



**LUMEN DYNAMICS**

PUTTING YOU IN CONTROL

...a founding member of the UV LED Curing Association

## Optimizing UV-LED Curing – Print Applications

*Nidal Abbas, MBA*  
*Group Product Manager*

- Introduction of Lumen Dynamics (LDGI)
- UV LED in Digital Print
- Critical Parameters
- LDGI Ink Curing Studies



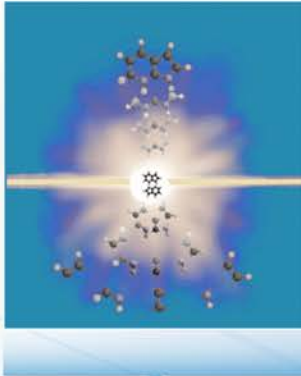
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Our mission is to revolutionize the way researchers,  
manufacturers and printers do their work

A technology company committed to providing customer  
solutions through the innovative application of light

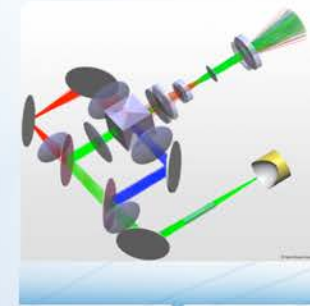
# What We Do



PHOTOCHEMISTRY  
EXPERTISE



LIGHT GENERATION



OPTICS

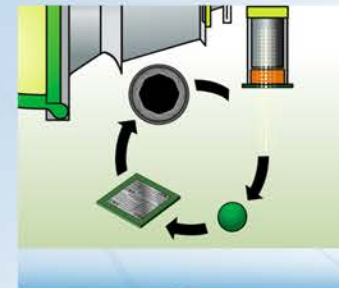
OUR



EXPERTISE



RADIOMETRY



CONTROL SYSTEMS

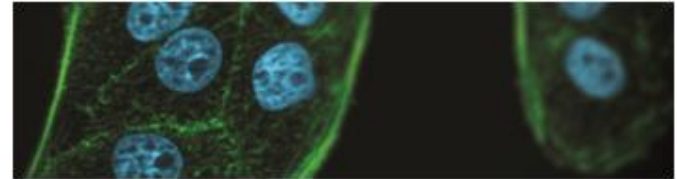
# Our Market Focus

Lumen Dynamics is a global leader in the design, manufacture, and marketing of light-based delivery systems. Our focus is within the following market applications:

## X-Cite®

Fluorescence Illumination • In Control

- *Life Science Cellular Imaging*



## OmniCure®

UV Bonding • In Control

- *Medical Device and Optoelectronics Manufacturing*



## Excelerate®

Print Quality • In Control

- *Graphics Digital Printing*



# Our Approach...

**Close collaboration with our customers and rigorous application testing.**

*We bring:*

- Patented LED technology platform for UV applications
- Knowledge of UV curing
- 27 years of experience in making commercial, cost-effective UV solutions





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## UV LED in Digital Print

# LED Benefits for Digital Printing

- Narrow optical spectrum
  - Cooler cure (no Infrared), allows printing on heat sensitive substrates
- Long lifetime (>10000 hrs)
  - Lower operating costs, simplified maintenance
- **Air cooled now available**
  - Simplified printer architecture
- Instant on/off
  - No warm-up or cool-down time, simplified mechanical design (no shutters)
- Environmentally friendly
  - No Hg, Ozone, lower energy consumption
- Simplified electronics
  - No high voltage ignition, reduced cost for printer electronics and shielding

For more details read [LED UV Curing in Wide-Format Digital Printing](#), *SGIA Journal*, Q1 2010





# Status of UV-LED Adoption in Print

IT Strategies estimates 30% of digital printers now come with LED or option for LED curing

- Digital Single Pass Applications – Label, industrial marking
  - Widespread adoption for pinning and full cure by companies such as Atlantic Zeiser, ITW, etc.
- Digital Wide Format
  - Strong presence at entry level printers <15m<sup>2</sup>/hour
  - Recent introduction by EFI on GS platform >200m<sup>2</sup>/hr
- Analog Printing – Early stages but on its way...
  - Screen Print – LED optimized inks now available (Nazdar)
  - Offset Printing - Proof of concept demonstrations (Kamori)

