

KY nanoNET

**A Statewide Integrative Micro/Nano
Initiative for Collaborative Research,
Education and Outreach**



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Louisville, Kentucky 40292

Kentucky NanoNET

(KyNN)

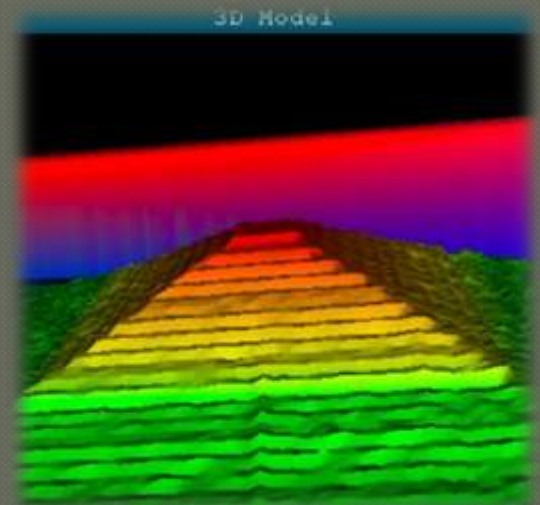
GOAL – To enhance the ability of KY's researchers to perform interdisciplinary micro/nano/MEMS research by addressing needs in the areas of - equipment (KORE), software (KRUNCH), networking (Web Portal), and outreach (STEM education).

4 Major Components

- KORE (equipment resources)
- KRUNCH (software resources)
- Web-based Portal (networking and connectivity)
- Outreach



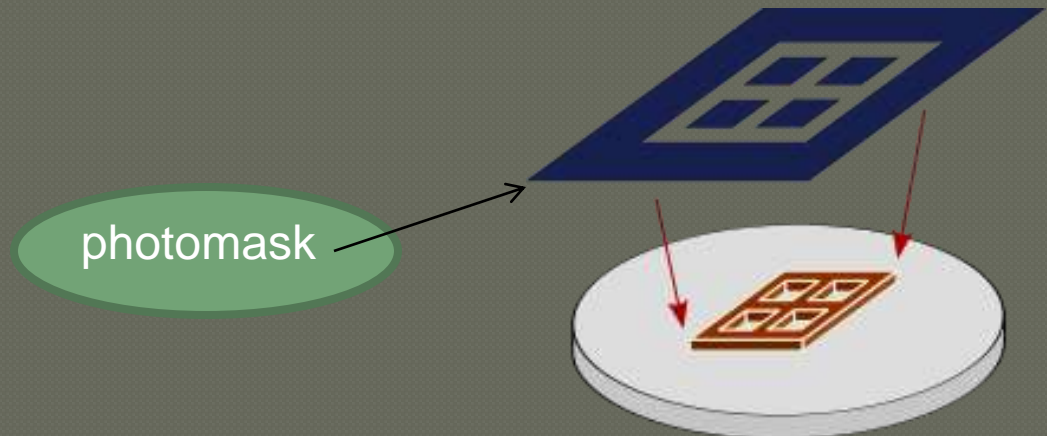
K.O.R.E



Kentucky Optical Resources

GOAL – To provide a statewide multi-user core infrastructure program for micro/nano photomask generation and advanced lithography

Typical research projects require 1-12 photomasks and several Universities in Kentucky have active micro/nano/MEMS research and education programs



Activities to Date

- Hired engineer (Curtis McKenna) and PhD student (James Loomis)
- Purchased new equipment
 - Heidelberg Laser Pattern Generator
 - CPK Spray/Etch/Develop System
 - Raith 150 E-Beam System
- Set up on-line mechanism for electronic file submission
- Purchased software to handle multiple data formats
- Visit University of Kentucky to provide a hands-on demonstration /tutorial on L-Edit to facilitate generation of photomasks.
- Fabricated many, many photomasks

Equipment Purchases

Heidelberg DWL-66FS Laser Pattern Generator

Status:

Delivered in year 1, installed in year 2 by Heidelberg.

Features:

- 0.6 μm minimum feature size
- 405 nm laser
- Photomask write time between a few hours to one day
- Grayscale lithography
- Direct write lithography on a wafer or die



Equipment Purchases

CPK Spin Spray Etch & Develop

Status:

Delivered 1st year,
commissioned 2nd year

Features:

Provides consistent and uniform
develop and etch rate, essential
for sub-micron geometries.



Equipment Purchases

RAITH 150 E-Beam System

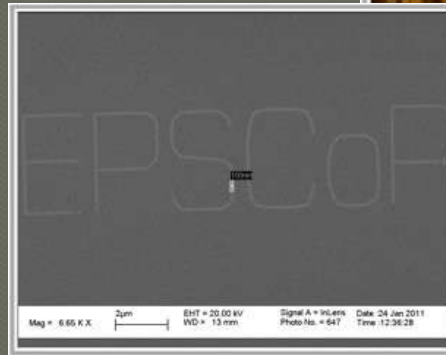
Status:

Purchased fall 2010,
initial training Jan. 2011

Features:

