Structure fabrication techniques and possibilities

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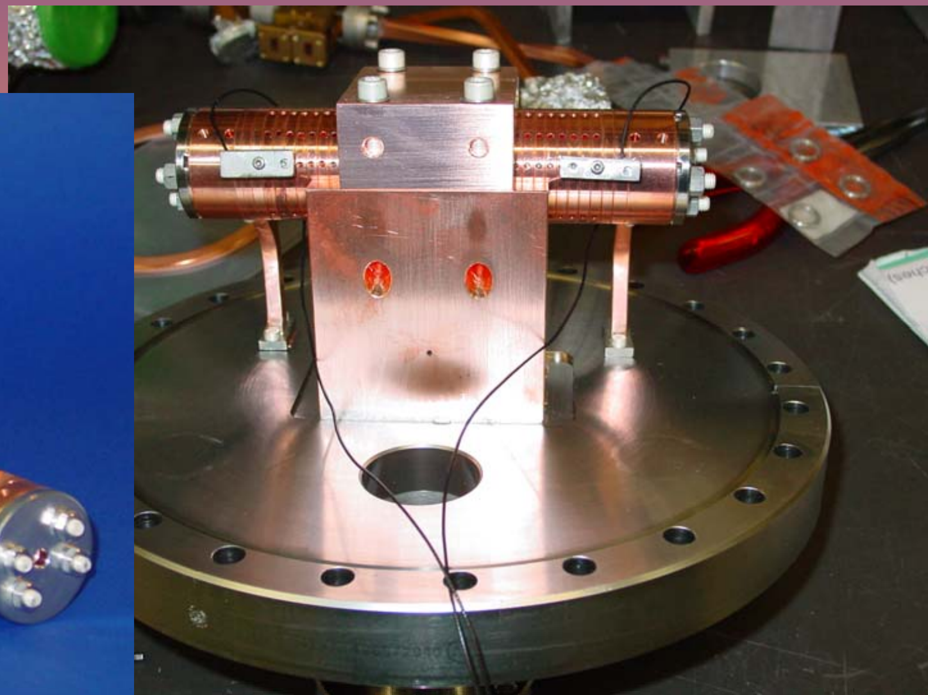
Disk structures
Quadrant structures

….most of it inspired by 30GHz tests and experience

Copper, disk structures

- Machining by diamond turning: shape accuracy of 2-3 µm in the iris region
- alignment of the disks on V-shaped marble before assembly in a stack: use external “cylinder” surface as reference.
- assembly by vacuum brazing or by bolting
- achieved accuracy?
- No rf-damping



