

# NCD Diamond Semiconductor System for Advanced Power Electronics Integration

Collaboration Overview for AKHAN and Argonne National  
Laboratory

Adam Khan  
Founder & CEO

AKHAN Technologies, Inc.

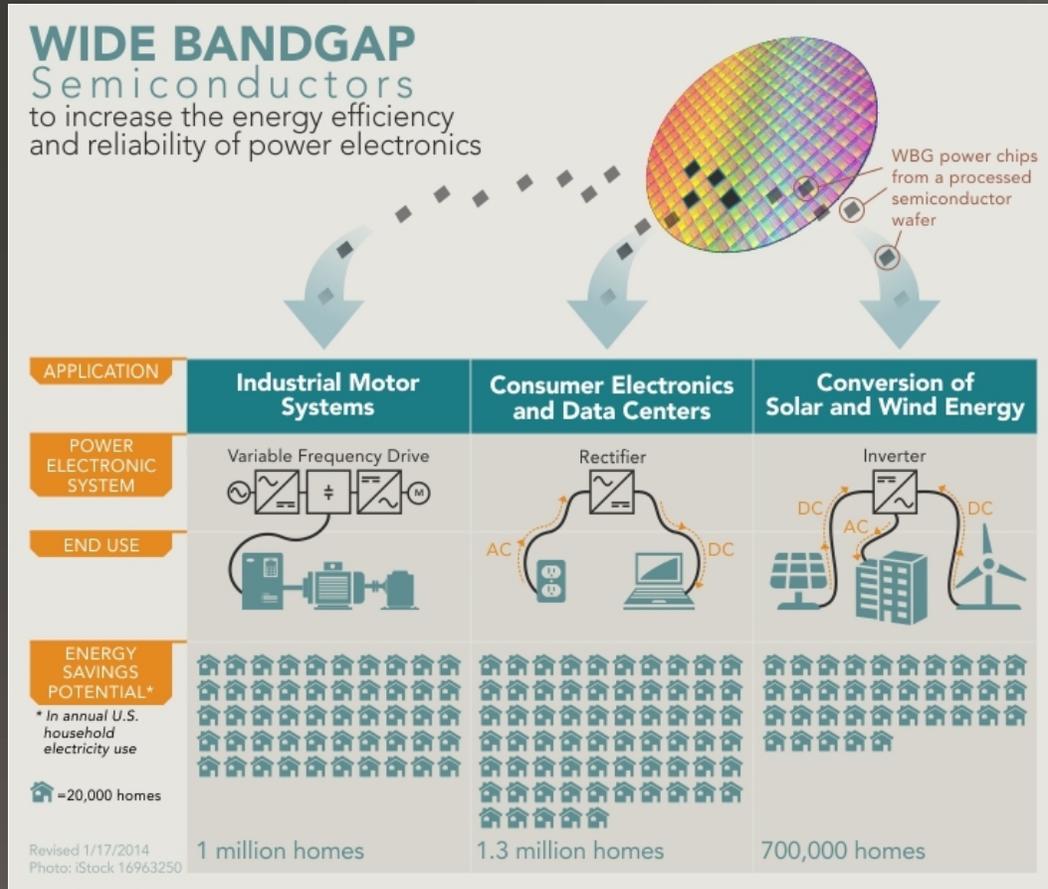
# About AKHAN Technologies

- Fab-lite Semiconductor Company specializing in **diamond semiconductor** technology
- Founded 2007, Hoffman Estates, IL
- Collaborating with **Argonne National Laboratory** (2012)
- Launched **Miraj Diamond™** Platform (2012), an Energy-Efficient Diamond Semiconductor Platform
- Product line addresses the needs of **automotive, avionics, defense, telecomm.** & greater power electronics markets (including **consumer electronics**)

