

Roll-to-roll manufacturing of large-area GaN sheets for photonics applications

*Vladimir Matias, Ph.D.
Founder and President*

EPIC World Photonics
Technology Summit 2022

January 24, 2022

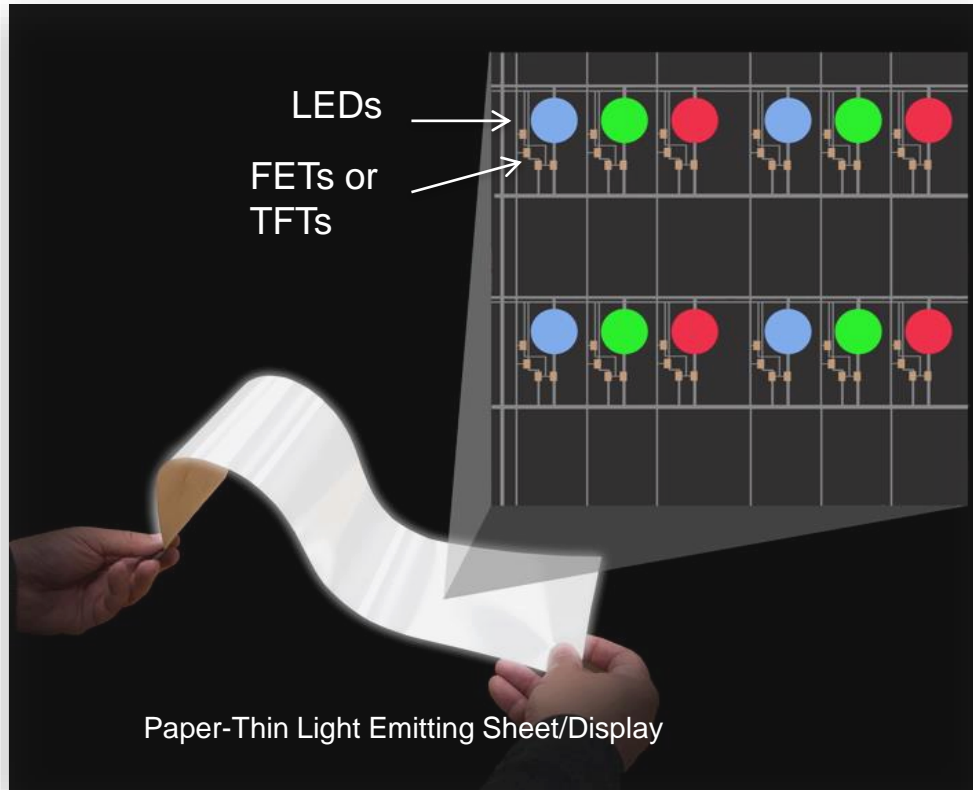


Imagine a Display:

- That has better color gamut than possible with displays today
- That is >10x more power efficient than an LCD
- That is super bright (>100,000 nits)
- That is paper-thin
- That is ultra flexible
- That is extremely fast and robust



This can be done with a *thin sheet of opto-semiconductor*



- Today's GaN-based LEDs are unparalleled sources of bright and efficient light
- *Monolithically* integrate LEDs, transistors, sensors in a sheet
- Creates a new paradigm for displays