# LED Curing – Technology Enablers

- Availability of high efficiency of UV LEDs
  - High power 1 x1mm<sup>2</sup> LED die (base building block)
  - Up to 500mW of power per die
- Availability of LED based light sources
  - LED Arrays with outputs > 8W/cm<sup>2</sup>
  - Requires advanced semiconductor packaging technology
- New ink formulations
  - Tailored to respond to spectrum of UV LED sources



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## Critical Parameters

# Main Performance Parameters

- Wavelength – match to chemistry
- Exposure area – application specific
- Irradiance – energy flux per unit time
- Dose -integrated energy delivered

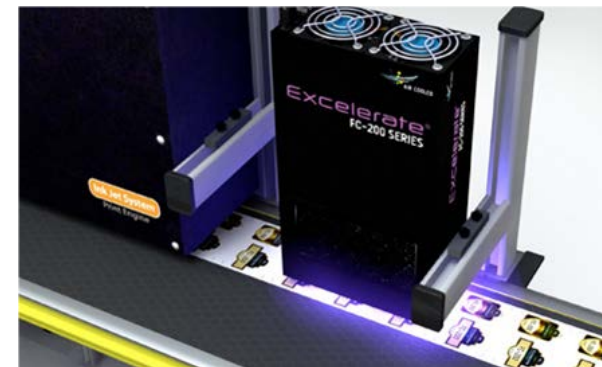
## Performance Factors

	Poor	Good	Excellent
Quality of Work	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Quantity of Work	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Dependability	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Communication Skills	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Supervision	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Leadership Skills	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Initiative	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cooperation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Relations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Adaptability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



## Dose vs Irradiance

- Arc lamps—wavelength and PI package used to optimize curing
- Monochromatic LEDs—dose and irradiance are the key controls
  - Dose means more LEDs (at basic level – assuming optical collection is optimized) and implies higher cost



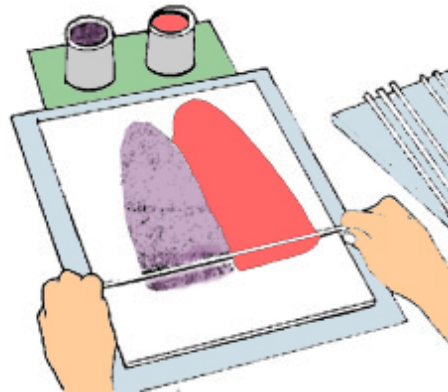


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## LDGI Ink Studies

- In-house testing program
- Program objectives
  - understand current state of the art in LED inks
  - optimize LED curing units based on ink and application



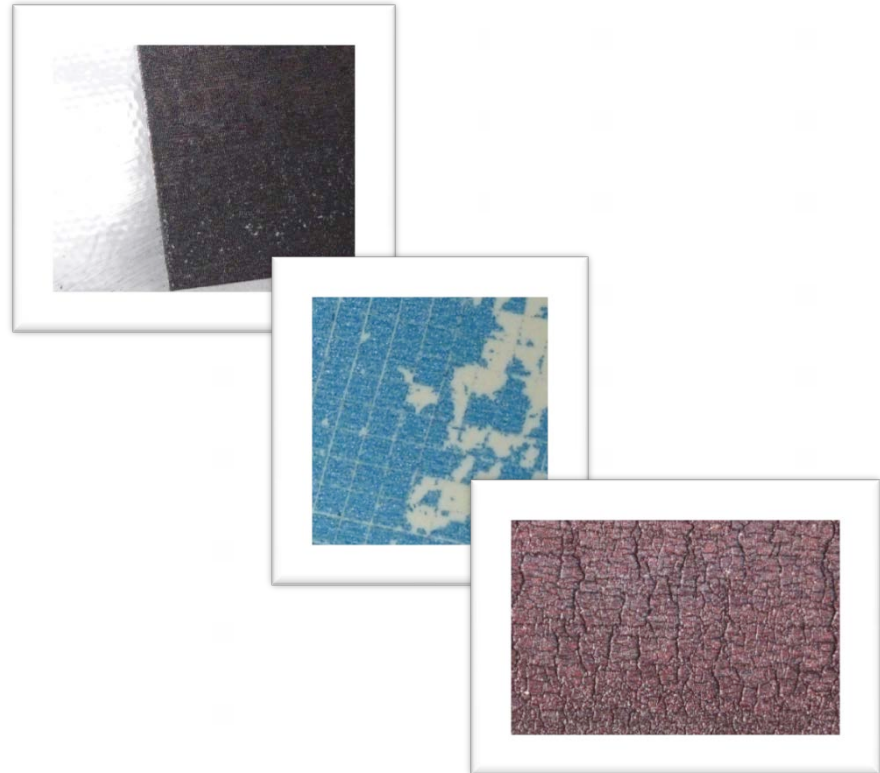
**Drawdown Sample Preparation  
Technique**