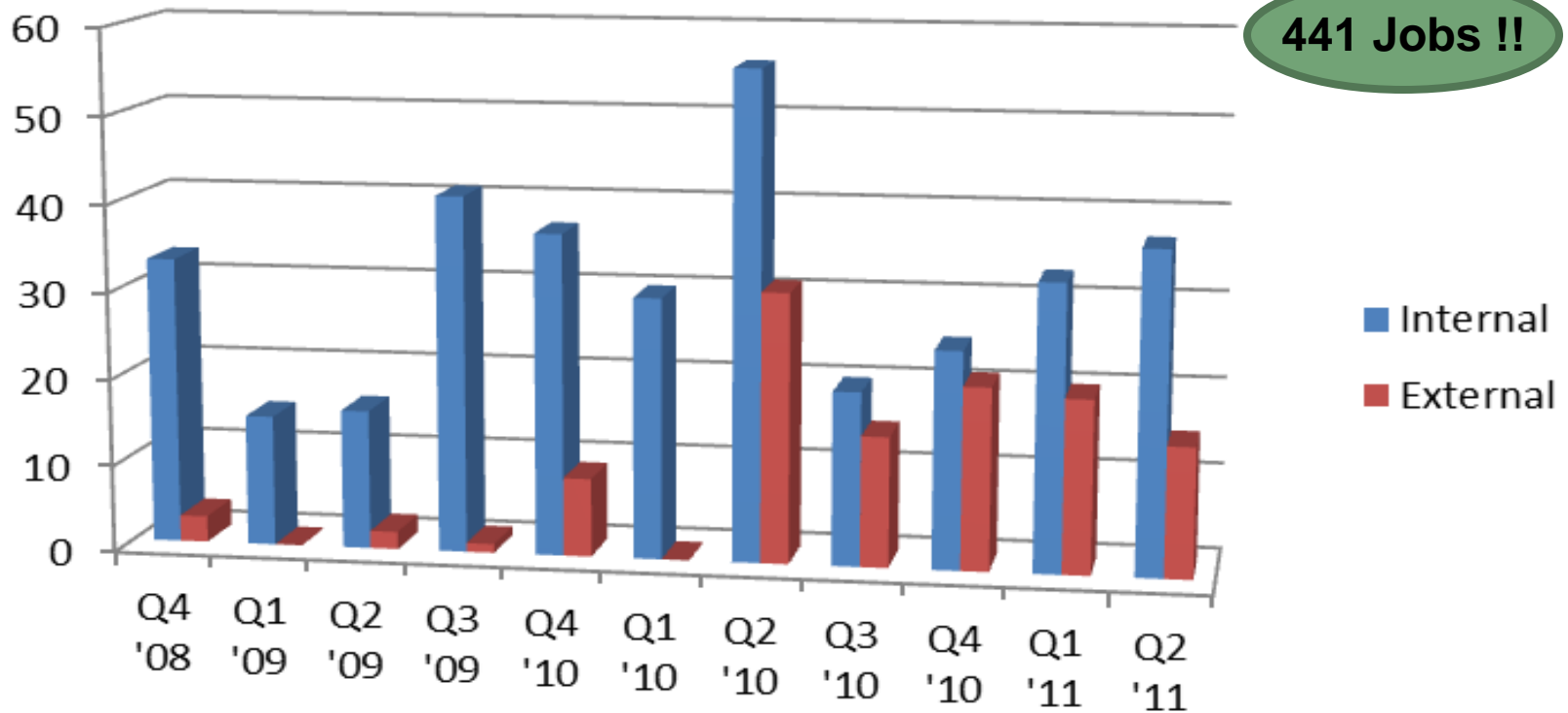
50 nm “easily achieved”

20 nm “with effort”



Masks Produced

Quarterly Customer Summary



NOTE: "JOBS" REFERS TO NUMBER OF MASKS GENERATED

External Users (1 year)

External Users Include:	Number of Jobs completed
Google (Silicon Valley)	6
Irvine Sensors (California)	25
University of Kentucky	4
SBG Labs Inc (California)	9
Cornell	8
Princeton	2
Purdue	1
Louisville Science Center	1
Albany – SUNY	2
Grand Valley State Univ.	7

Impact on UofL Research (1 Qtr)

PI Name	Start-up / Grant	Grant value
Dr. Thomas Berfield	Start-up Funds	NA
Dr. Cindy Harnett	Grant – NSF	\$400,000
Dr. Kevin Walsh	Grant – Navy	\$4,688,681
Dr. Sean Fu	Start-up Funds	NA
Dr. Balaji Panchapakesan	Grant – NSF	\$302,173
Dr. Stuart Williams	Start-up Funds	NA
Dr. Palaniappan Sethu	Grant – University of KY Research Foundation	\$388,120
Dr. Gina Bertocci	Grant – National Institute of Justice and the Dept. of Justice	\$800,000

Grayscale Lithography Conversion Software

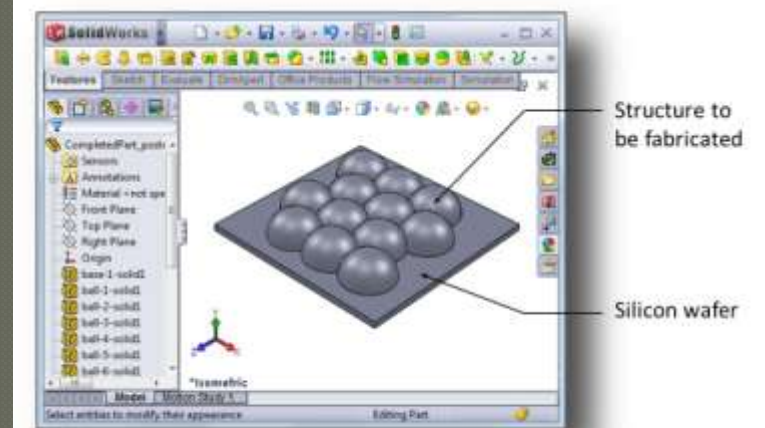
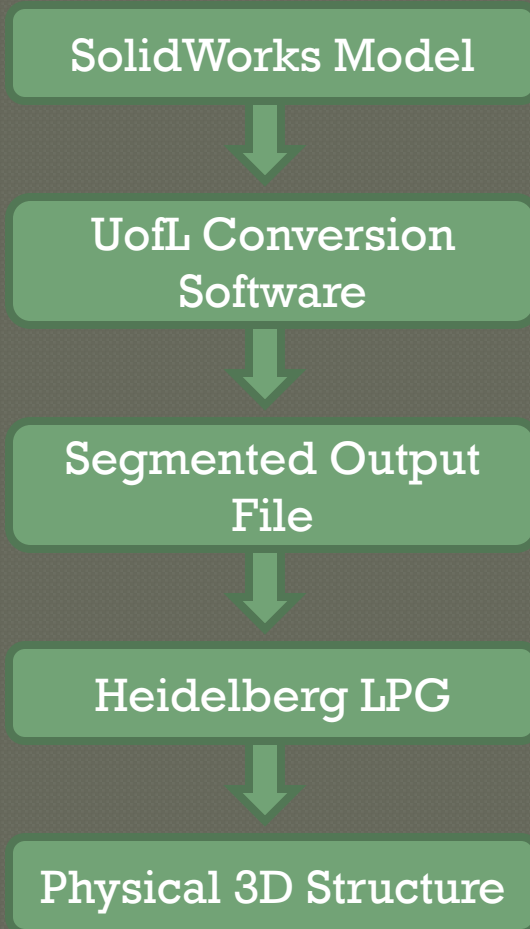


Fig 1. Designing part in SolidWorks

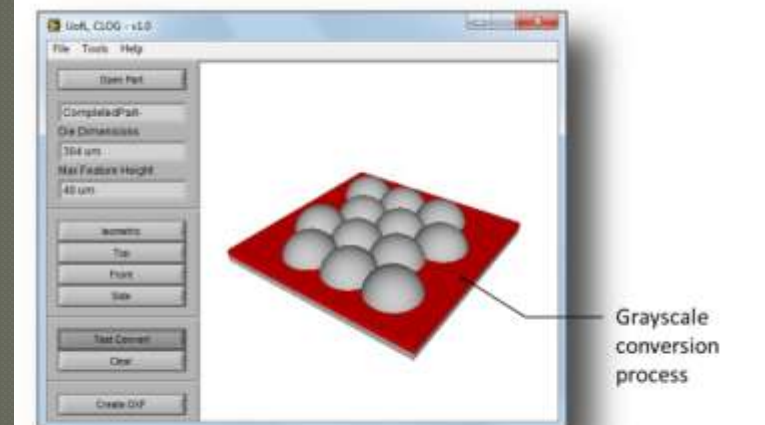


Fig 2. UofL mask generation software

* No MEMS or Fab Training required !!!

