Center for Solid State Electronics Research

Self-Study Report

FY 2005 – 2010

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1. Center/Institute Goals

The Center for Solid State Electronics Research (CSSER) serves as the intellectual home for ASU faculty, staff, and students requiring processing expertise in the general area of solid state electronics. We also support academic users from other universities as well as small and large businesses that require access to advanced fabrication and characterization tools.

CSSER's mission is to conduct research, develop process technologies and provide educational programs that will engender international leadership in solid state electronics. In support of this mission we have three main goals; i) to provide our users with open-access to a state-of-the-art toolset; ii) to ensure that all of our users are adequately trained, and; iii) to maintain a safe working environment. To achieve these goals the CSSER management and staff have a number of on-going tasks:

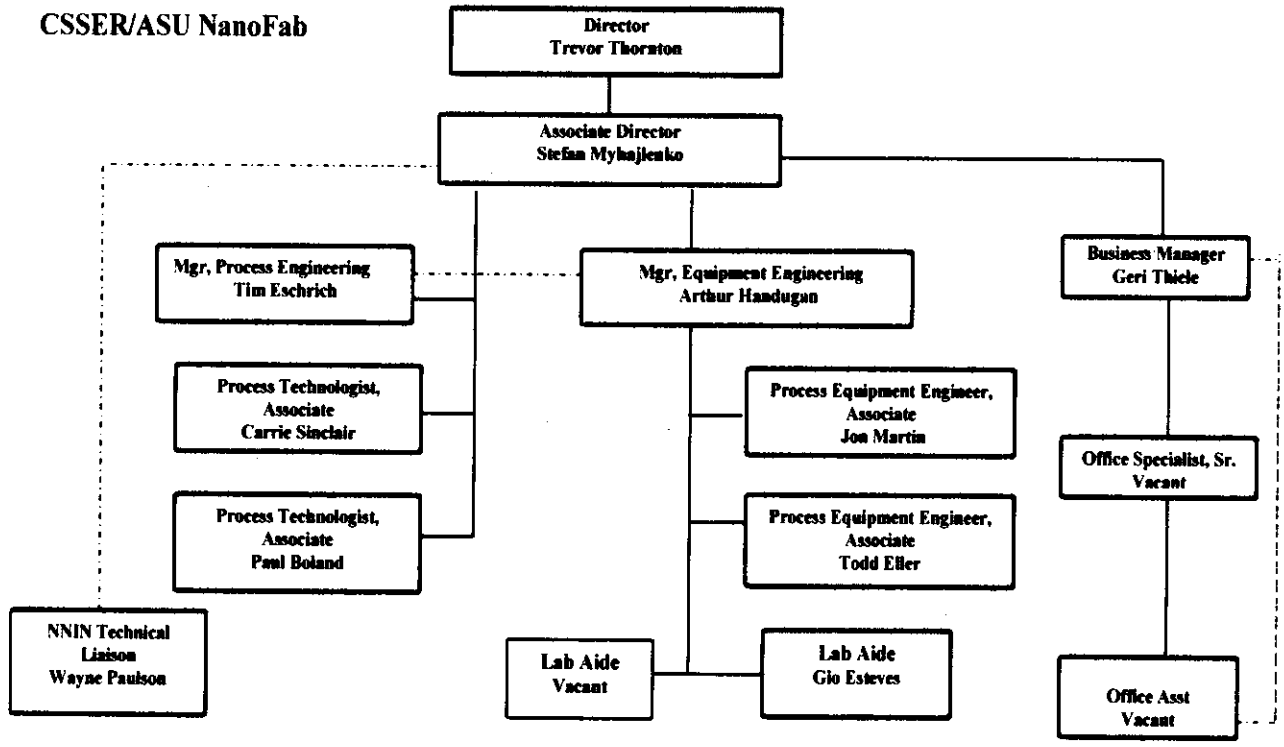
- Updating our fabrication and characterization toolset as new capabilities become available.
- Maintaining the toolset through a recharge program based on user fees.
- Providing our users with the necessary training to operate the CSSER toolset and how to work safely in hazardous, multi-user laboratories.
- Providing our users with process development support.