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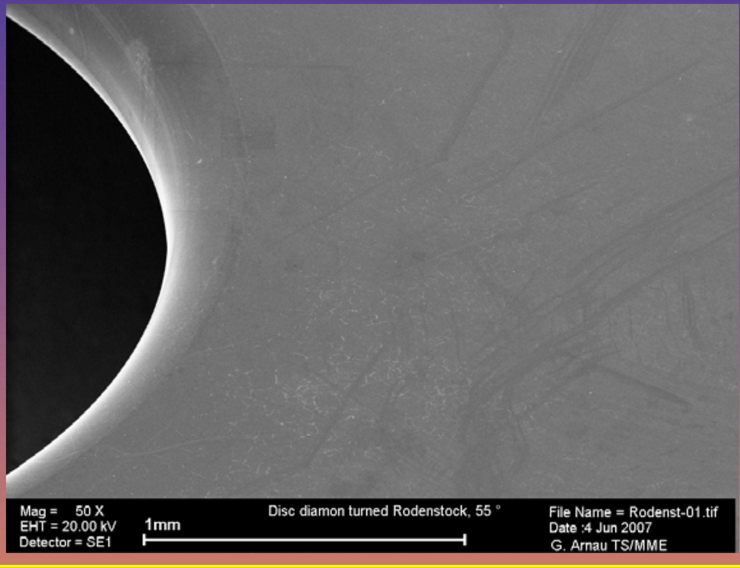
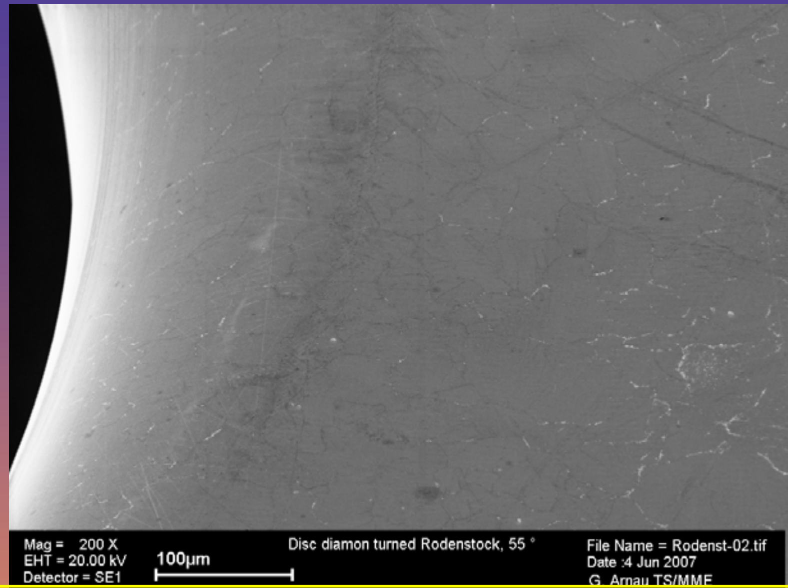
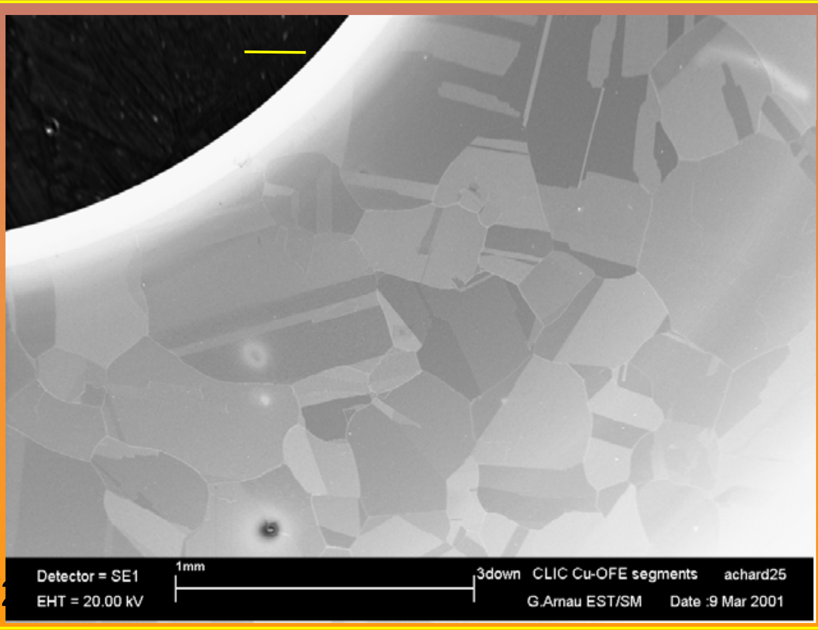
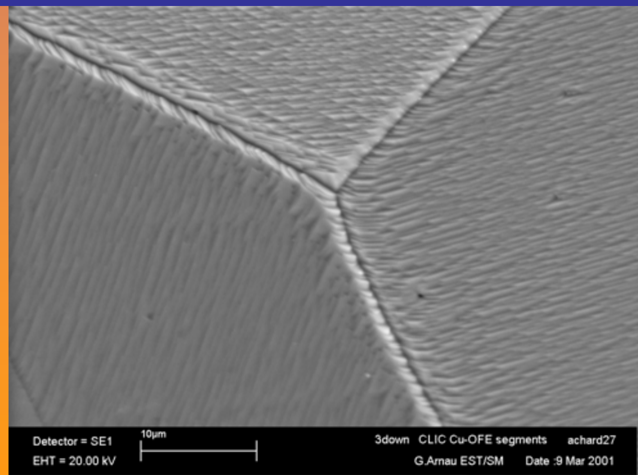
30 GHz copper structures: surface quality