Grayscale Lithography Conversion Software

The conversion software offers a variety of options to allow for use with a range of photoresists as well as lithography machines. These features include:

- 2 through 512 layer sections (*Z resolution control*)
- Linear and nonlinear segmentation
- XY resolution control

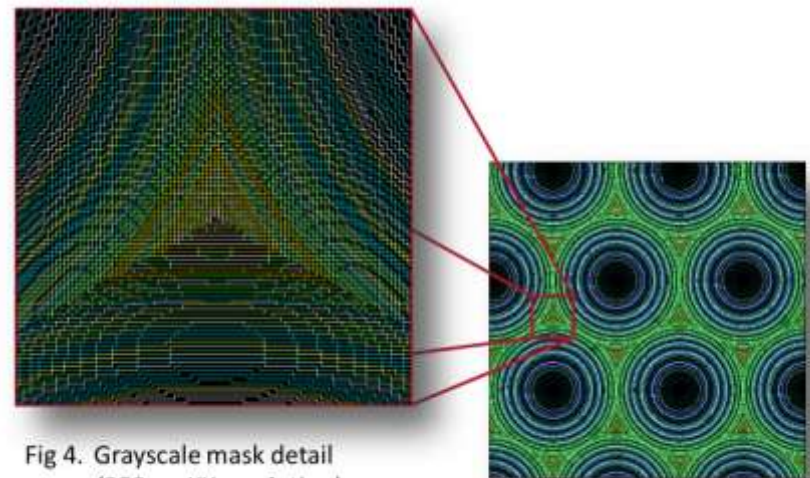
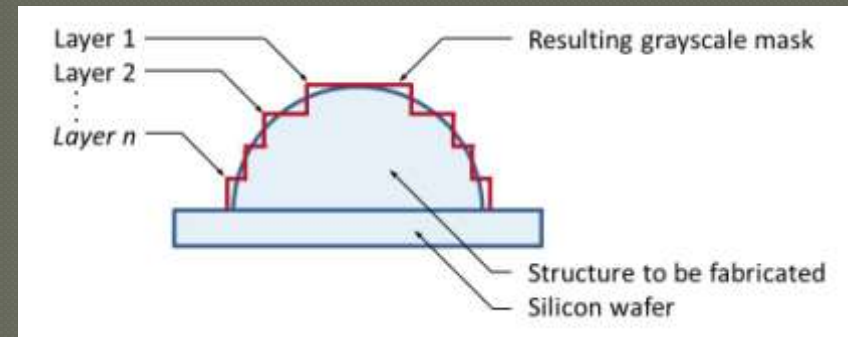


Fig 4. Grayscale mask detail
(250nm XY resolution)

Fig 3. Grayscale mask

Grayscale Lithography Conversion Software

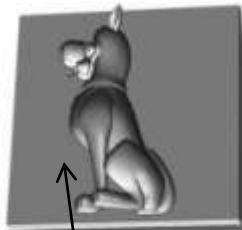


Fig 5. Scooby Doo model and grayscale mask



3D Structure in Resist

UL EPSCoR Software

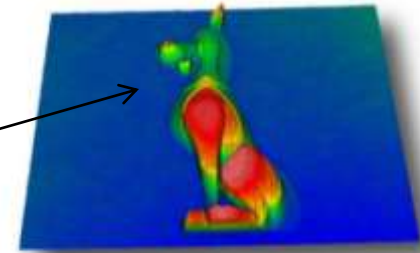


Fig 6. Interferometer scan of fabricated Scooby Doo (approximately $800\mu\text{m} \times 300\mu\text{m} \times 3\mu\text{m}$)

SolidWorks Model

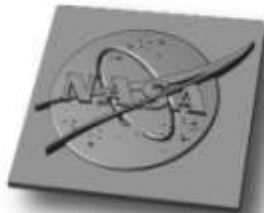


Fig 7. NASA logo model and grayscale mask

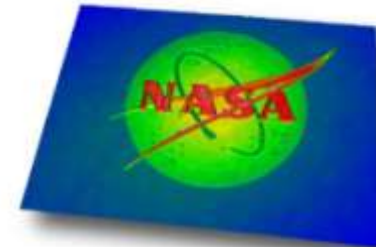
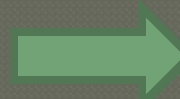


Fig 8. Interferometer scan of fabricated NASA logo (approximately $750\mu\text{m}$ diameter $\times 3\mu\text{m}$)