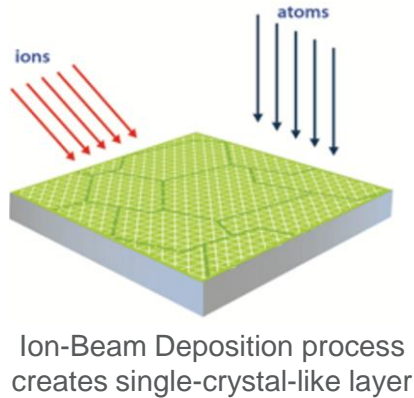


Problem – Not possible up until now

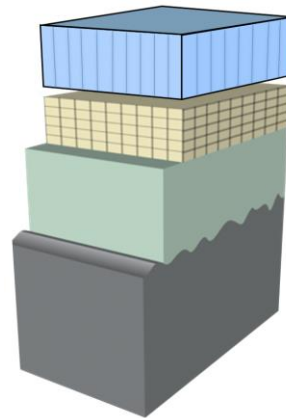
- Need epi-GaN devices ***in large areas*** – **X**
today's GaN LEDs are made on 6" sapphire wafers
- Need epi-GaN devices ***at low cost*** – **X**
today's epi-GaN costs \$2-3/cm²
- Need a ***flexible and robust substrate*** – **X**
today's LED substrates are rigid wafers

iBeam's Breakthrough: High-quality LEDs on a Metal

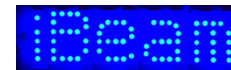
- *First-in-the-world Epitaxial InGaN LEDs fabricated* directly on polycrystalline metal foil (no transfer)
- Single-crystal templates of large-area substrates such as metal, glass and ceramics, replace single-crystal wafers - **GANOX**
- Fundamentally transforms how LEDs are *manufactured and used*



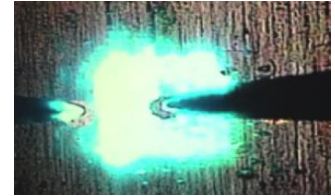
Epitaxial GaN
iBeam Crystal Aligned Layers
iBeam Planarization Layer
Unpolished Metal Substrate



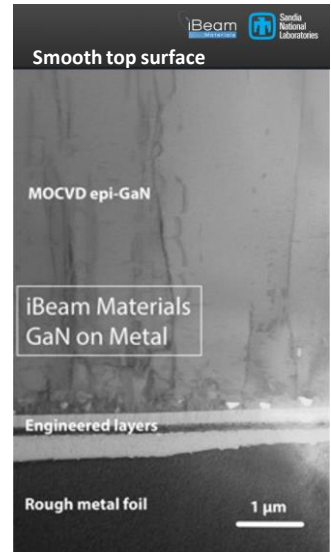
Template
(replaces single crystal substrate)