# LDGI Evaluation of Cured Ink Films

Application: drawdown

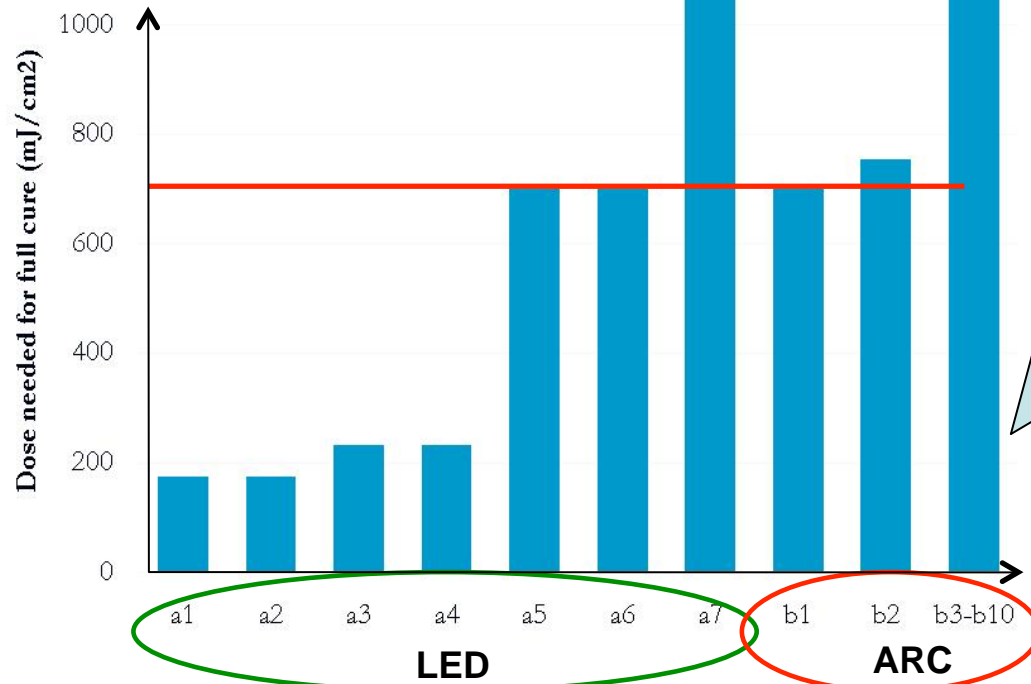
Cure assessment:

- Color transfer
- Surface tack
- Surface hardness
- Solvent resistance
- Adhesion to the substrate





