WBS 1.1.1.5

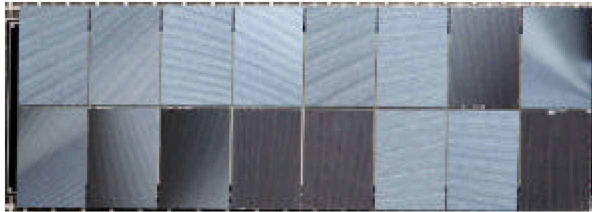
Pixel Module Assembly & Test

1. **Technical Status**
2. **Goals for 2002**
3. **ETC 02**

Module Technical Status

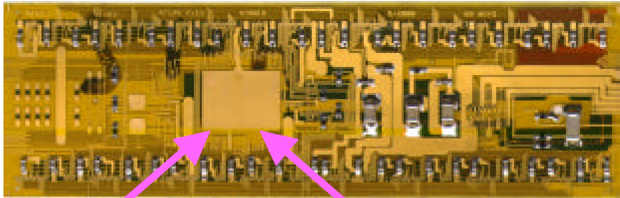
- **Single module concept well established**
- **Technology choices have been made for all components**
- **Assembly methods have been developed but not yet debugged for mass production**
- **Final prototypes (all production components) have not yet been built**
- **A pixel system with multiple modules has not yet been demonstrated.**
- **Long term reliability of pixel modules not yet thoroughly tested**

Technical Status: The Module

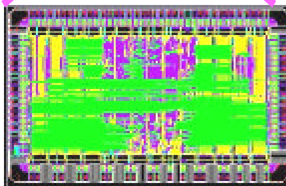


Bare Module
(thinned chips bump bonded to sensor)

Glue (attaching flex hybrid to bare module)

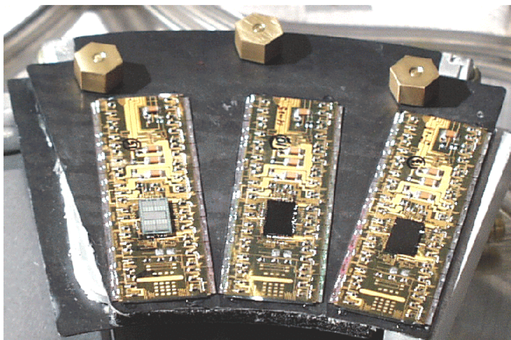


Flex Hybrid (WBS 1.1.1.4)



MCC Chip (treated as a hybrid component)

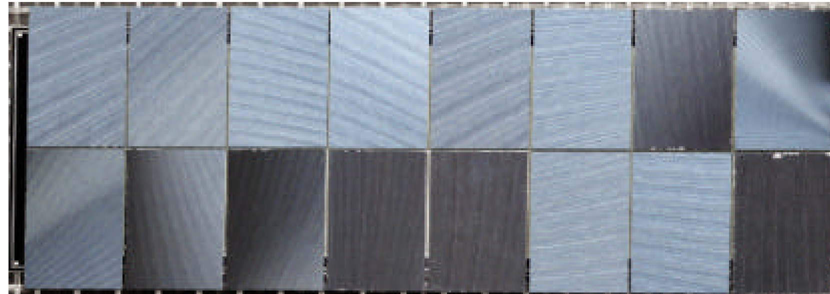
Wirebonds (Connect flex hybrid to bare module)



Pigtail (Differentiates disk & barrel modules)