LED on Metal

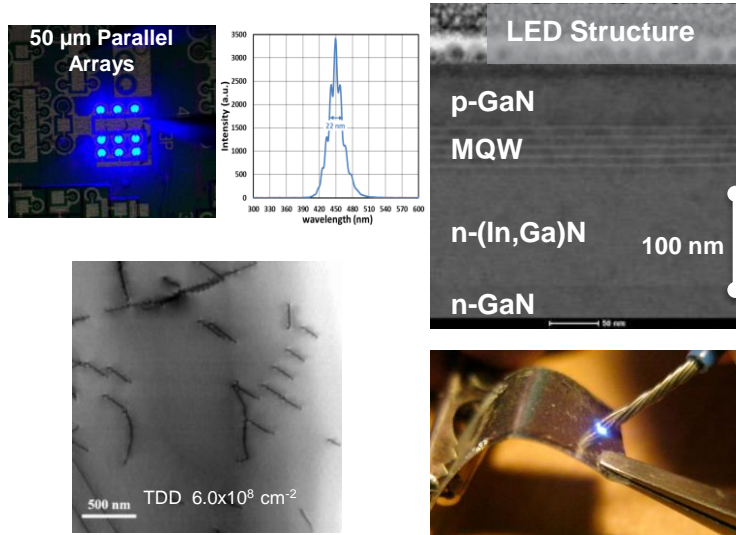


GaN on Metal Structure
ELECTRON MICROSCOPE IMAGE

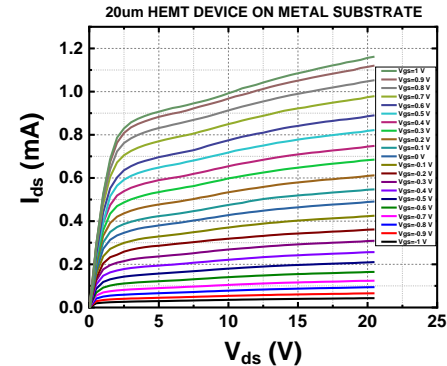
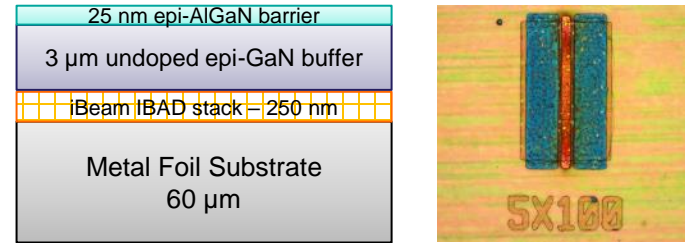


GANOX Enables GaN Devices in Large Areas

InGaN LEDs on a metal foil



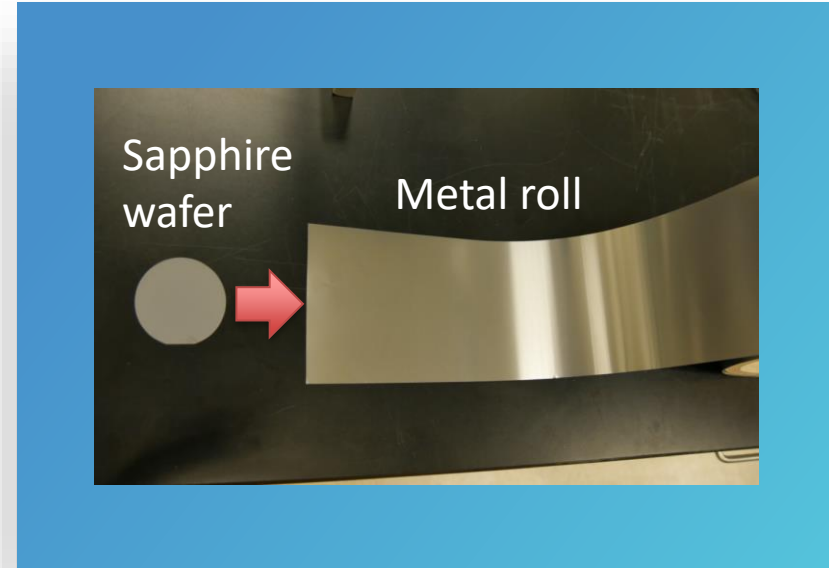
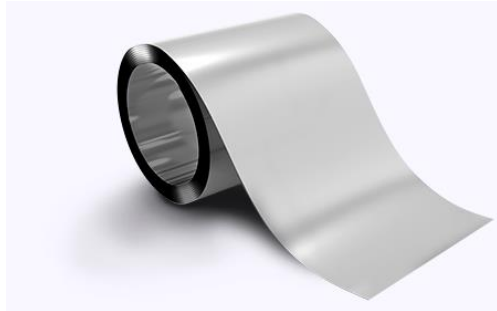
GaN/AlGaN HEMT on a metal foil