The clearest indication that we are fulfilling our mission is to maintain and grow our user base and to increase recharge revenues year on year. Our local ASU user base continues to flourish as evidenced by their high level of success in funded research proposals over the last 5 years. At the same time we are quickly growing our external user base as a result of our participation in the **National Nanofabrication Infrastructure Network** (NNIN). The NNIN is a consortium of the top 14 schools in the country funded by the National Science Foundation to provide open-access to fabrication and characterization facilities for the nation's academic and industrial nano-technology community. We were invited to join the NNIN in March 2009 and have seen the number of external academic and industrial users increase by 140+% since 2005. Within the State of Arizona we have academic users from the University of Arizona and Northern Arizona University. Our national visibility has grown substantially in recent years with external academic users from Harvard, University of Colorado, University of Hawaii, University of Iowa, University of Washington and Vanderbilt to name a few. Internationally, we have had users from Tec de Monterrey (Mexico) and the University of Padua (Italy). In respect to industrial users, both start-up and large companies have used the facility, as well as tapping into CSSER NanoFab's foundry (prototyping) services. Arizona start-ups have included companies such as, ChemUrja (fuel cells), Ambature (energy), Fluidic Fuel Cell (energy), HVVi Semiconductors (RF power devices), Tempronics (energy), Rose Street Labs (renewable energy), Laser Components DG (photo-detectors) and Surfect Technologies (interconnects). We've also dealt with start-ups from the east and west coasts such as, NABsys from Rhode Island (genome sequencing), KISLED from Florida (plasmonic devices), First Point Scientific from California (particle beam technology), and Sonata Biosciences also from California (microfluidics). Larger semiconductor companies have included Freescale (TX), Verity Instruments (TX), and Integra Technologies (CA).

2. Organizational Structure

CSSER currently employs 8.5 FTE staff members and one part-time student worker. These positions are supported by a combination of funds from the Fulton Schools of Engineering, the NSF funded NNIN contract (~1.7FTE positions) and from the cost-recovery recharge program. In January 2009 budget constraints required us to implement a reduction-in-force and 1.5FTE positions were eliminated comprising one FTE engineering staff member and a 0.5FTE office specialist. The full-time office specialist was offered the remaining 0.5FTE position but declined to take it. The position is currently vacant and in effect we reduced the CSSER staff by 2 FTE positions.

Center for Solid State Electronics Research



Organizational chart for the Center for Solid State Electronics Research

The following ASU faculty and research staff (past and present) have been active CSSER contributors from the **Ira A. Fulton Schools of Engineering (71 in total).**

1. **School of Electrical, Computing and Energy Engineering** (40 in total): Abbas Abbaspour-Tamijani, Richard Akis, Hugh Barnaby, Jonathan Bird, Jennifer Blain-Christian, Stuart Bowden, Junseok Chae, Hung Chang, Rodolfo Diaz, David Ferry, Dominic Gervasio, Stephen Goodnick, Ravi Gorur, Frank Jahnke, Michael Goryll, Martin Hill, Bruce Kim, Michael Kozicki, Deirdre Meldrum, Maria Mitkova, Cun-Zheng Ning, Gary O'Brien, George Pan, Stephen Phillips, Shalini Prasad, Marco Saraniti, Dieter Schroder, Brian Skromme, Stephen Sweeney, Nongjian Tao, Trevor Thornton, Clarence Tracy, Konstantinos Tsakalis, Dragica Vasileska, Bert Vermiere, Seth Wilk, Hongbin Yu, Hongyu Yu, Frederic Zenhausern, and Yong-Hang Zhang.

2. **School for Engineering of Matter, Transport and Energy** (25 in total): James Adams, Terry Alford, James Anderson, Hamdallah Bearat, Aditi Chattopadhyay, Uttiya Chowdhury, Nik Chawla, Lenore Dai, Sandwip Dey, Erica Forzani, Cody Friesen, Hanqing Jiang, Jerry Lin, Subhash Mahajan, James Mayer, Michael McKelvy, Nathan Newman, Thomas Picraux, Jonathan Posner, Gregory Raupp, Karl Sieradzki, Henry Sodano, Ampere Tseng, Brian Vogt, and Anneta Razatos.