## Recent Awards/Recognition



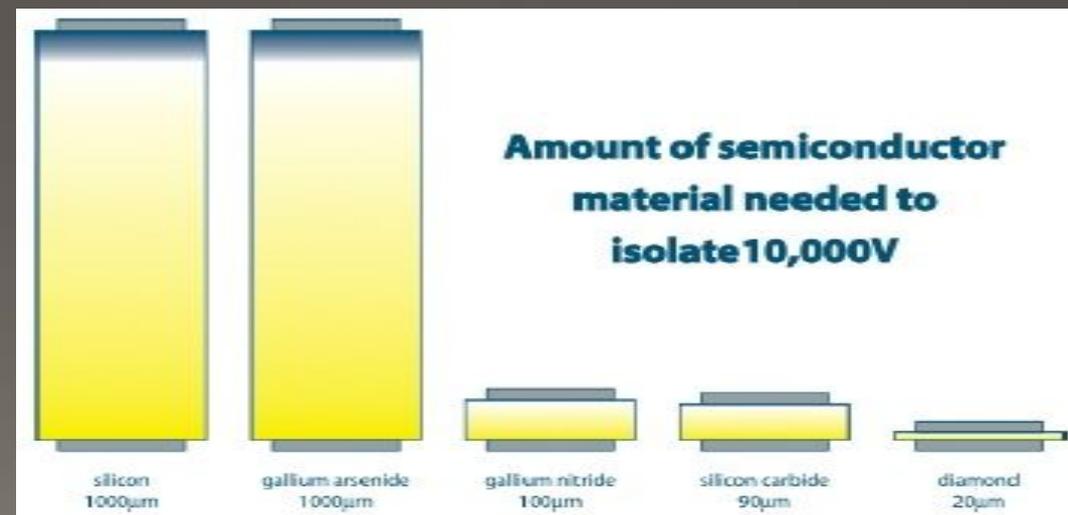
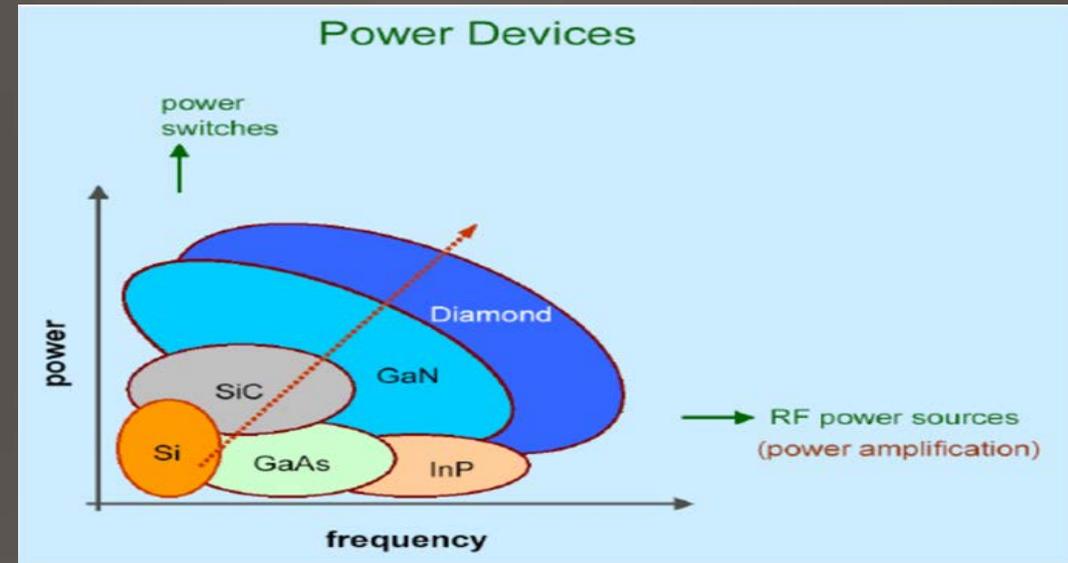
# “Wide Band Gap Semiconductors : Essential To Our Technology Future” The White House Blog



- DOE institute will develop infrastructure needed to make **WBG semiconductor**-based power elec. cost comp. w/ silicon chips **in the next 5 yrs.**
- Working with more than 25 partners across industry, academia, and state and federal organizations
- the institute will provide shared R&D, manif. eqpmt., and prod. testing to create new semi tech **up to 10x more powerful** that current chips on the market.
- **Diamond** is well known to be the **“Ultimate WBG Material”**

# Diamond as a Successor Technology

- ❖ Diamond conducts heat **5x better** than **Copper**, **22x better** than **Silicon**
- ❖ Diamond **Highly Enabling** for Power Electronics...
  - ❖ **Superior performance** capability compared to Si
  - ❖ **Thinner/smaller** than Si counterparts for equating function



# AKHAN Work with Dept. of Energy & Argonne National Laboratory

- 3 User Proposals (Center for Nanoscale Materials)
- Excl. licensee of ANL Low Temp. Diamond Deposition System
- Cooperative Research And Development Agreement (CRADA) with Dept. of Energy