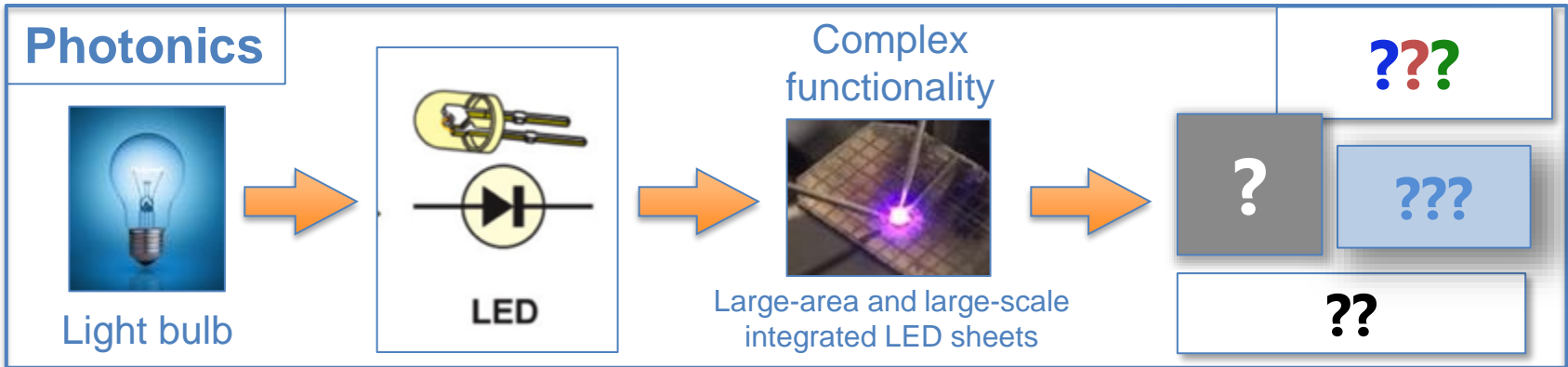
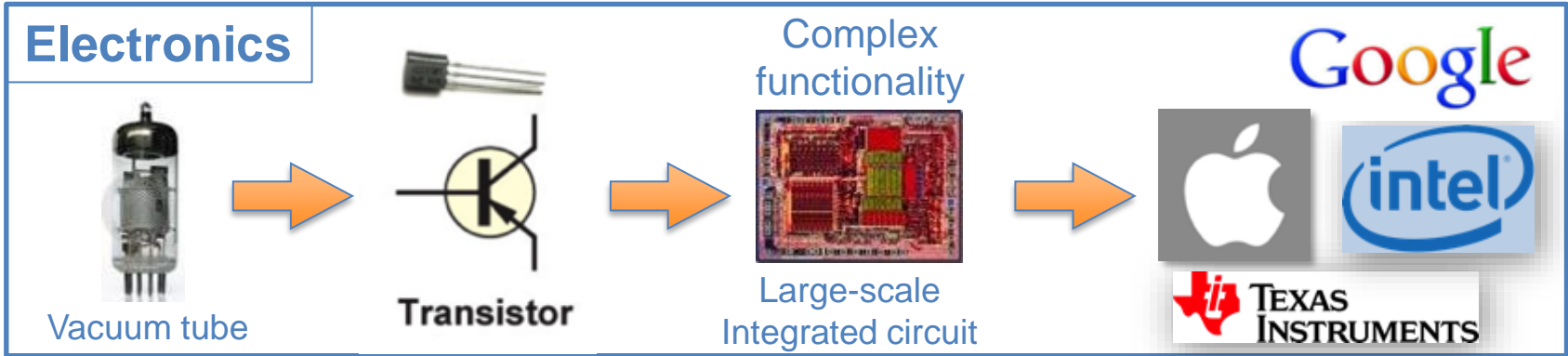
GaN-on-Metal Threading Dislocation Densities (TDD):
mid to high $10^8/\text{cm}^2$ (similar to GaN on sapphire)

GANOX Enables Manufacturing in Large Areas

- Only by depositing in large-areas is true scaling possible
- Ultimate scaling: kilometer lengths are possible via roll-to-roll ($>10,000\times$)
- Cost reduction $> 20\times$ possible



GANOX Enables Large-Scale Monolithic Integration of LEDs



iBeam Materials, Inc.

Company

iBeam incorporated in **2011**

Non-dilutive funding to date **\$6M**, Investment **\$2M**

Partnering is a strategic component of our go-to-market plans. Samsung is our first strategic partner.