3. **School of Biological and Health Systems Engineering** (4 in total): Antonia Garcia, Jiping He, Jit Muthuswamy, and Alyssa Panitch.

4. **School of Sustainable Engineering and the Built Environment** (2 in total): Bruce Rittman and Paul Westerhoff

The following ASU faculty and research staff (past and present) have been active CSSER contributors from the **College of Liberal Arts and Sciences (20 in total).**

1. **School of Space and Earth Exploration** (5 in total): Peter Buseck, Laurence Garvie, Amy Jurewicz Laurie Leshin, and Thomas Sharp.

2. **Department of Chemistry and Biochemistry** (7 in total): Devens Gust, Mark Hayes; John Kouvetakis, Marc Porter, William Petuskey, Joseph Wang, and Hao Yan.

3. **Department of Physics** (7 in total): Jeff Drucker, Stuart Lindsay, Jose, Menedez, Robert Nemanich, Peter Rez, David Smith and Ignatius Tsong.

4. **School of Life Sciences** (1 in total): Ferran Garcia-Pichel.

The following ASU faculty and research staff (past and present) have been active CSSER contributors from **ASU Polytechnic campus and other ASU units (10 in total).**

1. **BioDesign Institute** (6 in total): Jian Gu, Roger Johnson, Jin He, Bharath Takulapalli, Peter Wiktor, and Peiming Zhang.

2. **College of Technology and Innovation** (3 in total): David Folts, Lakshmi Munukutla, and Arunachalanadar Madakannan.

3. **The Flexible Display Center** (1 in total): Shawn O'Rourke

Below we present the breakdown of unique users by ASU affiliation between 2005 -2009. The users include graduate students, post-doctoral associates, scientists, etc. The table also includes the number of undergraduate and graduate students that take the EEE435/591 class entitled "Fundamentals of CMOS and MEMS processing". This course is offered by SECE and is regularly taken by students in CLAS.

	2005	2006	2007	2008	2009
Ira A. Schools Of Engineering	Users	Users	Users	Users	Users
School of Electrical, Computing and Energy Engineering	53	53	56	54	63
School for Engineering of Matter, Transport and Energy	23	29	47	34	24
School of Biological and Health Systems Engineering	8	7	5	4	5
School Of Sustainable Engineering and the Built Environment	1	1	0	0	0
Sub-Total	**85**	**90**	**108**	**92**	**92**
College of Liberal Arts and Sciences					
School of Space and Earth Exploration	2	0	1	0	0
Department of Chemistry and Biochemistry	4	3	5	6	7
Department of Physics	8	6	2	5	6
School of Life Sciences	1	0	0	0	0
Sub-Total	**15**	**9**	**8**	**11**	**13**
Undergraduate/Graduate Education					
EEE435/591 Fundamentals of CMOS & MEMS	**16**	**17**	**16**	**16**	**16**
Other					
The Biodesign Institute	8	4	10	13	9
College of Technology and Innovation	2	1	1	1	5
The Flexible Display Center	2	2	1	1	1
Sub-Total	**12**	**7**	**12**	**15**	**15**
External	**7**	**8**	**6**	**13**	**17**
Grand Total	**135**	**131**	**150**	**147**	**153**

3. Key accomplishments

- CSSER Retreat
  Hassayampa Inn, Prescott, AZ, Jan 9 -11, 2005
  A two day brain-storming program attended by 17 faculty, 7 post-doctoral research scholars and 3 invited graduate students.

- Data supplied by Arizona Technology Enterprise (AzTE) suggests that > 50 patent disclosures were prepared by faculty using CSSER facilities to demonstrate their inventions. As a result of these disclosures 46 patents have been issued. The intellectual property contained in these issued patents is now the subject of two license agreements with Arizona companies, with another two agreements currently under negotiation.

- Technology and IP developed in CSSER laboratories has lead directly to the incorporation of six 'spin-out' companies.

- In 2006 Phase II of the Cleanroom Code Compliance upgrade was completed. This $2,000,000 project replaced original HEPA filters with almost 100% ULPA coverage, replaced wet-benches, improved HVAC and enhanced life-safety systems.