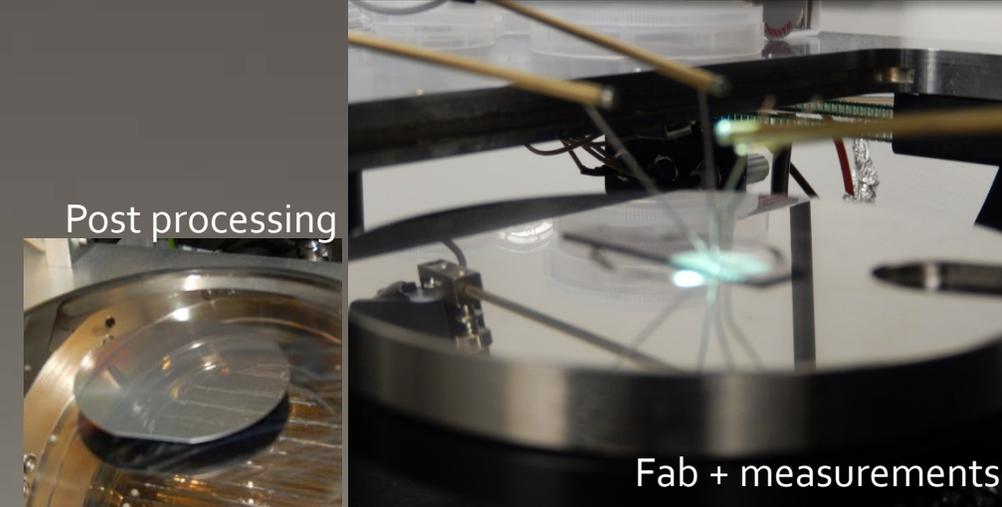
# Work Performed at CNM

## CNM Rapid Access Prop# 30281:

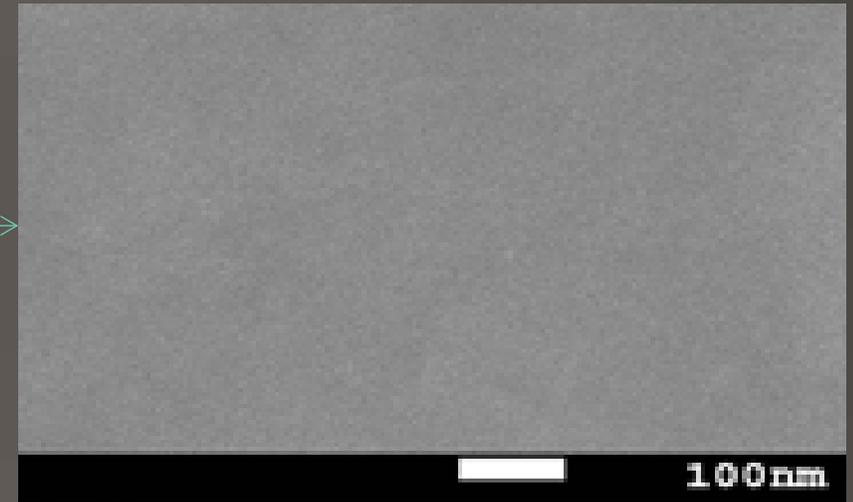
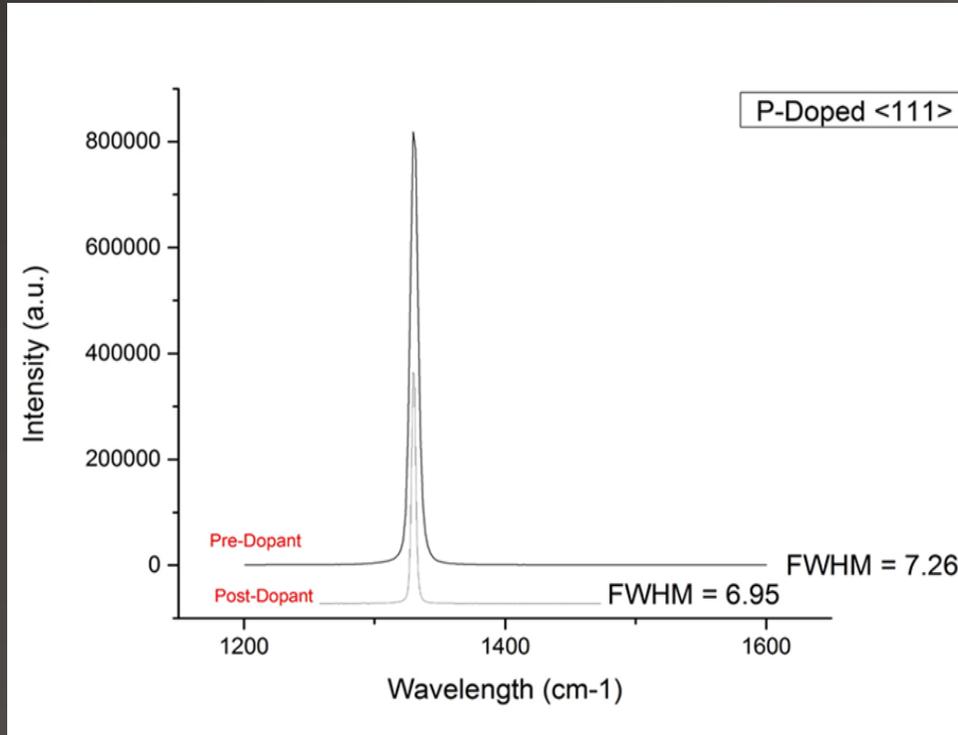
- Initial Characterization
  - Morphological, Phase, and Elec. Char. (via AFM, SEM, Raman, Keithley SCS in tandem with probe station & PPMS)
  - PIN Diode Device Characterization