# Ink Type Dose Comparison



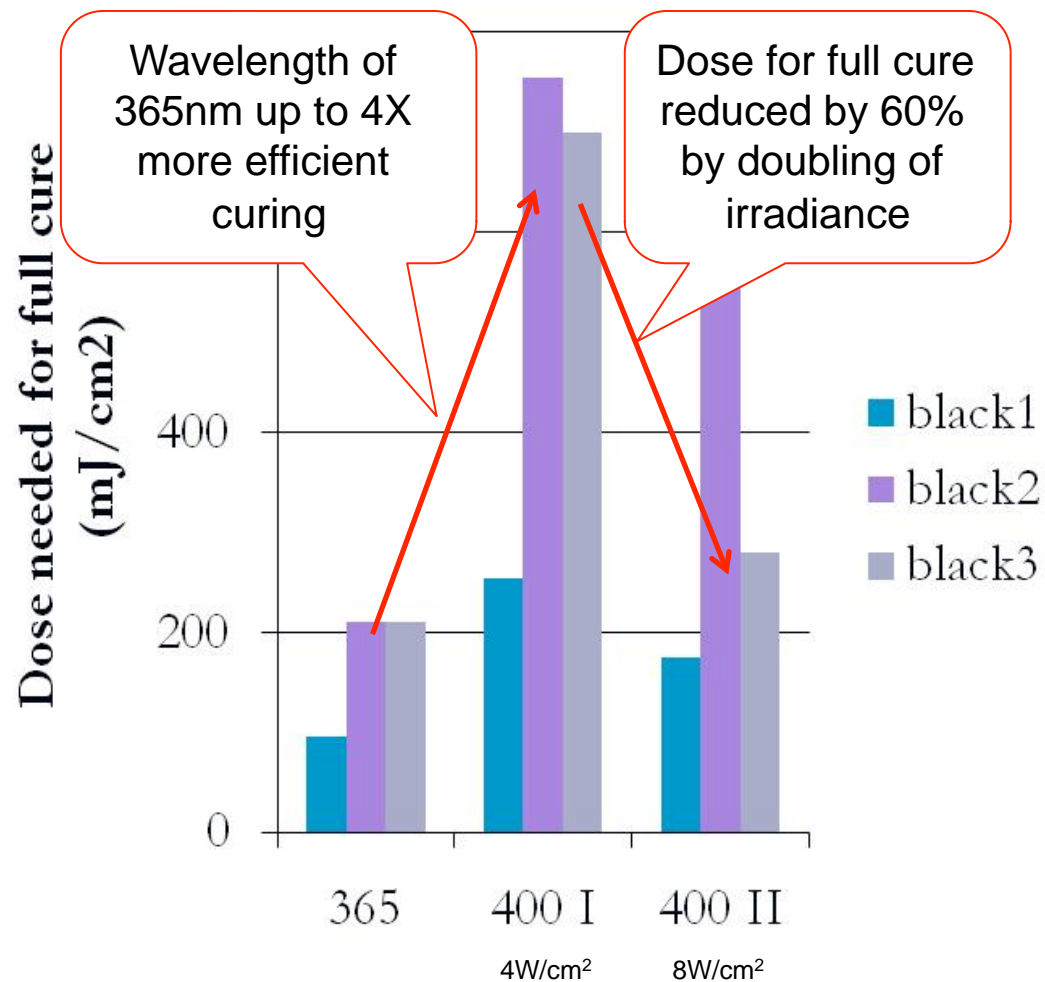
## Key Observations:

- Difficult to get a good surface cure
- Surface cure was improved when using 365nm LED or a higher irradiance source
- Even within LED inks, dose requirements vary considerably