- Over $1,300.000 in new equipment and capabilities has been added to the Cleanroom facility. Funding came from a variety of sources including Foundation, Dean's Office cost sharing, faculty start-up, and Recovery Act monies. The list of equipment includes replacement furnaces with 6-inch capability, improved PECVD, replacement ebeam evaporator, new XeF2 etcher, new optical aligner with 8-inch capability, Parylene coater, critical CO2 dryer, ZnO sputter magnetron, upgrades to the direct laser-writer, and additional metrology tools

- Ph.D. Production: With the assistance of ASU Office of Institutional Analysis we have tracked down Ph.D. graduation rates for students who have been CSSER facility users back to 2007 and compared with overall Ira A Fulton Schools of Engineering numbers for the same period: see summary table below.

Year	Fulton Schools	CSSER	CSSER associated Ph.D as % of Fulton Total
2007	119	22	18.5
2008	124	13	10.5
2009	119	17	14.3
Total	362	52	14.4

- ASU Site: National Nanotechnology Infrastructure Network (NNIN)
  National Science Foundation
  03/01/2009 – 02/28/2014
  $2,500,000

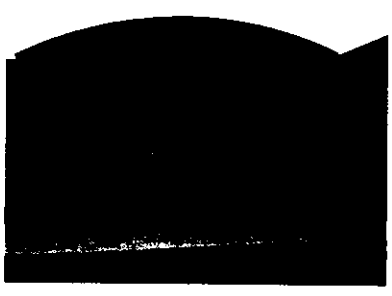
- CSSER User Survey of all faculty and student users during Spring 2009. The 84 users who completed the survey showed strong support for the CSSER mission and its execution. The survey provided a 'wish list' of equipment that the faculty desired and this list was used to identify key tools for an MRI proposal later in the year.

- National Science Foundation, Major Research Instrumentation (MRI) Program
  09/01/2009 – 09/01/2010
  $550,000
  Funding for major 'work-horse' tools identified by ASU faculty as part of the User Survey.

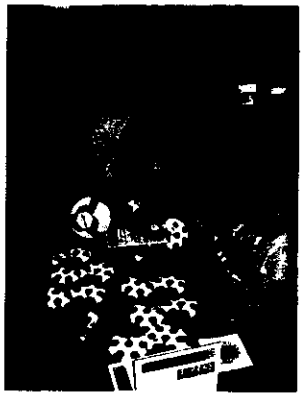
- National Science Foundation, Research Experience for Undergraduates
  03/01/2009 – 02/28/2014
  $187,500
  Provides support for 5 students each year to visit the ASU campus for 11 weeks during the summer to work on a research project with an ASU faculty member.

- Since joining the NNIN CSSER has asked faculty to track their journal and conference publications resulting from research that took place in NNIN supported CSSER labs. In 2009 the ASU faculty listed 25 journal publications and 39 conference papers. Four external faculty users listed conference papers in 2009 that had benefited from access to CSSER facilities.

- Membership in the NNIN has provided funds for a meaningful education and outreach activity focused on nanotechnology. NNIN supported CSSER staff and students worked with 8 teachers from Palomino Elementary School to teach a solar oven project to 137 middle school students. Palomino is a Title 1 school with a high percentage of students for which English is a second language. *For many of these students the NNIN solar oven class was the only science content they would see during the year.*



- In collaboration with the NSF supported Center for Nanotechnology in Society (CNS), CSSER has been presenting 'hands-on' nanotechnology demonstrations at a number of public venues. The demonstrations have been developed by the Nanoscale Informal Science Education Network (NISE Net) – see http://www.nisenet.org/. CNS and CSSER staff train ASU participants in best practices for these public demonstrations during two sessions. Once trained, our student volunteers have helped with a booth at the Tempe Festival of the Arts (March 26-28, 2010). They have also presented at the Arizona Science Center on a number of occasions. Our estimates suggest that more than a thousand individuals have taken part in these activities at one or other of the events.



4. Listing of All Proposal Activity and External Funding

Data provided by the Fulton Schools of Engineering Dean's Office showing the breakdown of CSSER related proposals and funded awards are listed in the tables below. Our faculty were very successful winning external research contracts with a total of >$12M awarded from $52.7M in research proposal recognition during the 5-year period FY06-10.