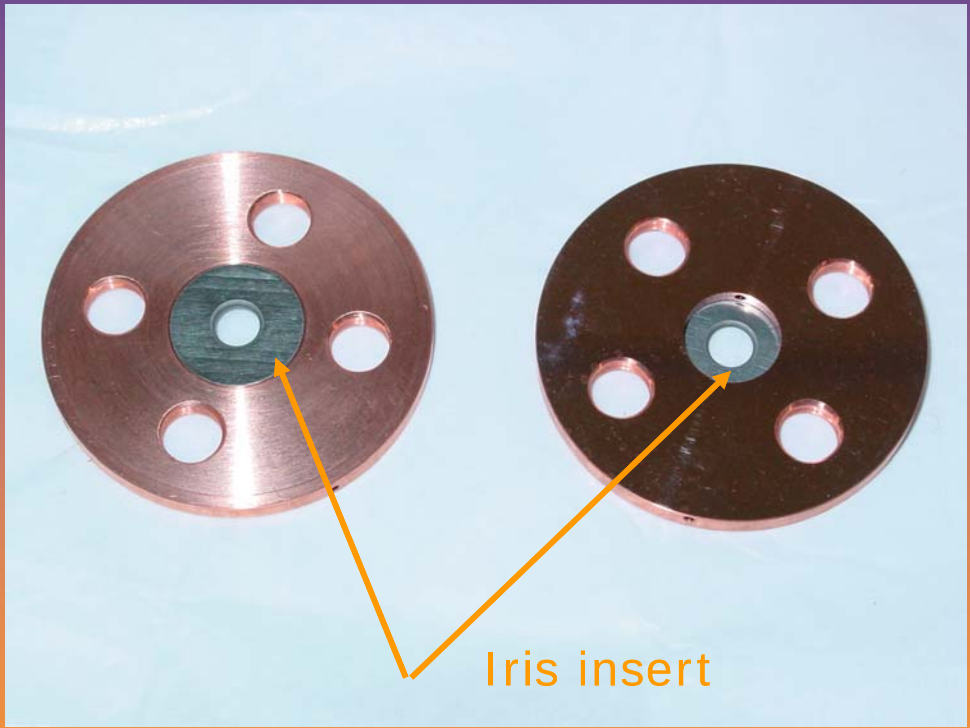


Recrystallization after thermal treatment
(vacuum brazing cycle at 820 C)