Fig 9. Hemisphere array model and grayscale mask

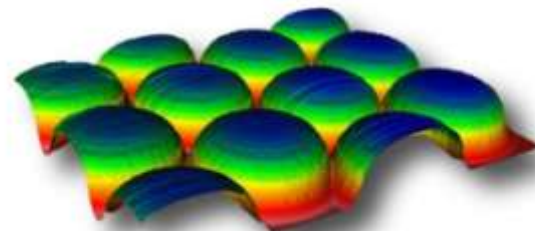
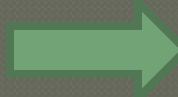
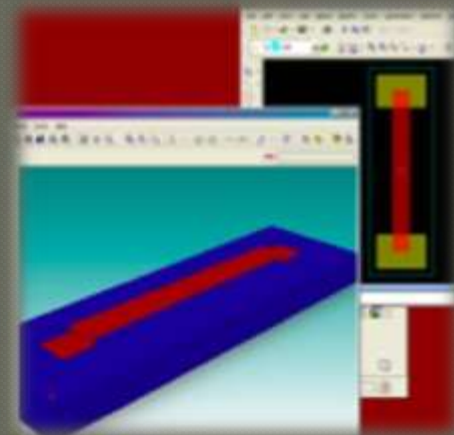
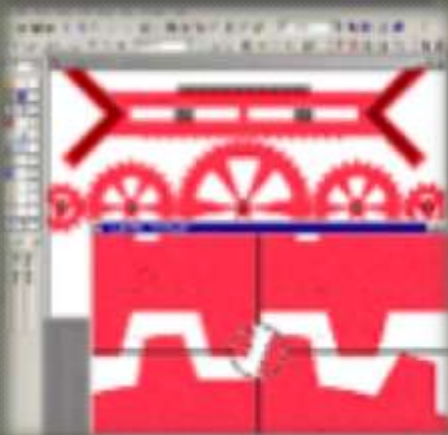
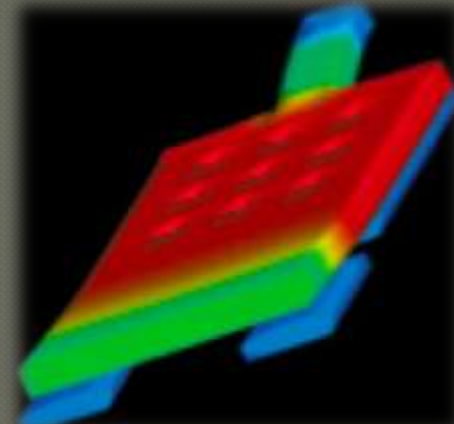
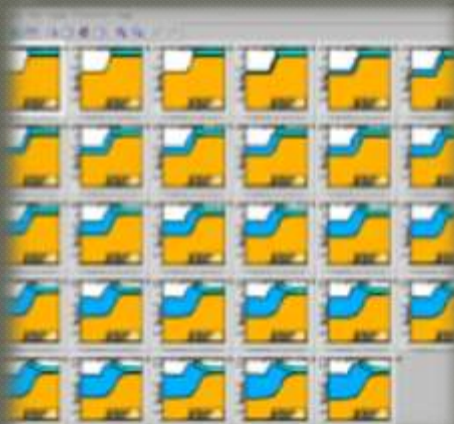
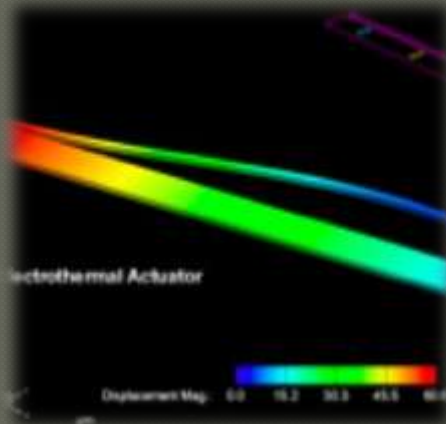


Fig 10. Interferometer scan of fabricated hemisphere array (approximately $800\mu\text{m} \times 600\mu\text{m} \times 3\mu\text{m}$)

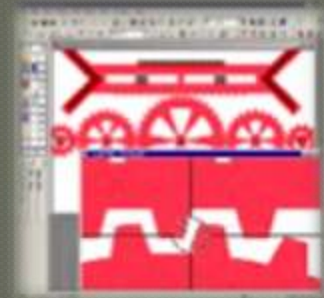
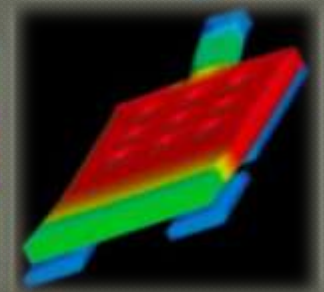
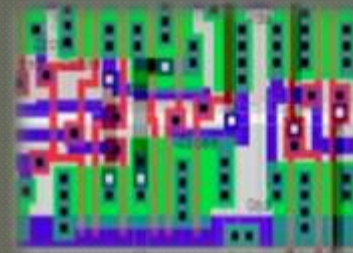
K.R.U.N.C.H.



Kentucky Research Users of Nanotechnology CAD Hub

GOAL - Provide KyNN researchers and teachers with the latest in expensive commercial “micro/nano” CAD tools through a shared portal system, much like the NSF nanoHUB for free micro/nano shareware tools

Software – Layout, design, process simulation and modeling

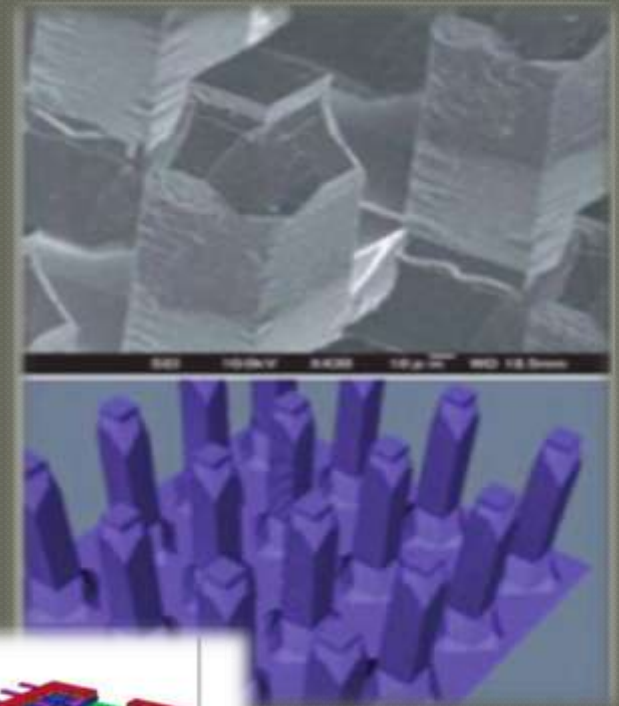


Activities to Date

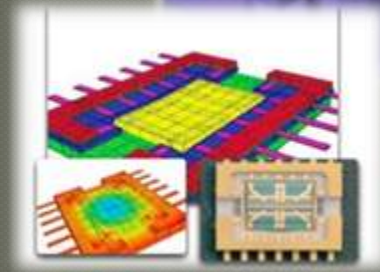
Deployed four commercial software suites

IntelliSuite (Software 1 of 4)

- Huge range of simulation capabilities, including: Electro-Thermo-Mechanical, Microfluidics, Electromagnetics, and Etching
- Also can run mask, fabrication, packaging, simulations in virtual cleanroom