## CNM Prop.# 30651:

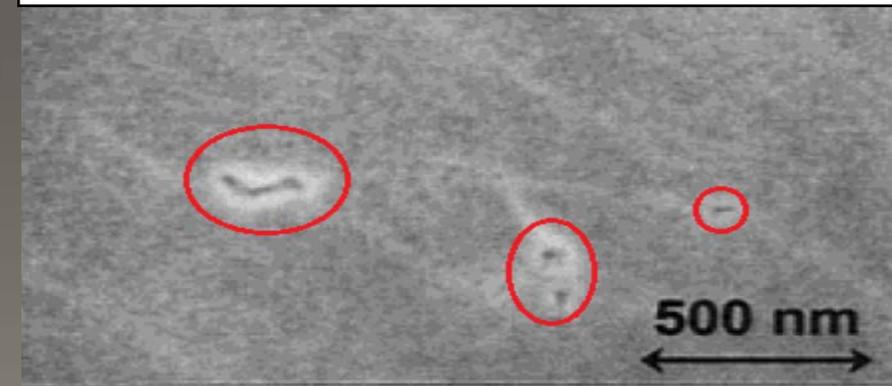
- Synthesis and process Demonstration on Various Grain Scales (NCD, MCD, & Single Crystal)
- Tested in Various Environments
  - Ultra High Vac and Temps. Between 2K and 380K
  - Post Exposure to H-Plasma
- Advanced Device Demonstrations
  - N-FET