Disk structures: other materials and configuration for bimetal

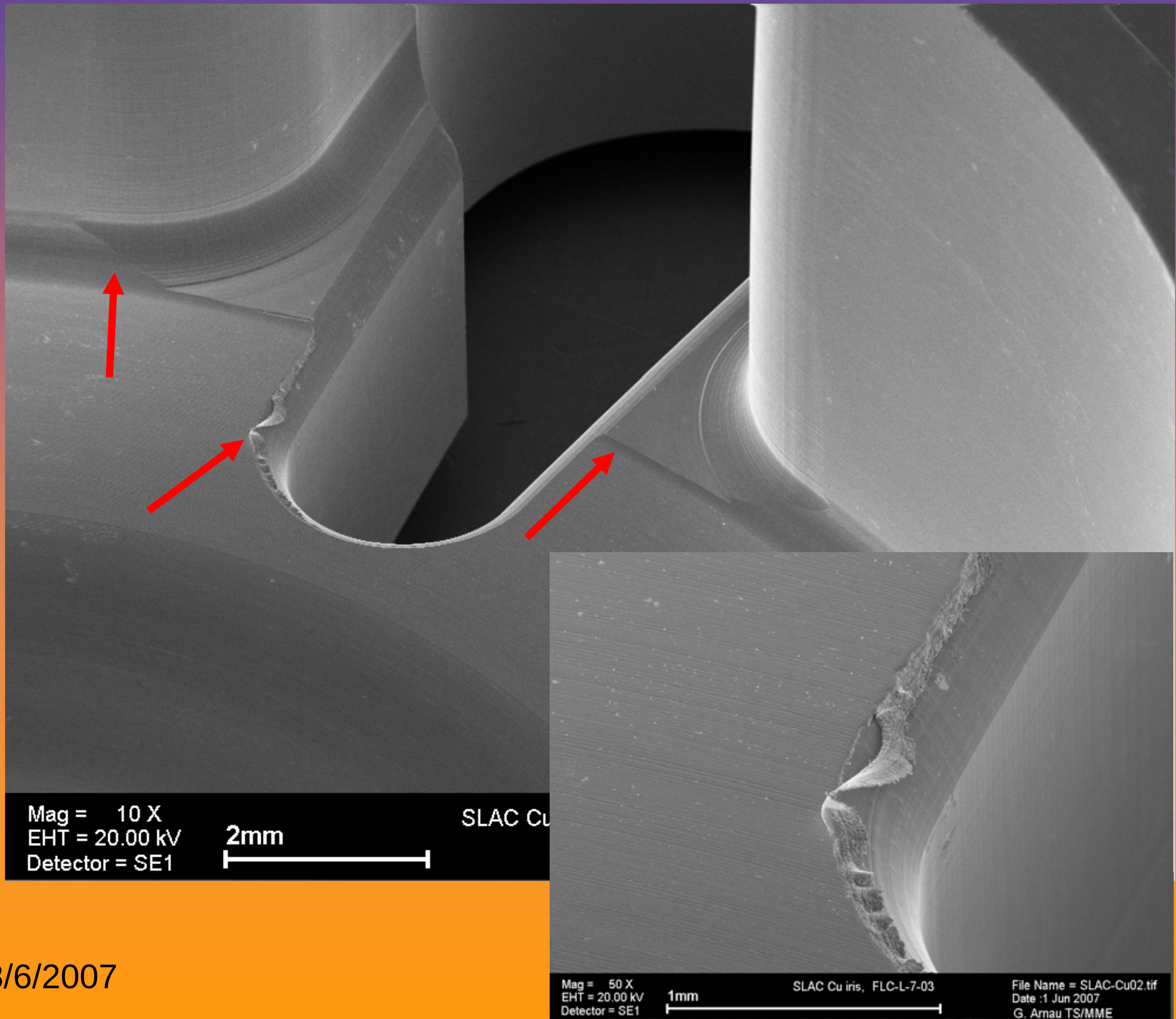


-Diamond turing with insert. Successfully tested with Mo and W irises (single iris or full structure)

-Insert of complete iris in new material or bi-metal (for iris tip only)

-Assembly by clamping (bolting) only, because of the difference in thermal expansion; potential problem for proper electrical contact (oserved copper transfer on refractory metal)

Copper disks with damping (SLAC design)



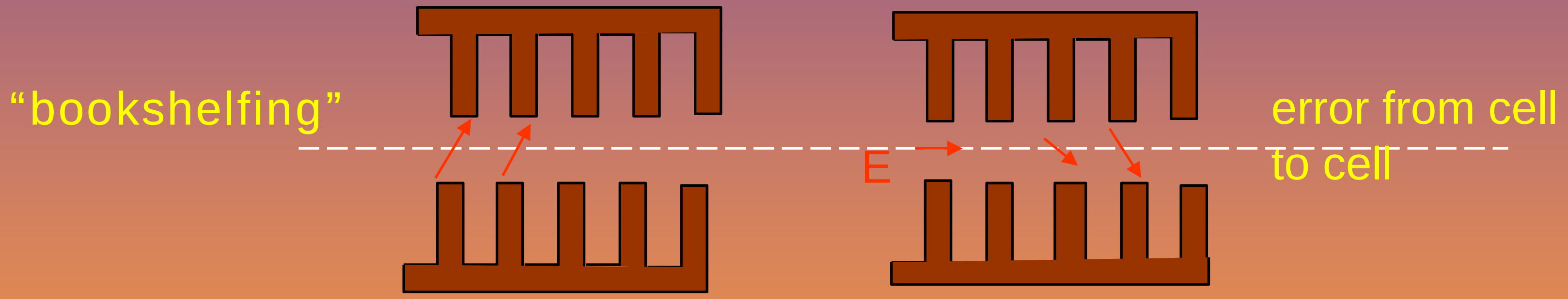
-Turning is no longer sufficient, milling is necessary to produce the radial slits

- Full 3D milling is needed to avoid steps and burrs

Why + / - 1 microns precision?