Vladimir Matias, PhD
Founder and President

Leading world expert in IBAD crystal alignment technology



Julian Osinski, PhD
VP Product Technology

25+ years in semiconductor industry, device and QD applications expert



Klaus Kunze, PhD
Director Chemical Technology

25+ years in materials/chemical coatings industry; expert in solution coating, >130 patents.



Board of Directors



Michael Pachos, MBA
iBeam Board Director

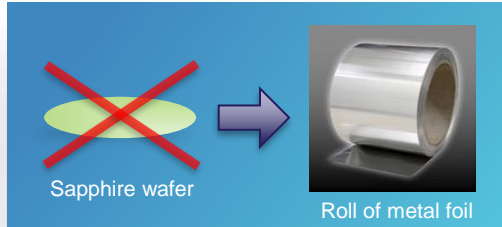
Managing Director at **Samsung Ventures**; Focus on Consumer, Display, and IT related investments



Mike Krames, PhD
iBeam Board Director

Renowned expert in LED technology, Former Soraa CTO, Lumileds EVP, Head of HP Advanced Labs, advises iBeam on LED technology

iBeam's Breakthrough: LEDs, FETs on Flexible Metal Foil



Achievements:



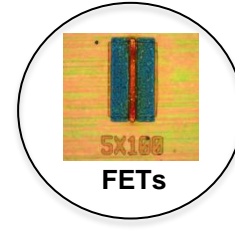
2016

First-in-the-world
InGaN LEDs directly
on metal foil



2017

iBeam's two
fundamental patents
are issued



2018

Arrays of microLEDs
on a flexible metal
substrate



2019

First-in-the-world
GaN transistors on
metal foil

Samsung Investment

2020

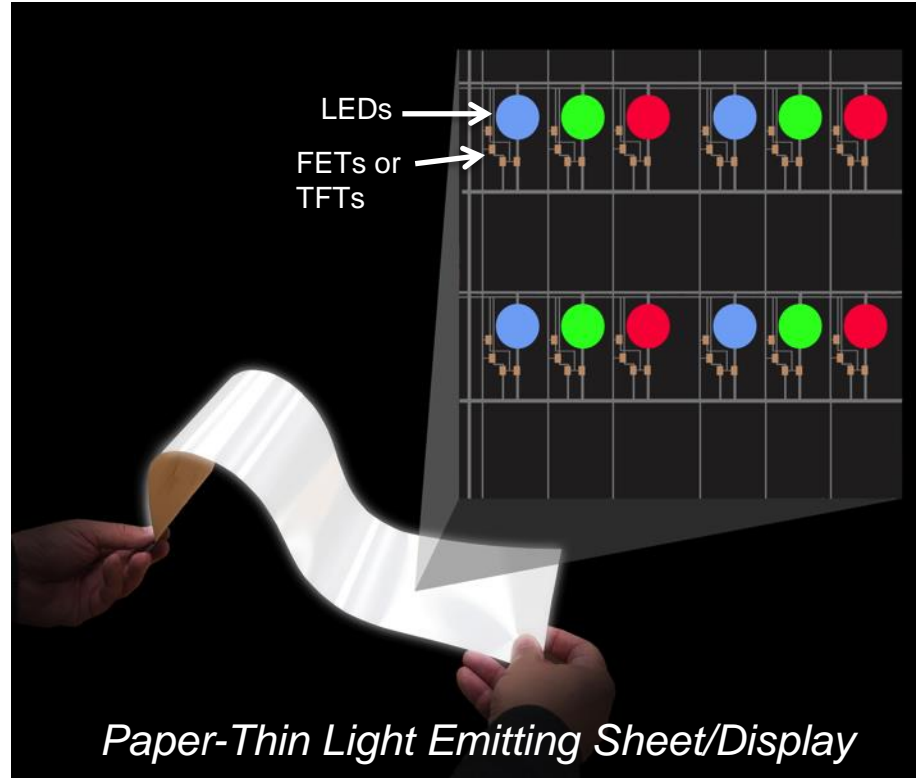
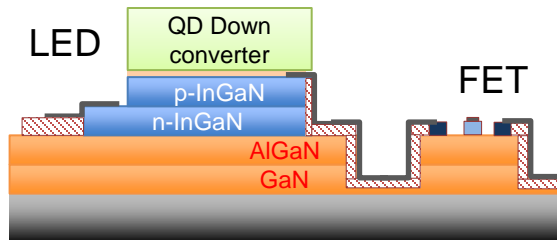
Two partner JDAs
Samsung Repeat
Investment