Mounting on local supports

Technical Status: Bare Module



Bare Module: Thinned chips bumped on sensor

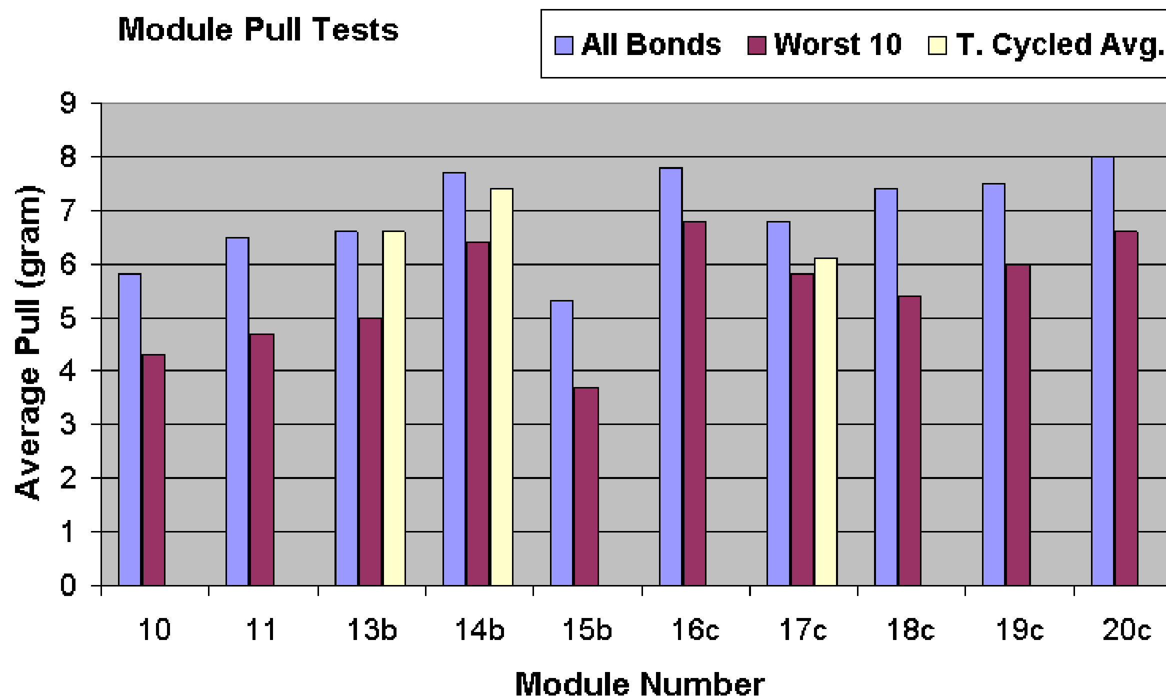
- IC Wafer thinning and dicing is part of this WBS
- Bumping split between IZM, Germany (Solder) & AMS, Italy (Indium)
  Bumping and flip chip are **NOT** a US responsibility
- Volume and product uniformity to be demonstrated
- Bare modules need to be probed and X-rayed
- **Bumps are a potential show-stopper:**
  - Continued prototyping & QC are critical
  - Mechanical stress must be kept under control

Technical Status: Glue (Hybrid to Bare Module)

- **Hybrid Tales pigtail strain**
- **Full module is picked up by the hybrid**
- **=> Hybrid must be attached to bare module (other than by wirebonds)**
- **But Hybrid and Bare Module CTEs different => coupling can put stress on bumps**
- **Use soft glue, eg. Ecobond 45**
- **Glue only under MCC, pigtail & 4 corners (No glue under wirebond pads!)**
- **This is still an area of development…**