0. Frequency matching (about 4MHz deviation per μm on cavity radius at 30 GHz), or tuning

1. Longitudinal alignment precision : <5 μm
   alignment error of the irises induces transversal kick on the beam ; this effect is independent of frequency (11 or 30 GHz) if we keep similar iris aperture

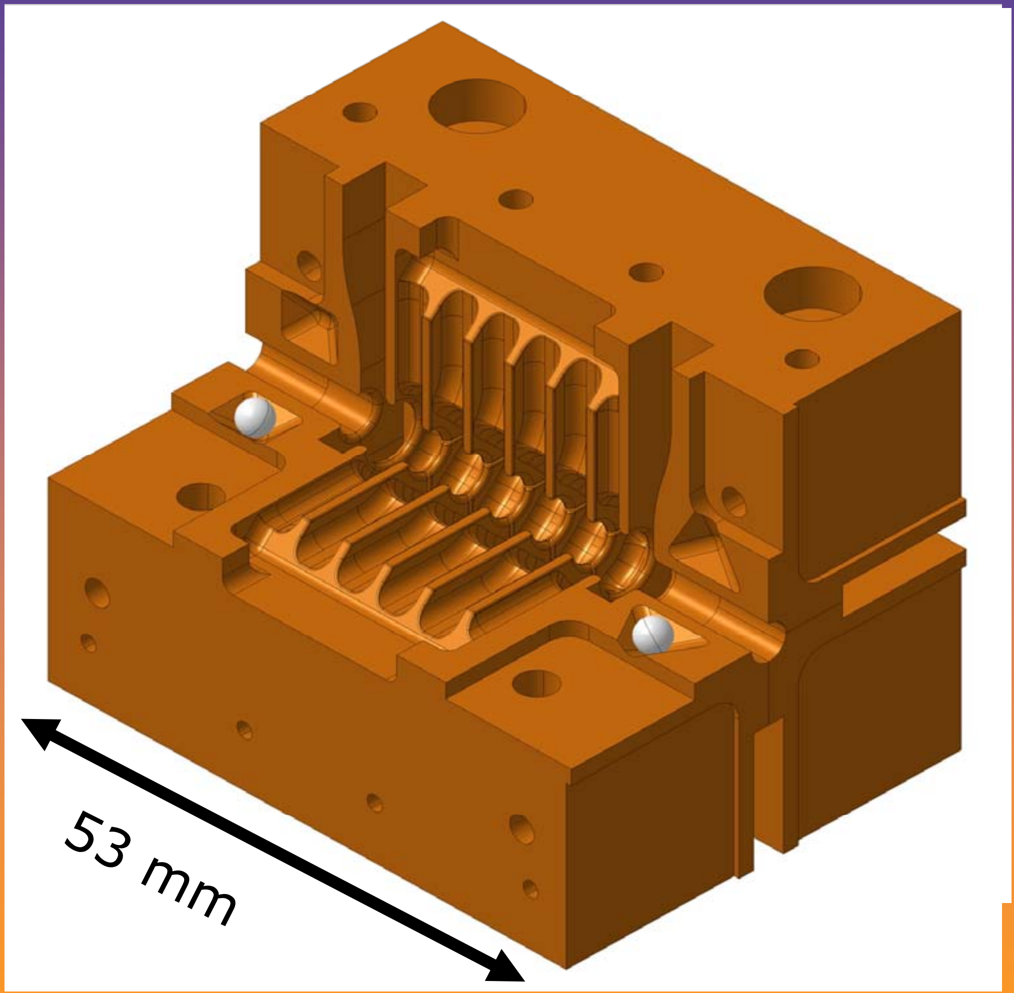


2. RF – to-beam phase: better than 0.1^0 (some microns on cavity shape) to preserve efficiency and beam stability

3. Avoid steps and kinks on the surfaces (field enhancement β)

4. Ra should be around ¼ of the skin depth to preserve electrical conductivity

Copper quadrant structures: example 30GHz



- machining by 3D milling (carbide tools)

- alignment of the quadrants by balls and gooves (plastic deformation of copper): possible improvement?