	Fiscal Year				
	2006	2007	2008	2009	2010
Investigator Person Full Name	Recognition $	Recognition $	Recognition $	Recognition $	Recognition $
Abbaspour-Tamijani,Abbas			434,357	80,955	
Akis,Richard	69,960	12,980	629,616		
Barnaby,Hugh James	44,160	158,523	170,697	137,368	
Chae,Junseok	347,541	192,076	30,000	100,615	
Chang,Hung		161,995	119,331		
Clark,Lawrence T	3,300				
Ferry,David K	783,840	903,000	1,627,399	268,593	1,117,121
Forzani,Erica Silvia		151,839			
Friesen,Cody A	154,865	30,000	291,006		
Goodnick,Stephen Marshall	1,436,508	1,558,734	952,258	109,863	
Goryll,Michael				412,602	1,014,478
Johnson,Shane Richard			200,000	126,921	
Kozicki,Michael N	45,827	128,051			
Mamaluy,Denys		375,484			
Muthuswamy,Jitendran		1,957,652		618,404	697,440
Myhajlenko,Stefan	77,204	215,868	291,426	178,244	401,862
Ning,Cun-Zheng		935,000	1,119,844		
Paulson,Wayne Marvin			85,890	10,890	126,144
Phillips,Stephen M	248,886	39,993	32,000		
Picraux,Samuel Thomas	286,348				116,812
Posner,Jonathan Dov	45,190	199,553			
Prasad,Shalini				2,005,865	773,886
Roedel,Ronald J					608,128
Saraniti,Marco			989,061	26,250	226,486
Schroder,Dieter K	95,799	18,000	1,553,123	203,433	687,128
Skromme,Brian John		100,705			
Sutanto,Jemmy					196,236
Tao,Nongjian	530,487	1,844,877	199,808		
Thornton,Trevor John	371,401	1,385,203	3,448,916	1,134,288	6,258,030
Tracy,Clarence Joseph		110,194	128,121	24,675	
Vasileska,Dragica	842,395	397,961		200,721	148,865
Vermeire,Bert	3,750				
Yu,Hongbin	660,000	1,279,017	271,950		419,773
Zhang,Yong-Hang	868,387	774,084	480,000	250,000	1,157,840
Total	6,915,848	12,930,788	13,054,804	5,889,687	13,950,227

Table 4.1: Total CSSER recognition in dollars for proposals submitted during FY06-10

	Fiscal Year				
	2006	2007	2008	2009	2010
Investigator Person Full Name	Recognition $	Recognition $	Recognition $	Recognition $	Recognition $
Abbaspour-Tamijani,Abbas			74,993		
Akis,Richard	53,460			18,000	
Bakkaloglu,Bertan	11,315				
Barnaby,Hugh James	48,909	40,041	128,761	145,317	108,496
Chae,Junseok				60,000	41,442
Ferry,David K	322,330	209,496	7,500	11,055	117,342
Friesen,Cody A	52,000	85,540			
Goodnick,Stephen Marshall	523,376	158,424	42,993	4,422	55,691
Johnson,Shane Richard					22,500
Kozicki,Michael N	481,255	30,000			
Muthuswamy,Jitendran	150,000	418,093	407,308	240,730	910,290
Myhajlenko,Stefan					47,000
Ning,Cun-Zheng			300,000	80,000	443,480
Phillips,Stephen M			44,793	7,075	9,070
Picraux,Samuel Thomas	74,830				
Prasad,Shalini				61,479	87,216
Saraniti,Marco			39,600	97,402	33,000
Schroder,Dieter K	63,850	60,000	127,299	86,758	46,683
Skromme,Brian John			100,704		
Tao,Nongjian	184,038		362,990	-7,544	-3,645
Thornton,Trevor John	640,326	344,288	504,227	219,564	1,608,878
Vermeire,Bert	8,750	5,000			
Yu,Hongbin			195,000	162,000	
Zhang,Yong-Hang		100,000	55,017	250,000	623,066
Total	2,614,439	1,450,882	2,391,184	1,436,257	4,150,509

Table 4.2: Total CSSER recognition in dollars for external awards received during FY06-10

During the period FY06-10 CSSER related faculty submitted a total of 198 external research proposals of which 111 were awarded. The success rate is greater than 56% bucking the national trend where some agencies report success rates of less than 10%.