**Having an LED specific ink formulation is critical to achieving full cure!**

Source: Kuta et al 2010

# UV Source Dependence – Wavelength and Irradiance



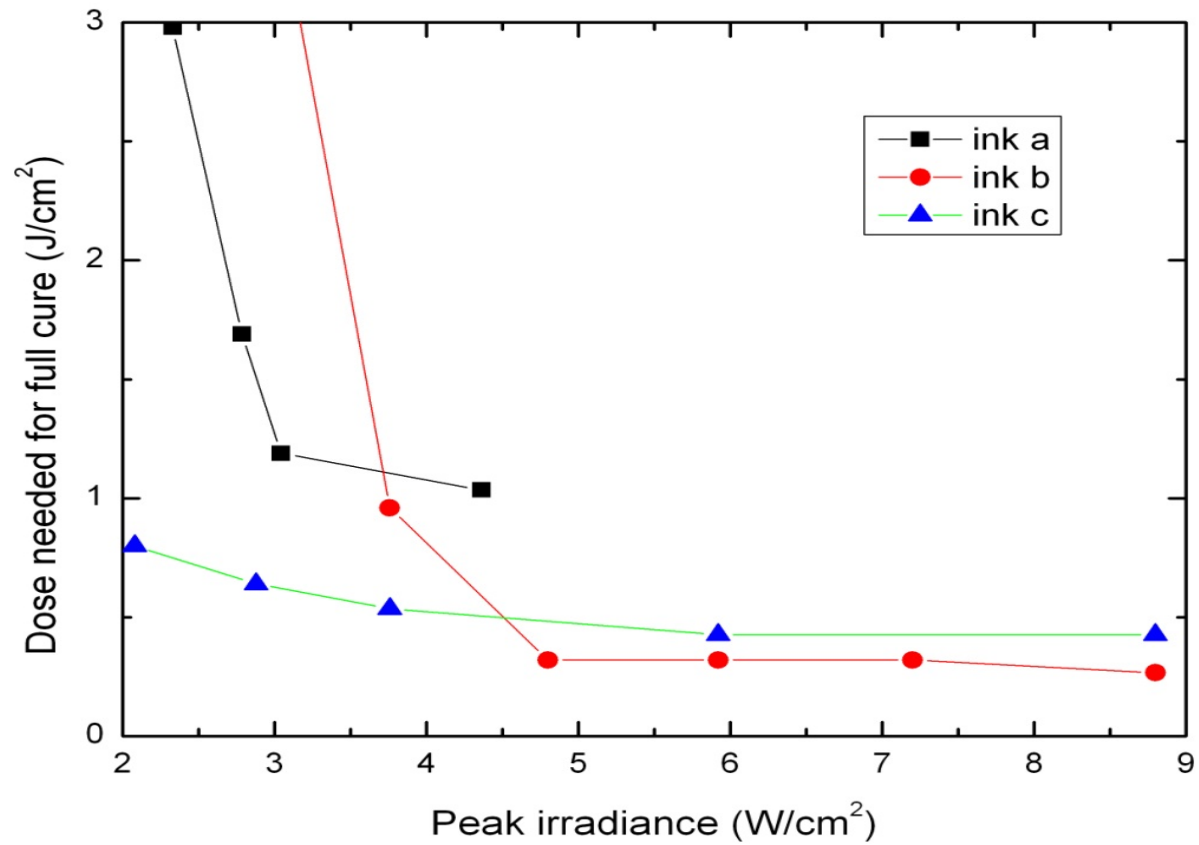
Source: Kuta et al 2010

# Ink Color Dependence

- Optical filtering by the color pigment also impacts the cure efficiency
- Inks with different colors (C, M, Y, K) perform differently
  - Yellow and black inks typically need more dose (20% – 30%) to be adequately cured with  $4\text{W}/\text{cm}^2$  compared with  $8\text{W}/\text{cm}^2$



# Irradiance vs Dose Data



Source: LDGI internal report

- There is a non-linear inverse relationship between dose and irradiance required to achieve full cure
  - Higher irradiance requires less total dose
- Underlying mechanisms:
  - higher polymerization/curing rate combats oxygen inhibition at the surface leading to better surface cure
  - Improved depth of cure based on Bouguer-Lamber Law leads to more complete bulk cure
  - Increased contribution to layer adhesion

- Full cure of UV digital inks is possible with current LED sources
- Surface cure can be a problem for inks that are not optimized for UV LED sources
- Ink formulations optimized to enhance the cure efficiency of LED based UV sources can dramatically reduce the dose requirement
- A successful printer design requires careful match of the LED source with an optimized ink formulation

Thank you...

For Additional information:

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UV LED Curing Association  
([www.UVLEDCuring.org](http://www.UVLEDCuring.org))



Lumen Dynamics is a founding member of the UV LED Curing Association

UVABC's On-Line Resource Center  
(<http://www.uvabcs.com>)