Actual VS Modeled Fabrication



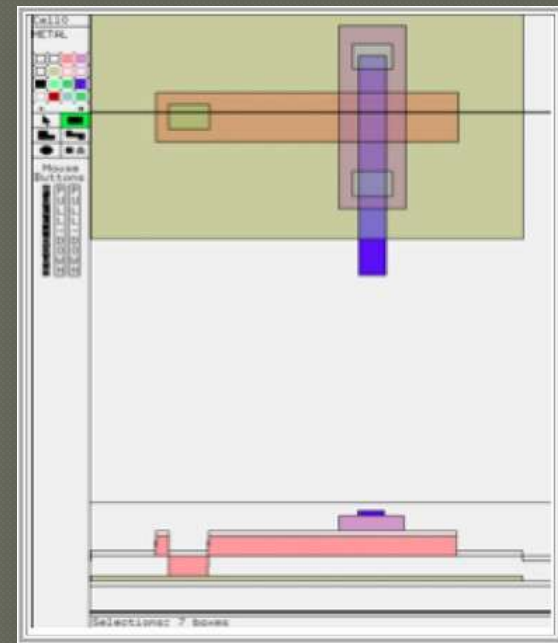
Design & Simulation Tools

Activities to Date

Tanner EDA (Software 2 of 4)

IC design & layout suite, electrical
Simulation

L-Edit (mask creation)



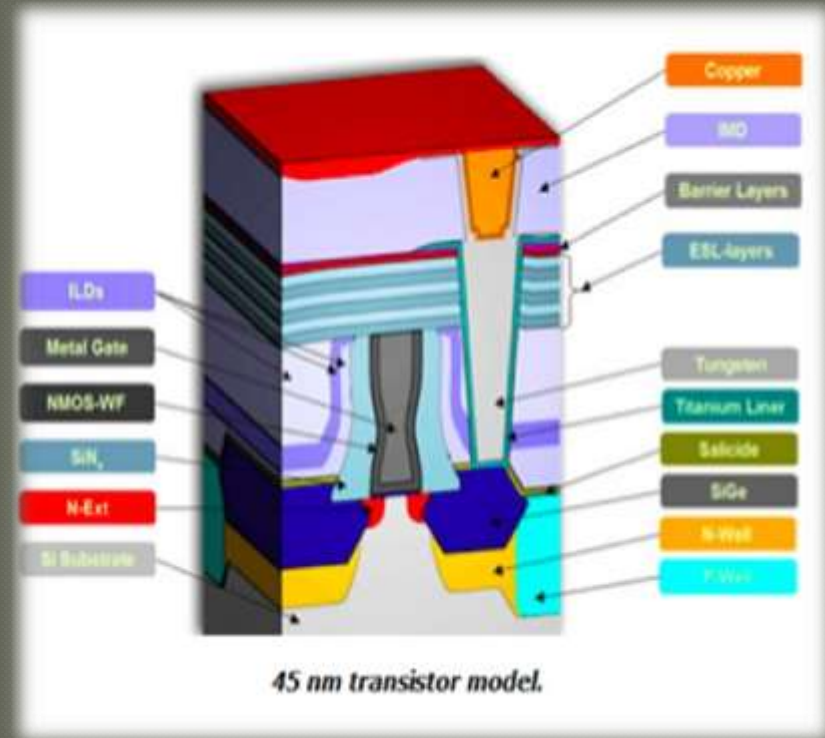
Activities to Date

Silvaco TCAD (Software 3 of 4)

Fab process simulation
(ion implantation,
diffusion, oxidation,
etching, etc)

Text based input

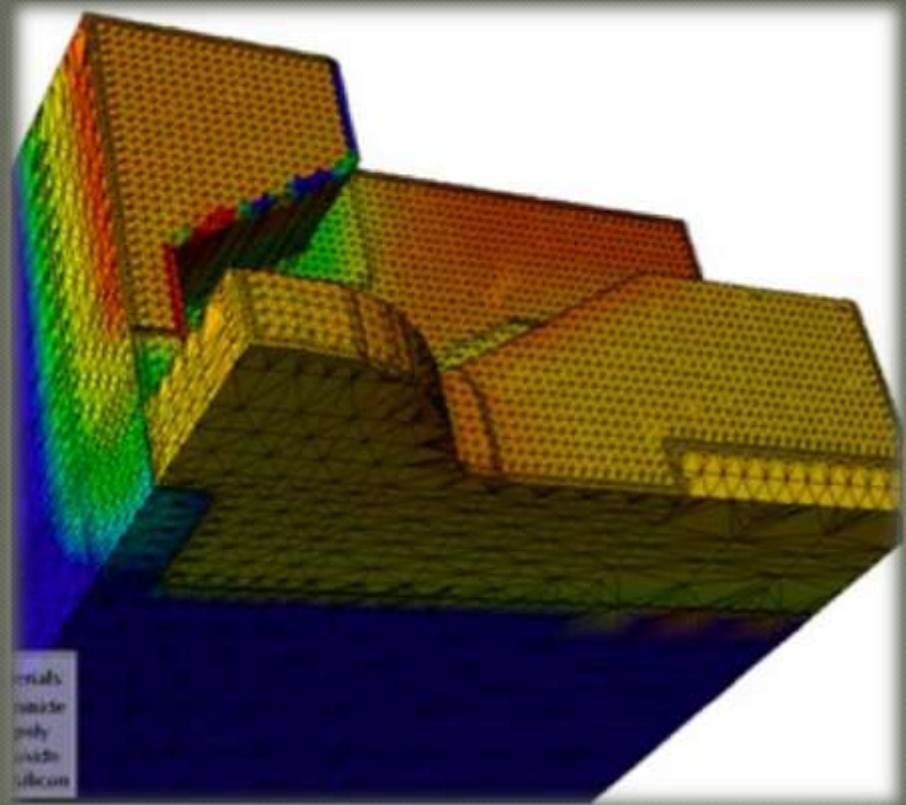
Currently used in ECE
543 at UofL and WKU



Activities to Date

CoventorWare SEMulator (Software 4 of 4)

SEMulator emulates Silicon processing in software, allowing you to fabricate your device in a virtual 3D environment



Activities to Date

REMOTE ACCESS AND SECURITY

Made the commercial software available to local (direct network access) and off campus users (VPN)

Established a secure, remotely accessible VPN for external (non-UofL) Users

- Web interface
- VPN software automatically installs
- Access from outside the UofL campus
- Shared software and installation instructions are directly downloadable through the website



