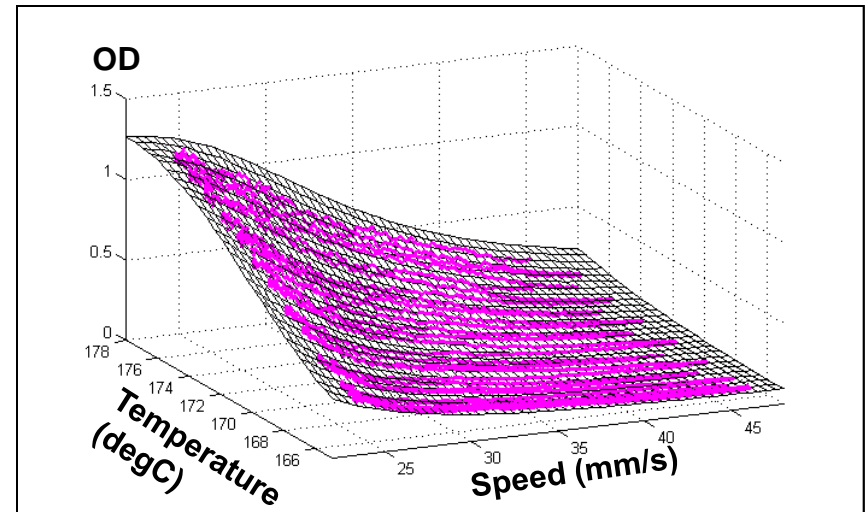
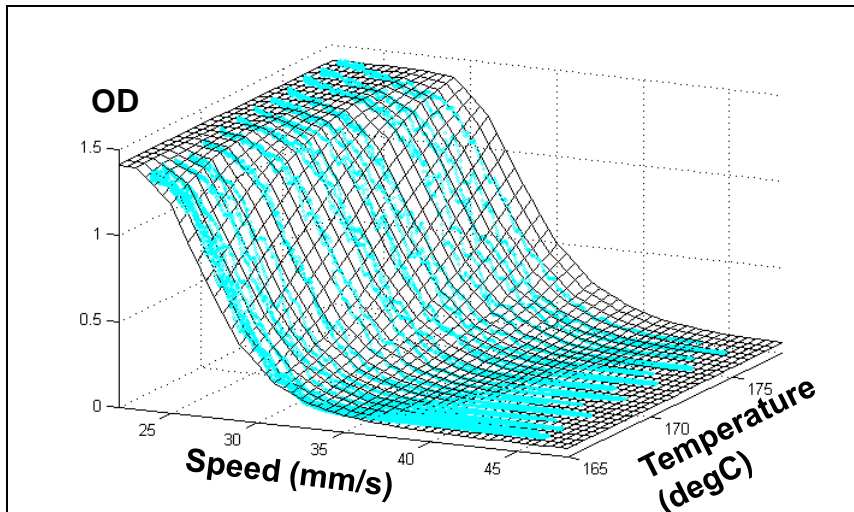
$$R(t) = \exp\left(A - \frac{Q}{T(t)}\right)$$

The optical density D of each Dye layer in the thermally exposed media is:

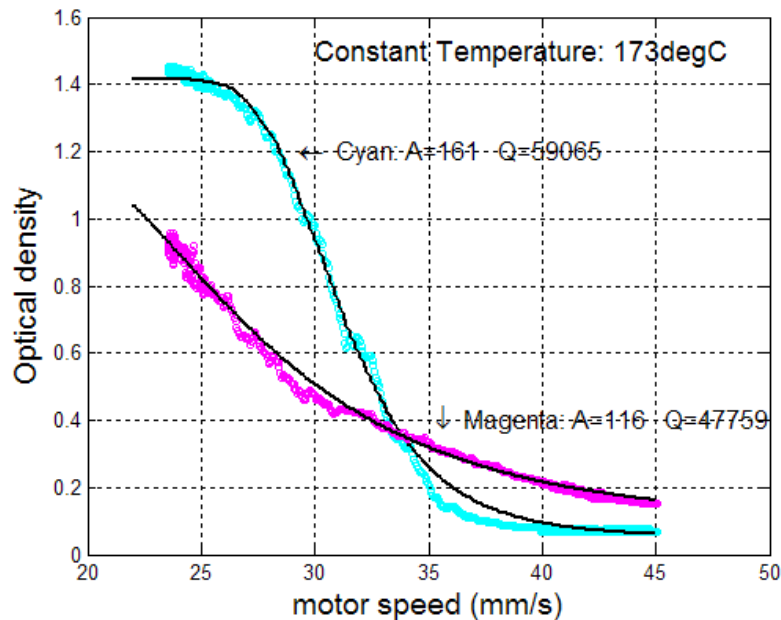
$$D = D_{\min} + (D_{\max} - D_{\min}) \left(1 - \exp\left(\int_{\text{Depth}}^{\text{Depth} + \text{thickness}} \int R(t, z) dt dz \right) \right)$$
$$R(t, z) = \exp\left(A - \frac{Q}{T(t, z)}\right)$$

Combining Comsol model with MatLab to fit the data and calculator Dmin, Dmax, Depth, Thickness, A and Q

Results of the Comsol Modeling of the Gold Printer



Fitting results



Fitting results:

Cyan: A = 161
Q = 59065
Thickness = 2
Depth = 42
Dmax = 0.05
Dmin = 1.37

Magenta: A = 116
Q = 47759
Thickness = 2
Depth = 12
Dmax = 0.08
Dmin = 1.27