# N-type Data Comparison



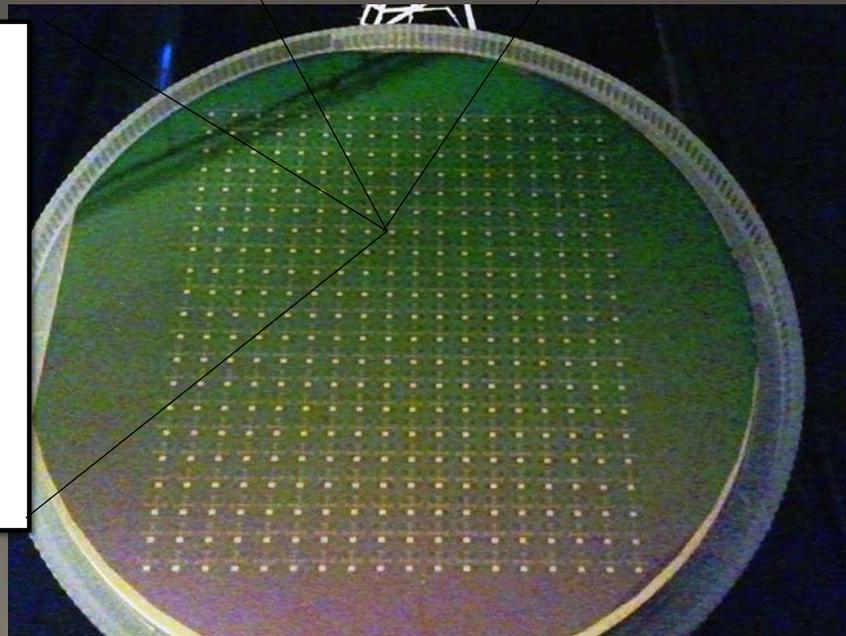
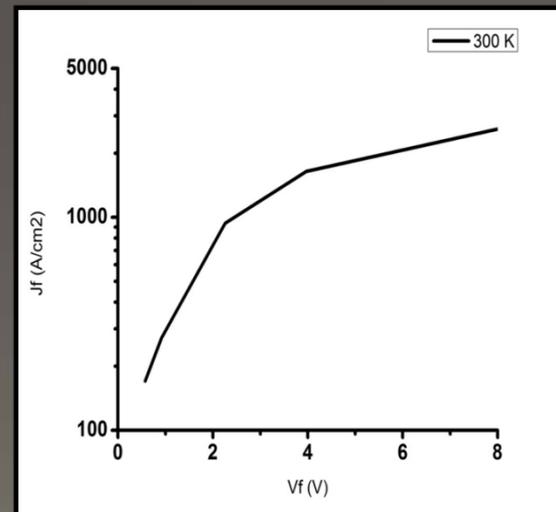
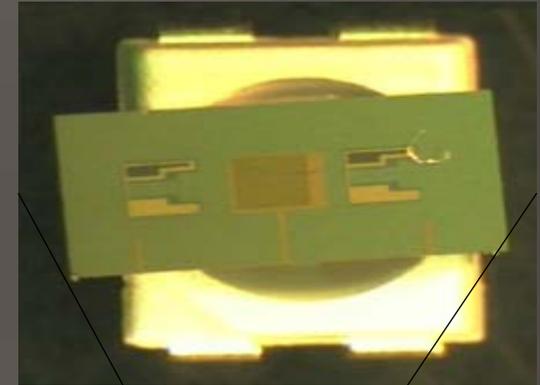
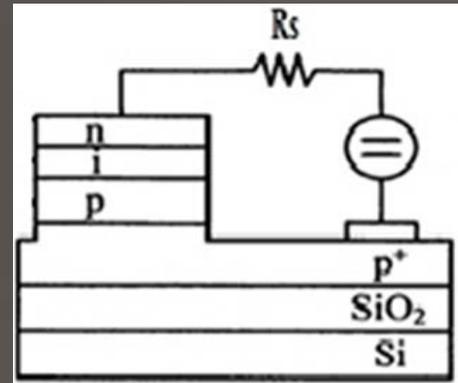
Source: S. Koizumi, *phys. stat. sol. (a)* 172, 71 (1999)



- The FWHM remains almost same indicating high crystal quality even after ion implantation
- No evidence of pitting

# NCD-Based PIN Diode

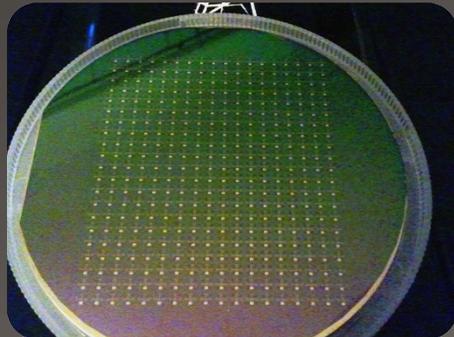
- Fabricated Devices are 1000x smaller than Si based counterparts and carry 1,000,000x more current under same forward bias\*
- Low associated costs and superior performance are highly enabling for next generation of power electronics



# The Miraj Diamond™ Platform



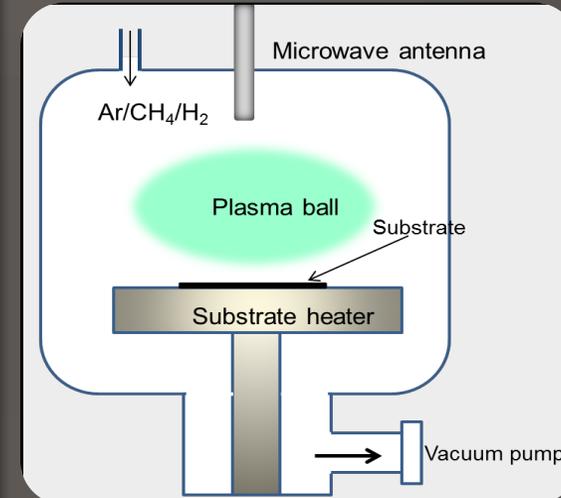
Nanocrystalline  
Diamond-On-  
Substrate Deposited  
at 400C