Virtual Private Network (VPN) Hardware

Activities to Date

TRAINING

- State-of-the-art training facility at UL
- 60" LED Flat screen
- 1 Dedicated Instructor Workstation
- 8 High-End workstations
- 16 Student/Trainee capacity



Results/Outcomes to Date

- Since made available, over 150 students, researchers, and faculty have used the software (50+ current users of the shared software)
- Successful usage of the software for on and off-campus

Entity	Date Range	Course Number	Title	Software Package
UofL	Spring 2011	ECE 600	The MOSFET	Silvaco
UofL		ECE 633/644	Microelectronic Design and Fabrication	L-Edit, Silvaco
UK	Fall 2010	EE 599	Intro to M/NEMS	L-Edit
UofL		ECE 543	Microfab	Silvaco, L-Edit
WKU		EE 599	Intro to MEMS	Silvaco, L-Edit
UofL	Spring 2010	ECE 600	The MOSFET	Silvaco
UofL		ECE 636/637	MEMS Design and Fabrication	L-Edit, CWare
UofL	Spring 2009	ECE 600	Advanced MEMS	CoventorWare

"This is pretty incredible software now that I semi-understand it. "

KyNN Web Initiatives

KY NANONET

Connecting Kentucky's Micro/Nano Community

WELCOME ABOUT KYNN KYNN NODES KYNN EQUIPMENT DB KYNN RESEARCHER DATABASE CONTACT US

WELCOME TO THE KY NANONET
CONNECTING KENTUCKY'S MICRO/NANO COMMUNITY.

The goal of the KyNN is to provide the tools you need to better collaborate and share the many resources in the Bluegrass State.

This five year initiative, funded by the NSF EPSCoR, is broken into three interconnected parts:

- KyNN is the communication portion of the initiative and consists of this web portal, several social media components and an informational database created to the micro/nano community in Kentucky.
- KyNN-ED is a shared academic initiative that will provide access to several high-end commercial packages for all of Kentucky's Universities.
- KyNRE is an infrastructure project to provide a resource for custom high-resolution mask generation state of Kentucky.

The Kentucky Nanonet project is housed out of UofK's Micro/Nano Technology Center with Dr. Naveen Kulkarni as the PI. Although founded by UofK, the initiative has already grown to include at least one node at each major Kentucky schools. These nodes represent laboratories performing research in some aspect of the technology.

For more information please feel free to Contact Us.

KY NANONET

Connecting Kentucky's Micro/Nano Community

KYNN - GALLERY

On May 12, 2010 over 100 7th grade from Newburg Middle School visited the UofK, Micro/Nano Technology Center.

On May 13, 2010 - 40 middle school students from Ascension Middle School visited the MNTC, Micro/Nano Technology Center.

On April 17, 2010 21 students from Louisville's Ascension High School, Ascension visited the UofK, Micro/Nano Technology Center.

21 high school seniors from Newburg Middle School visited the MNTC on April 9, 2010.

KyNN Home

KyNN Equipment Database

Please click here to enter the Database. If you are not a node admin, please choose GUEST to login.

Welcome to the KyNN Equipment Database
This resource is designed to give a clearer picture of the capabilities available within the Ky Nanonet. This list of equipment is constantly evolving as KyNN Nodes add new tools and products.

Researcher Database - Find, Connect, Collaborate

Home Find Record List Find All

To submit your information for inclusion in the KyNN Main Site

The Kentucky NanoNET
Connecting Micro/Nano Community

Kentucky NanoNet

What's on your mind?

Search

Kentucky NanoNet
DR. Venkatakrishna Rao Jala - Building the engineering platform to synthesize molecular machines
Recent Posts available: 9992 - 9 Value Labels, MPE - 4 Value Labels, Plant Value Labels, Kentucky NanoNet, engineering platform for synthesizing cellular and molecular machines, Bioengineering, nanotechnology, university of Louisville, interdisciplinary research

5 replies at 9:45am - Comment Like Share

Kentucky NanoNet
Newburg Middle School 7th-Grade Visits MNTC
May 13, 2010 - Over 100 seventh grade students from Newburg Middle School visited the Micro/Nano Technology Center's Classroom on May 13, 2010.

May 13 at 9:45am - Comment Like Share

Kentucky NanoNet
Seminar - "Magnetic Nanoparticles for Biomedical Applications"
May 13, 2010 - The "Engineering Platform for Synthesizing Cellular and Molecular Machines" seminar series continues with Dr. Zhen-Feng Ren of the Laboratory of Materials and Systems Composites on May 27, 2010. Dr.

May 13 at 9:45am - Comment Like Share

Kentucky NanoNet
Ascension Middle School Visit the Micro/Nano Technology Center
May 13, 2010 - 40 students visited the UofK, Micro/Nano Technology Center on May 13, 2010. The students learned about micro and nanotechnology and the research being conducted at UofK.

May 13 at 9:45am - Comment Like Share

Kentucky NanoNet
Dr. Andre Gobin - NIR Absorbing Gold Nanoparticles

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Kentucky NanoNET

Overview Discussions News Jobs Subgroups Manage More...