Next Step

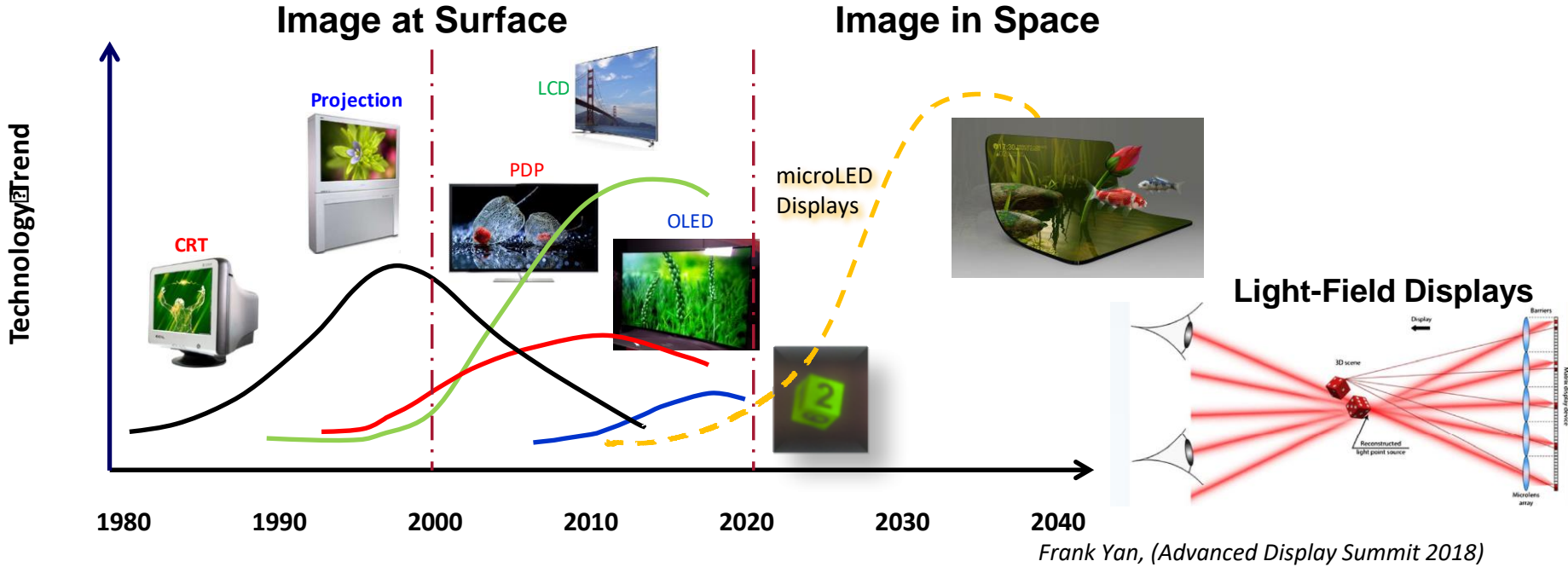
Achieve milestones for scalable
low-cost manufacturing process

GANOX Technology for Monolithic MicroLED Display

- **Monolithic integration** of LEDs for μ LED displays with NO TRANSFER
- Yield and Reliability improve greatly compared to mass transfer approaches
- Overlaid TFTs or epi-integrated GaN transistors to control LEDs
- QD downconversion for red and green colors, easily exceeding DCI-P3 gamut
- **Paper thin and flexible substrate**