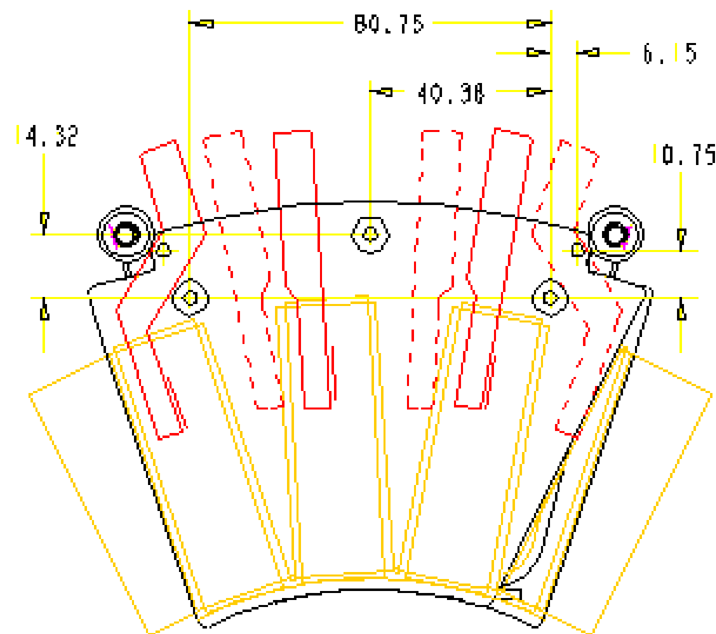
Technical Status: Wirebonds

- Approx. 500 wirebonds/module
- From Au plated Cu to FE chips
- Aluminum wedge bonding
- Encapsulate?
- Potential issues
  - Poor metalization (Hybrid fab. Q.C.)
  - Contamination (Plasma clean)
  - Chlorine ions (long term)



Technical Status: Pigtail

- **Disk Sectors need 2 pigtail designs. Layouts in progress**
- **Current plan for both barrel and disks is to attach pigtail to flex before gluing flex to bare module**



Technical Status: Attachment to local support

- **Maximum thermal coupling**
- **Weak mechanical coupling (less stress on bumps) but maintaining alignment**
- **Baseline is CGL (thermal grease) + UV-cure tacks**
- **Other candidate adhesives being considered: Ecobond 45, Silicone (glue tests in Europe)**

Technical Status: Thermal Cycling Tests

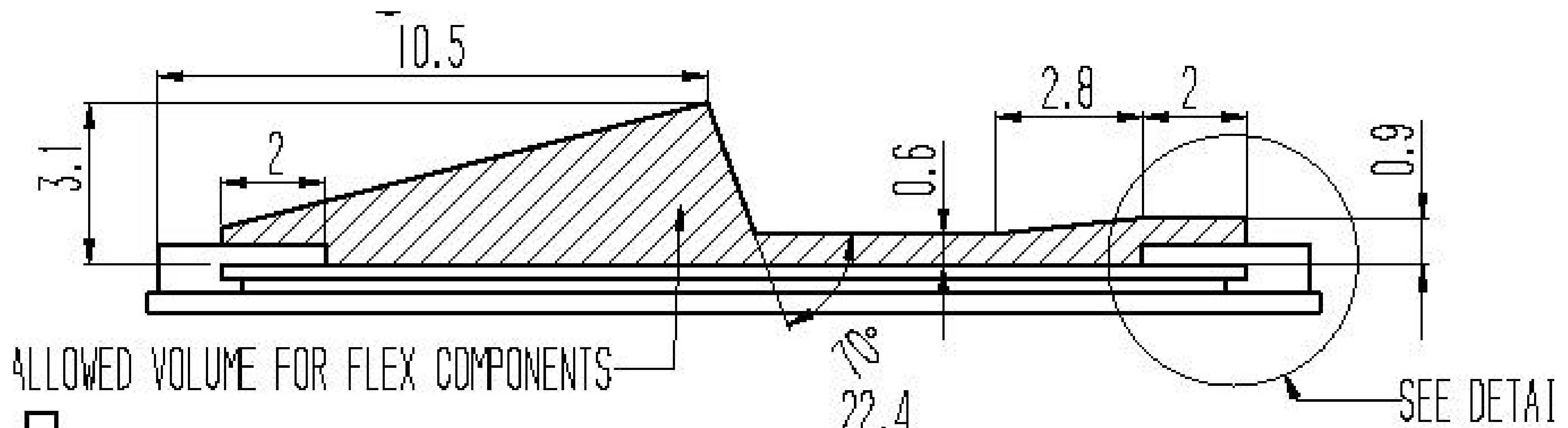
- Main goal is to see if/when bumps fail
- Cycle between room temperature and –35°C
- Present data are inconclusive
- Modules, both electrical and dummy have been cycled at LBNL, Bonn & Genova.
- Parts cycled were a mixed bag in various states of disrepair and each with some unique characteristic.
- At LBNL
  - 1 Solder Bump dummy module failed (bumps seemed low quality)
  - 3 Indium Bump dummies survived 30 cycles
  - A few bumps in one chip of a 4th Indium dummy failed (had prior damage)
- Need more systematic tests