Semiconductor  
devices fabricated  
on the diamond

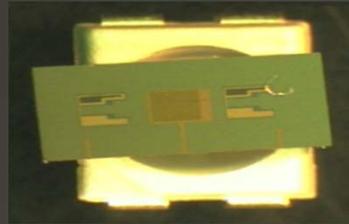


MPCVD Reactor at CNM

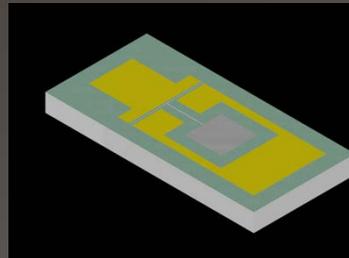
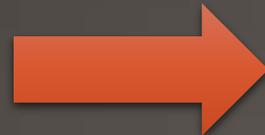


Producing diamond by  
cracking methane gas  
using microwave  
plasma process

# Applications



Diodes

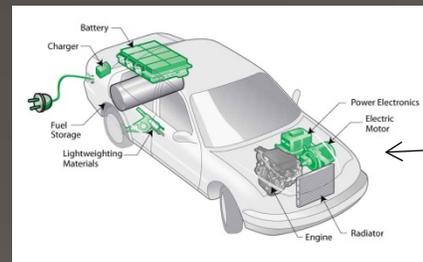


Transistors

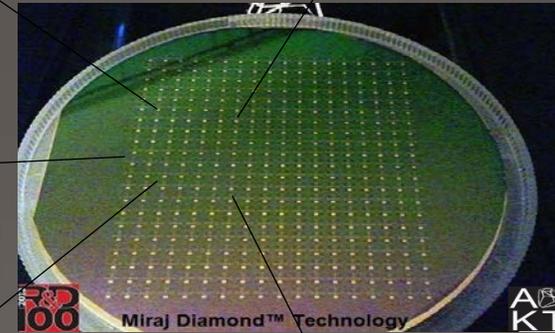
Faster supercomputers



Advanced Radar & Telecomm.



Automotive (HEV)



Sensors for Harsh Environment



Next Gen. Aerospace & Avionics

# Challenges:

- Initially long lead times [CRADA & License] (+4 months)

Resolution since: short form and long form CRADA versions

- Quicker turns on licensing discussions

# Successes:

- 3 Successful User Proposals and CRADA:
  - 2 New Patents Filed
  - 3 Papers Published
  - Multiple Industry & Business Awards
  - Several New Products in Development (Thermal Management and Semiconductor Wafer Materials)



# Successes:



ChicagoBusiness.com

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**Chip startup gets \$3.5 million to keep HQ in Illinois**

September 17, 2014

The state wants Gurnee to be known for computer chips as well as roller coasters and outlet stores: It's offering \$3.5 million in incentives to lure a Hoffmann Estates-based semiconductor company to move its headquarters to Gurnee instead of another state.

## Gurnee Courts Tech Company Courts: CEO a Gurnee Native

Daily Herald

Daily Herald (Arlington Heights, IL)  
September 17, 2014 | [Copyright](#)

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By Bob Susnjara [bsusnjara@dailyherald.com](mailto:bsusnjara@dailyherald.com)

Gurnee Mayor Kristina Kovarik is seeking support from other local taxing agencies for a combined \$2.3 million package of proposed financial incentives to a Hoffman Estates semiconductor company that supporters say could lead to a version of Silicon Valley in the village.

# Ways to Further Improve:

## Development:

- Research Aimed Around Well Identified Problem Sets with private/public funding well earmarked where IP generated is independently valuable (e.g. clean tech/energy efficiency)

## Outreach:

- Case Studies of Successful Lab to Fab Deployment of both technology and IP
- Need to Connect Research Geared Entrepreneurs to Lab Capabilities (CleanEnergy Trust, CleanTech Open, EnergyFoundry, etc.)



# Thank You for your Attention!

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