News: Latest News

- Submit a news article
- Manage news feeds

Most Activity
Latest News
Recently Submitted
Recent Discussions

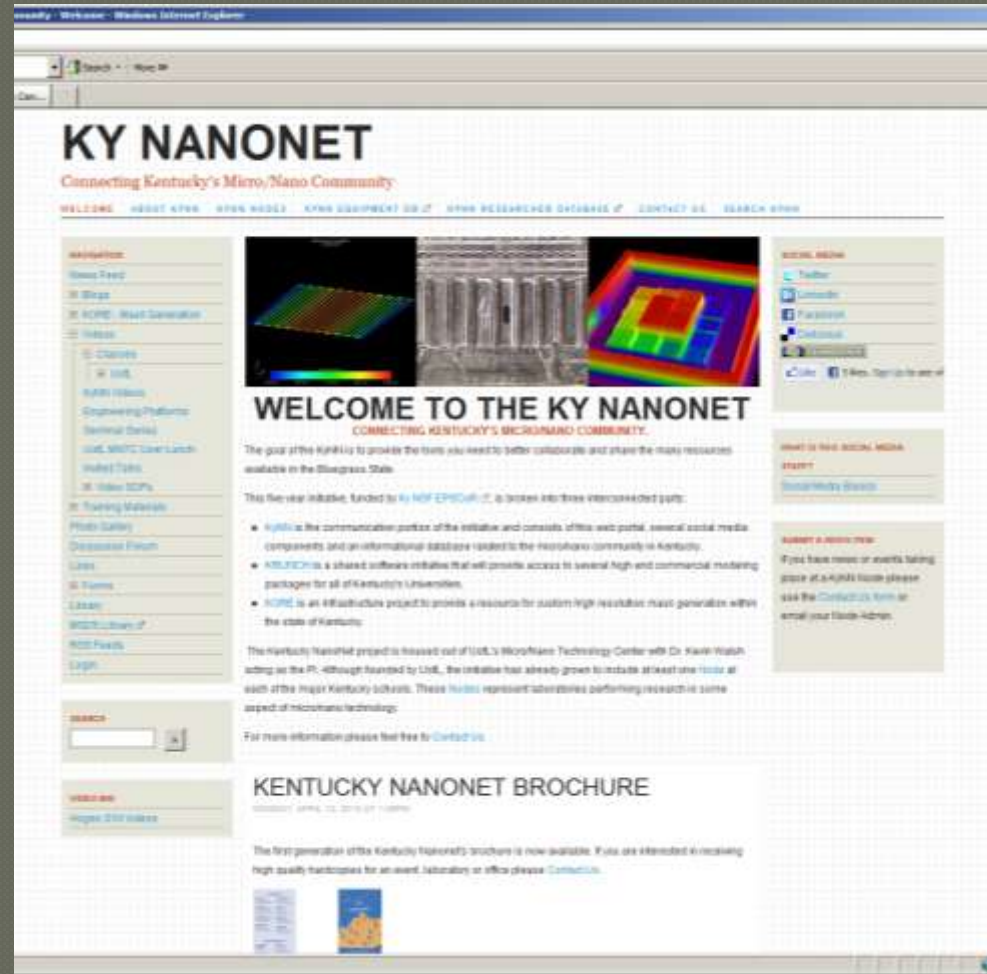
News: Latest News

- DR. Venkatakrishna Rao Jala - Building bio-...
From: kyannanet.org | May 14, 2010 | Delete | Follow discussion
- Newburg Middle School 7th Grade Visits MN...
From: kyannanet.org | May 13, 2010 | Delete | Follow discussion
- Seminar - "Magnetic Nanoparticles for Biome...
From: kyannanet.org | May 13, 2010 | Delete | Follow discussion
- Ascension Middle School Visit the Micro/Nan...
From: kyannanet.org | May 11, 2010 | Delete | Follow discussion
- Dr. Andre Gobin - NIR Absorbing Gold Nanop...
From: kyannanet.org | 1 view | May 07, 2010 | Delete | Follow discussion
- Newest Heavy Element Discovered
From: kyannanet.org | May 07, 2010 | Delete | Follow discussion

KyNN Web Initiative

Goals:

- To provide a statewide virtual network to allow Micro/Nano Researchers from across the state to connect, collaborate and share resources more effectively.
- Provide an online clearinghouse for information related to micro/nano technology research in Kentucky



The screenshot shows the KY NANONET website interface. The main heading is "KY NANONET" with the tagline "Connecting Kentucky's Micro/Nano Community". Below this, there is a navigation menu with links for "WELCOME", "ABOUT KYNN", "KYNN MODEL", "KYNN EQUIPMENT", "KYNN RESEARCHER DATABASE", "CONTACT US", and "SEARCH KYNN". The main content area features a large image with a 3D surface plot and a colorful square pattern, with the text "WELCOME TO THE KY NANONET" and "CONNECTING KENTUCKY'S MICRO/NANO COMMUNITY". Below this, there is a paragraph explaining the goal of the initiative and a list of bullet points describing the initiative's components and goals. A search bar is visible on the left side of the page. At the bottom, there is a section for "KENTUCKY NANONET BROCHURE" with a link to download it.

Activities to Date

First generation of KyNN system operational

- www.kynanonet.org
- Equipment database
- Researcher database
- MSDS library for common chemicals
- Media distribution for video content
- Social Networking – Twitter and Facebook
- Work with “Engineering Platforms Initiative” to develop content for KyNN



The screenshot displays the KyNN Equipment Database interface. At the top, it says "KyNN Equipment Database" with a "Home" link. Below this, the page is titled "Testing Equipment" and "Cascade SUMMIT 11000B-M KyNN". A photograph of the equipment is shown on the right. To the left of the photo are three grey rectangular boxes. Below the photo, the following information is displayed:

- University:** Morehead University
- Name:** Cascade SUMMIT 11000B-M Probe Station
- Category:** Testing Equipment

At the bottom, there is a table with the following columns: "Tool Status", "Description", "Tool Details", "Notes", and "Documentation". Under the "Tool Status" column, there is a list of status options with radio buttons:

- Available
- Down - Preventive Maintenance
- Down - Awaiting Repair
- Not Installed
- On Order

Below the status list is a "Notes" section with a text input area.

Outcomes

12 Participating Nodes

- EKV - Department of Chemistry
- Morehead - RF/Micro Characterization Lab
- Murray - Microelectronics Lab
- UK - Catalyst Research and Testing Center
- UK - Center for Nanoscale Science & Engineering
- UK - Imaging Facility
- UK - Mass Spectrometry Facility
- UL - Institute for Adv. Materials & Renewable Energy
- UL - Micro/Nano Technology Center
- UL - Rapid Prototyping Center
- UL - Wireless & IC Design Lab
- Sullivan University College of Pharmacy

Activities to Date

Development of touch-based informational kiosk for use at KyNN home facility



Outreach



MNTC Tours* (Last Yr)

<u>Event</u>		<u>Participants</u>
● Fairview High School (Ashland)		6
● Seneca High School Visit		4
● St Rita's Catholic School MNTC Tour		18
● LSC Teachers Preview Night	20	
● NanoFury Lego First Team		8
● South Ripley High School		22
● KYNN Presentation @ UK		18
● Floyd Central High School		11
● Japanese School Teachers Tour		19
● Pleasure Ridge Park HS Tour	21	
● Westport T.A.P. Tour	27	
● Ascension Middle School Tour		32
● Women's Career Day Tours		30
● Ascension Catholic School Tour		38
● Noe Middle School Tour		94
● Oak Ridge Associated Universities Visit		7

* coordinated through Louisville Science Center and Speed Outreach Office

375

Molecules to the Max

- Sponsored IMAX nanotechnology film “Molecules to the Max” at the Louisville Science Center
- Premier event for over 150 Speed School Faculty, Staff and their Families
- Ran from April 1 - Nov 30
- Seen by over 8,500 kids and parents during its run
- Provided tickets to 250 JCPS students