Technical Status: Dummy Module Production

- **Electrically passive with bump bonds arranged in resistive chains**
- **Used to qualify bump deposition and flip chip vendors and for mechanical stress tests on bumps**
- **8" wafers of dummy FE die supplied by LBNL (11 wafers now at bump vendors)**
- **~70 dummy bare modules to start appearing 12/01 (~20 expected to make their way to LBNL)**

Technical Status: Module Envelope

- Envelope is constrained by stave geometry
- Not expected to change
- Flex hybrid designed to fit in envelope assuming 300mm FE chips.
- Further thinning of FE chips creates had-room within envelope (also good for material!)

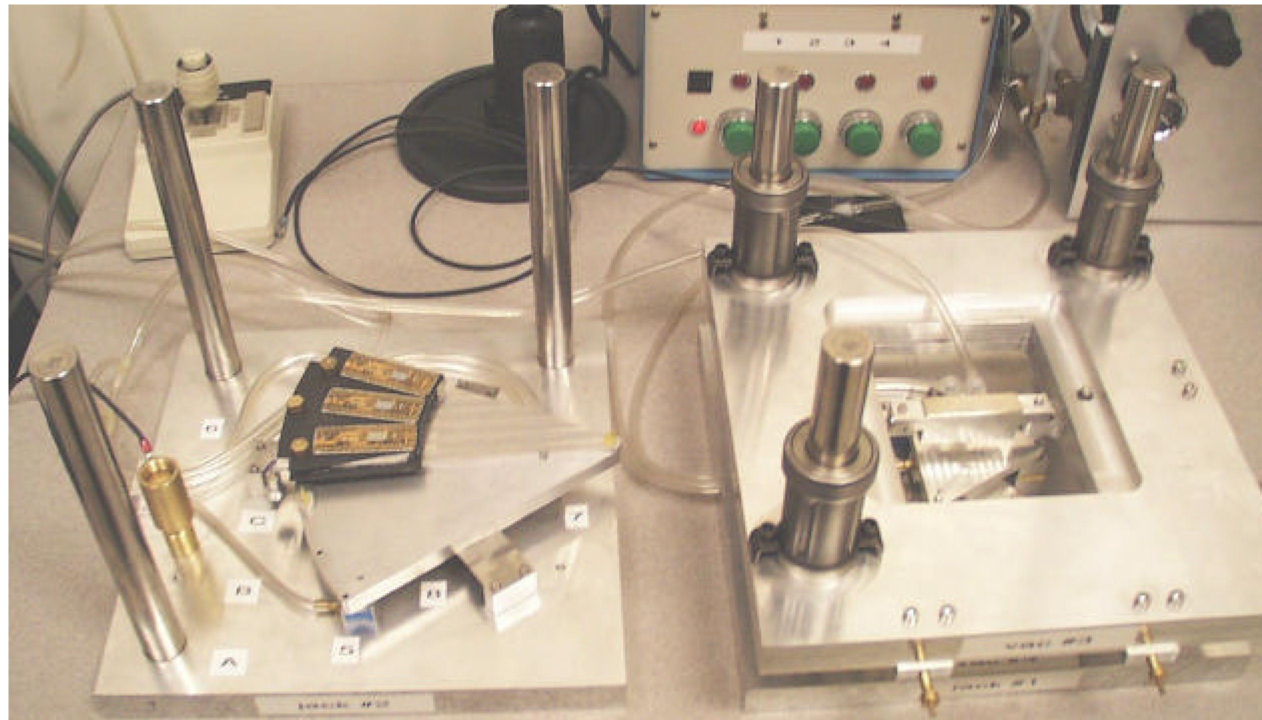


Technical Status: Wafer Thinning

- **Initial development for back-grinding 6" wafers done with Okamoto (S. Valley)**
- **Conclusion for 6" wafers**
  - **Anybody can do 250mm**
  - **150mm takes a lot of care as does handling of thinned wafers**
- **But now we have 8" wafers**
- **New vendor (Aptek, S. Valley) has proprietary process for thinning bumped wafers.**
- **Claim 150-200mm for 8" not a problem**
- **Wafers are stress relieved which also solves handling**
- **So far tested 6" wafers (140um)**