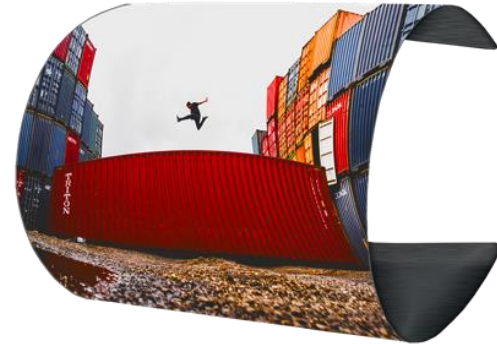
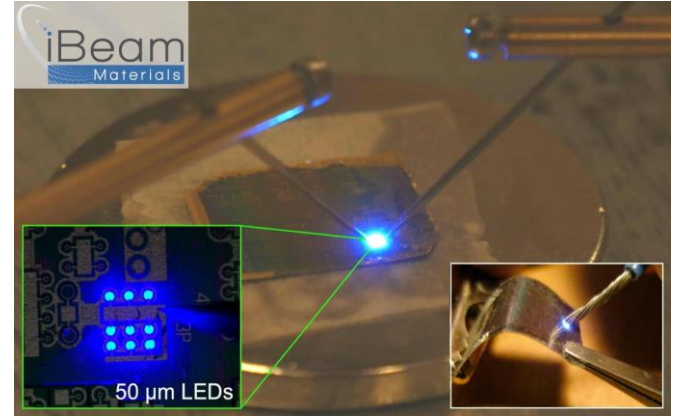
Evolution of Information Displays: Future in 3D



*Future Light-field displays will require billions of subpixels, making transfer impossible
Monolithic Integration becomes the only practical solution*

GANOX Disrupts MicroLEDs

- ✧ iBeam has a radically new LED technology using large-area metal foil:
 - High-quality LEDs and FETs demonstrated
 - Extreme-volume production scale up possible
 - Enables new product categories for wearables and mobile devices
- ✧ Monolithic integration of LEDs and GaN switching devices in large areas are a new approach for *flexible super-bright paper-thin microLED* displays



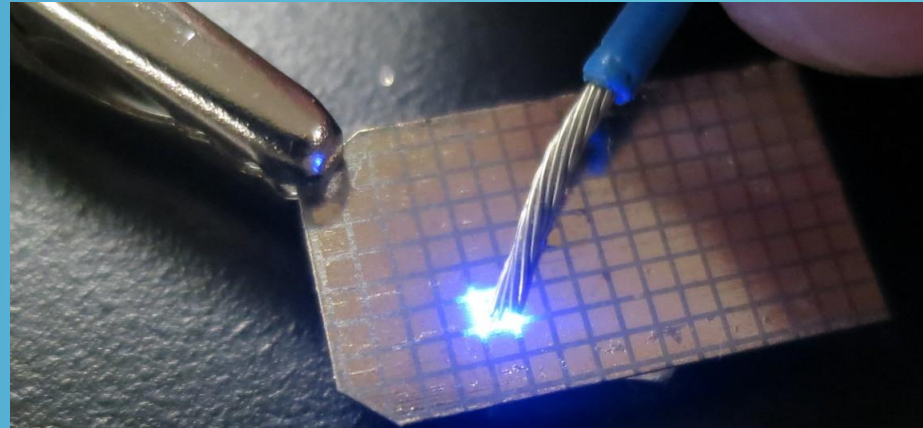
iBeam Materials

- Breakthrough disruptive LED platform
- Seeking key strategic partners and investors

Vladimir Matias

Founder & President
iBeam Materials
2778A Agua Fria St.
Santa Fe, NM 87507

www.ibeammaterials.com
vlado@ibeammaterials.com
+1-505-577-3193



First-in-the-world LEDs on metal foil



THANK YOU

Questions?