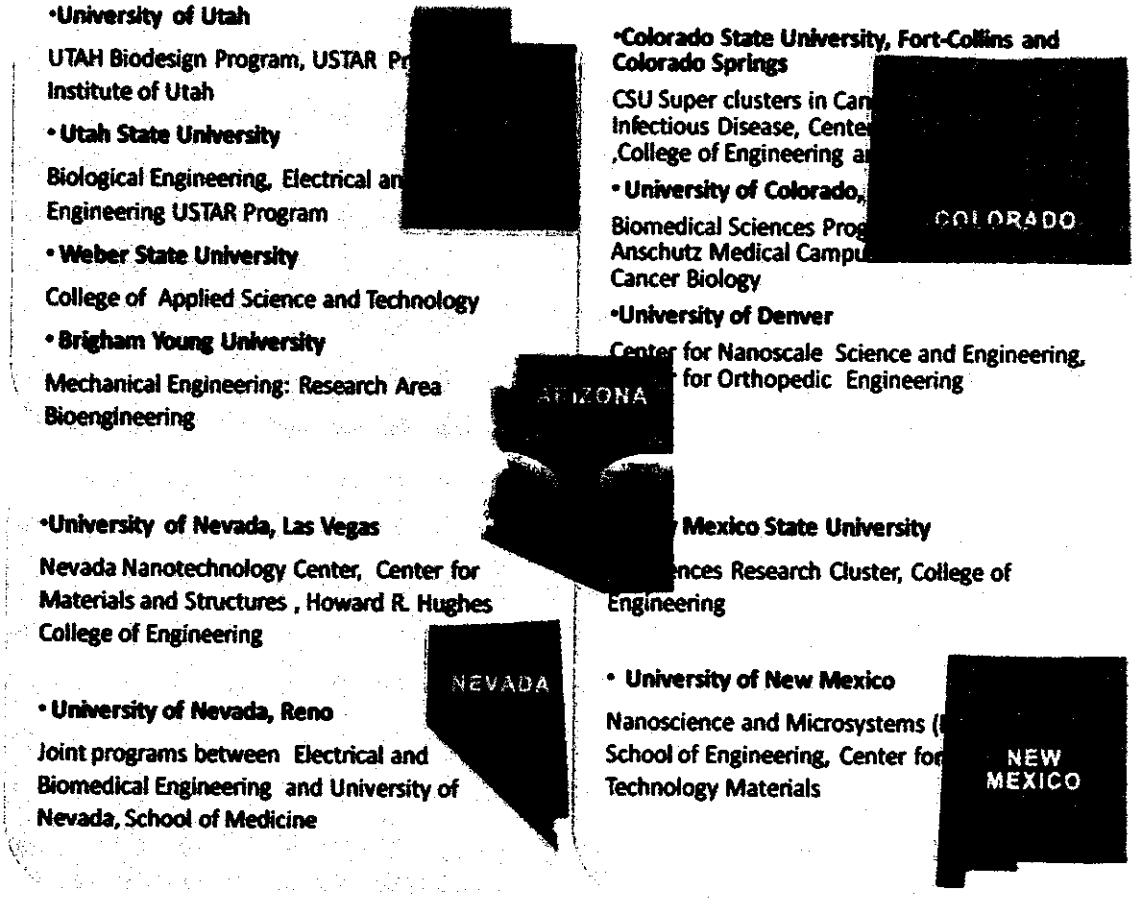
Fiscal Year	Total Proposals	Total Awards
2006	36	22
2007	40	17
2008	41	26
2009	45	17
2010	36	29

Table 4.3: The number of proposals submitted and contracts awarded during FY06-10

5. Future Strategic Plans

The technical area of expertise for the ASU node of the NNIN is the interface between organic and inorganic systems. To increase our national visibility in this area and to strengthen ties with other institutions, CSSER will host an NNIN Symposium in January 2011. The theme of the two day workshop will be "Organic/Inorganic Interfaces and their Health Science Applications". The symposium has 17 external speakers and a similar number from ASU faculty and students. Details can be found at the http://thornton.faculty.asu.edu/Research/NNIN_Workshop/.