Technical Status: Assembly Tooling

- **Tooling is well ahead of needs**
- **Production quality tooling prototypes in use throughout 2001**
- **Only minor revisions will be needed for production**

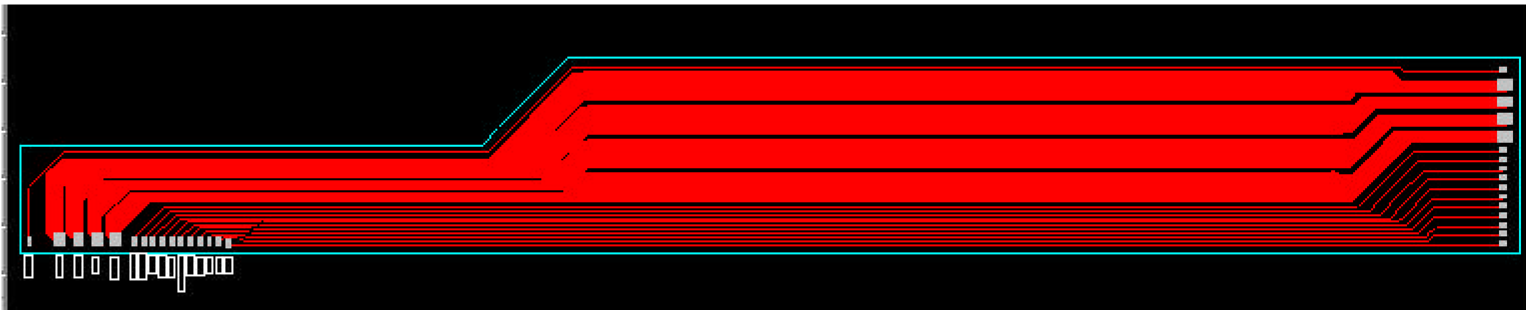


Goals For 2002

- Develop disk pigtail
- Demonstrate volume, uniformity, reliability
- Build and test Rad-Hard modules using final components
- System test
- Some tooling updates
- Module Burn-in System

2002 Goals: Disk Pigtail

- **Fabricate** **($2K)**
- **Assembly tests** **(80 hours tech. + $1K supplies)**
- **Iterate** **($2K)**
- **Total:**
  - **$5K**
  - **80 hours technician**



2002 Goals: Dummy Modules

- **Bumped FE dummy wafers to arrive at LBNL for thinning Dec. 01.** **($2K)**
- **Expect 15-20 dummy modules early 2002.**
- **Probe resistance chains** **(good job for student + $3K equipment OR brute force 3hours tech/module)**
- **Thermal cycle bare modules**
- **Probe again** **(student or more $$ for tech)**
- **Glue on flex hybrids** **(4hours tech/module)**
- **Wirebond & pull test** **(4hours tech/module)**
- **Wirebond resistance chains to test leads** **(4hours tech/module)**
- **Thermal cycle**

2002 Goals: Dummy Modules (cont)

- **Mount on Sectors** **(2hour tech/module + 20 hours Fred)**
- **Bond resistance chains to leads** **(6hour tech/sector)**
- **Thermal cycle**
- **Sector metrology** **(2hour tech/sector +10 hours Fred)**
- **Total including previous slide:**
  - **$5K**
  - **3 months FTE student (undergrad OK)**
  - **320 hours technician**
  - **30 hours Fred**
- **Possible additional needs:**
  - **New run of dummy FE wafers: $12K**