NanoDays 2010

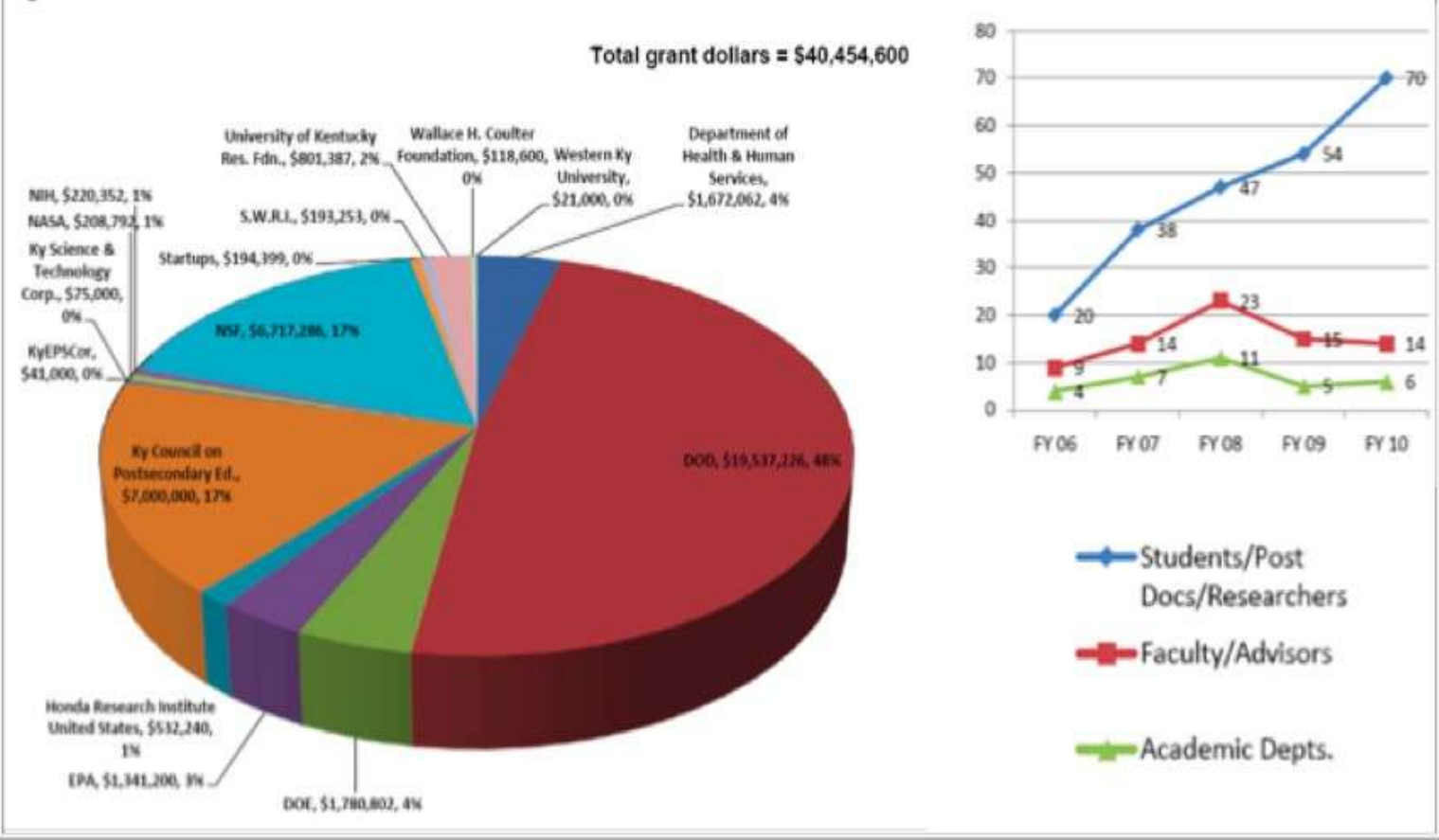
- April 1-3, 2010 at the LSC
- Attended by over 1,500 students from Ky region
- Annual event





KY NSF EPSCoR Impact: Real and Sustainable

Figure 11. Total Grant Dollars that have used the Cleanroom since October 2001



Conclusions and Future Direction

- KYNN Web-based Portal is operational with 12 nodes, equipment data base, researcher data base, news items and videos
- KORE has 3 signature tools (LPG, CPK, Raith) and producing masks for customers from around the country.
- KRUNCH is operational with 4 licensed commercial software packages, VPN, and a new training facility
- OUTREACH has touched over 5,000 K-12 students and their parents through tours and LSC activities
- FUTURE – purchase plasma metal etch tool, pro-actively engage nodes and KYNN users, develop software training modules, complete MEMS CAD training lab, continue outreach.

AAAS Recommendations

- 1) “recommends continued support for KyNN” and although “KyNN is receiving a relatively modest budget from EPSCoR (~\$200K/yr)”, the investment in KyNN equipment/infrastructure “is an enormous opportunity to leverage these funds to procure new programs that exercise the infrastructure”. **THANKS AND WE AGREE**
- 2) “KORE investments from this point forward should focus on new and differentiating capability (such as the Raith e-beam system) rather than ‘just’ replicating optical photomask processing” **EXPLORING THIS**
- 3) “At this point in the program, it is time to consider expanding the vision of KyNN from solely an infrastructure/enabling facility to one that can identify and promote areas of intellectual focus in the micro/nano area” ... “provide an intellectual basis for preparation of, and participation in, the next EPSCoR grant.” **BEYOND OUR CHARGE BUT HAPPY TO DISCUSS WITH KY EPSCoR LEADERSHIP. WOULD REQUIRE REALLOCATION OF RESOURCES AND EFFORTS**

AAAS Recommendations

4) “the claimed amount of KyNN funding from NIH related to micro- and nano efforts was small (approximately \$200K out of an overall \$40M). This represents a significant opportunity for growth”

“bioengineering could be a key user base for KyNN, yet NIH funding among KyNN users was relatively low”

“stronger links between advanced materials”.

AGREE BUT TAKES COORDINATION AND BUY-IN FROM OTHER INITIATIVES

5) “KyNN should position itself as a catalyst for integration of this EPSCoR effort as well as future KY EPSCoR and other externally-funded efforts.”

WE AGREE BUT TAKES EPSCoR COORDINATION