For CSSER to be successful within the National Nanotechnology Infrastructure Network we need to increase the number of external users from other academic institutions. This will increase the national visibility for both CSSER and ASU, while also helping our 'bottom line' by increasing the recharge revenue from user fees. To this end our first goal is to increase the number of users from the University of Arizona and Northern Arizona University. In 2009 we recruited our first user from NAU, Prof. Constantin Ciocanel. By working with Prof. Ciocanel we hope to increase the number of users from NAU once their faculty understand the capabilities that CSSER can make available. We have always had a steady stream of 2-3 users each year from UoA although this number has increased in recent months to the point that we currently have five UoA faculty users. Beyond our own borders we have identified a number of nanotechnology programs at other universities in the southwest (see montage below). We are now in the progress of targeting potential users from these schools with advertising and marketing materials that will be followed up by visits from CSSER faculty and staff.



The greatest challenges to CSSER over the last 18 months have been financial. The current budget crisis has meant our support from the Engineering Dean's Office has been reduced from $535k in FY09 to $250k in FY11 with further reductions expected in FY12. At the same time CSSER managed facilities have continued to provide infrastructure support to the entire Engineering Research Center (ERC) building including ultra-pure nitrogen gas and de-ionized water to non-CSSER laboratories. The CSSER staff also provides significant support in the area of Health & Safety, particularly as it relates to chemicals and other hazardous materials. The costs involved in supporting these services are significant with nitrogen gas alone coming to ~30k per year. Various cost-recovery programs to pay for these non-CSSER related expenses have been discussed over the years but to date none of them have been implemented.

6. Financial Summary

The table below shows revenues and expenditures for fiscal years 2008-2010. Explanatory notes 1-6 are provided on the next page.

	FY2008		FY2009		FY2010	
Revenues						
State Appropriations						
Personnel	$562,849		$531,809		$287,963	
ERE					$97,908	
OPS	$195,500		$49,252		$110,351	
Voluntary transfers in	$298,755	1	$255,817	2		
LOCAL Funds						
Internal recharge - CT21001	$423,056		$351,405		$415,000	
CT51001	$47,142		$30,846		$59,626	6
CT51002	$165		$165		$89	
CT51004	$5,555		$3,164		$3,164	
RID - CT51006	$20,310		$30,048		$44,544	
External recharge - CT51007	$250,660		$352,455	3	$226,422	
CT91001	$13,564		$88,155	4	$15,254	
Other Funds						
TOTAL REVENUES	**$1,817,556**		**$1,693,116**		**$1,260,321**	
Expenditures						
Personnel						
Salary & Wages	$689,709		$623,132		$476,907	7
ERE	$45,701		$39,542		$157,803	8
Operations						
Capital Equipment	$345,117		$108,421		$6,413	
Non Capital	$20,179		$5,205		$6,388	
LN2	$145,977		$140,139		$122,357	
Travel	$2,515		$2,446		$0	
Maint & Repair/Supplies/Gases	$396,326		$292,633		$329,752	
Transfers out	$2,700		$361,154	5	$0	
Internal Charges	$46,344		$25,328		$28,996	
TOTAL EXPENDITURES	**$1,694,568**		**$1,598,000**		**$1,128,616**	
TOTAL REVENUES - TOTAL EXPENDITURES	**$122,988**		**$95,116**		**$131,705**	9

1. Received additional money, $298,755 for new Tystar furnace
2. Stimulus money $255,817 entered by Financial Services at FY end into new account CT11006
3. Includes transfer from Foundation of $108,303
4. $77,125 transferred from EDO for CHA replacement
5. $76,600 EDO swap local for state funds; $277,562 moved to ET51055, budget stabilizer (stimulus funds swapped for state)
6. Includes $35,000 transfer from Foundation for PECVD install
7. EDO redistributed salaries to state at FY end
8. Because of redistributed salaries at FY end
9. Includes $35K transfer (see #5)