2002 Goals: Rad-Hard Modules

- **Assume 12 hot modules in FY02**
- **Bumped FE-I wafer thinning ($1K)**
- **Bare module probing (staff + $2K supplies)**
- **Attach pigtail to flex & wirebond (4 hours tech./module)**
- **Test Flex with MCC & pigtail (staff + $2K supplies)**
- **Glue flex on module (4 hours tech/module + 20 hours Fred)**
- **Wirebond (4 hours tech/module)**
- **Test, irradiate, test, test, test (staff + $2K supplies)**
- **Totals:**
  - **$7K**
  - **144 hours technician**
  - **20 hours Fred**

2002 Goals: System Test

- **Attach modules to sector(s) (40 hours Fred)**
- **Prepare setup assuming new PCC and support cards exist (80 hours tech. + $10K supplies)**
- **Test, test, test (staff)**
- **Total:**
  - **$10K**
  - **80 hours technician**
  - **40 hours Fred**

2002 Goals: Tooling

- **Flex V4 module vacuum pickup (10h. Fred + 20h. Shop)**
- **Video system for module tooling (20h. Fred)**
- **Adaptor for flex frame (20h Fred + 40h shop)**
- **Wirebonder chuck for flex frame (10h. Fred + 20h. Shop)**
- **Chuck for microwelding to pigtail (20h. Shop)**
- **Commisioning of plasma chamber (20h. Fred, 20h. Craft, $4K supplies)**
- **Module shipping/storage covers (40h. Shop + $1K)**
- **Totals:**
  - **$5K**
  - **80 hours Fred**
  - **160 hours shop/craft**

2002 Goals: Burn-in System

- **This would be a full time job for a postdoc we don't have + tech. Support.**
- **Can use electrical engineer + tech. Support**
- **Conservative estimate from WBS**
  - **880 hours engineer**
  - **880 hours drafter**
  - **440 hours shop**
  - **$21K board fabrications and purchases**

2002 Module Goals Total Excluding burn-in System

- $28K purchases
- 160 hours shop time
- 170 hours Fred
- 550 hours technician
- 320 hours student (more could be used for testing)

Summary of Numbers in ETC02

WBSNo	BS N	WBSDescription	BS Diction	Purchases	Engineer	Drafter	Shops	Technician	Contract Labor	Student
1.1.1.5		Module Assembly/Test	covers							
1.1.1.5.1		Design/Engineering	covers							
1.1.1.5.1.1		Prototype Design	the		880					
1.1.1.5.1.2		Production Design	n design		880	880				
1.1.1.5.1.3		Testing Design	ng design							
1.1.1.5.1.3.1		Mechanical Prototypes	ng time			440				
1.1.1.5.1.3.2		Functional Prototypes	engineer			440				
1.1.1.5.2		Development and Prototypes	covers							
1.1.1.5.2.1		X-ray Inspection	inspectio	$5,000						
1.1.1.5.2.2		Wafer Thinning	of	$6,000						
1.1.1.5.2.3		Wafer Dicing and Die Sort	prototype	$6,400						
1.1.1.5.2.4		Dummy wafers	wafers	$11,775						
1.1.1.5.2.5		Testing	labor,							
1.1.1.5.2.5.1		Tooling	for				732	880		
1.1.1.5.2.5.2		Assembly	assembly	$1,000				264	440	
1.1.1.5.2.5.3		Testing	includes	$21,000			440			880
1.1.1.5.2.5.4		Equipment	special	$15,000						
1.1.1.5.2.6		Module Attachment	labor,							
1.1.1.5.2.6.1		Tooling	tooling for				320			
1.1.1.5.2.6.2		Assembly	/attachme	$1,000				240		
1.1.1.5.2.6.3		Testing	prototype	$1,000				440		
1.1.1.5.3		Production	module							
				Purchases	Engineer	Drafter	Shops	Technician	Contract Labor	Student
TOTALS				$68,175	1760	1760	1492	1824	440	880
Minus burn-in				$47,175	880	880	1052	1824	440	880

Analysis

- ETC02 $$ includes $15K for equipment and $5K for x-ray which we should keep: **28+15+5 = 48!**
- ETC02 manpower is a bit high except for student
- Goals manpower estimate is sure to be low because new work will come up.
- Truth somewhere in between
- What do we do about Burn-in system? May be OK to put off to FY03