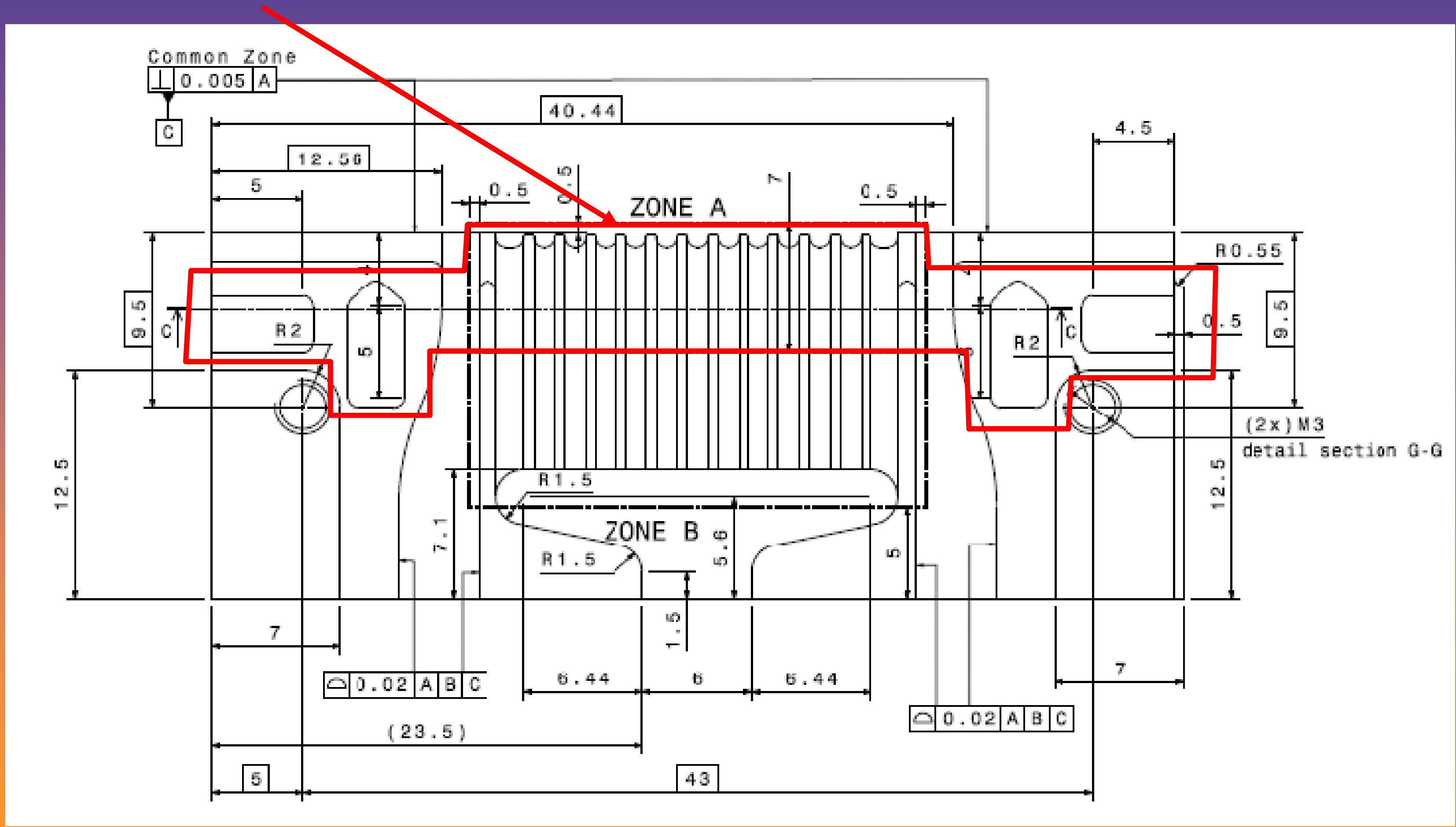
- assembly by brazing or by bolting

- achieved accuracy? Grooves are positioned at some 6 µm accuracy

- damping implemented in the design

Tolerances:

5 µm shape tolerance



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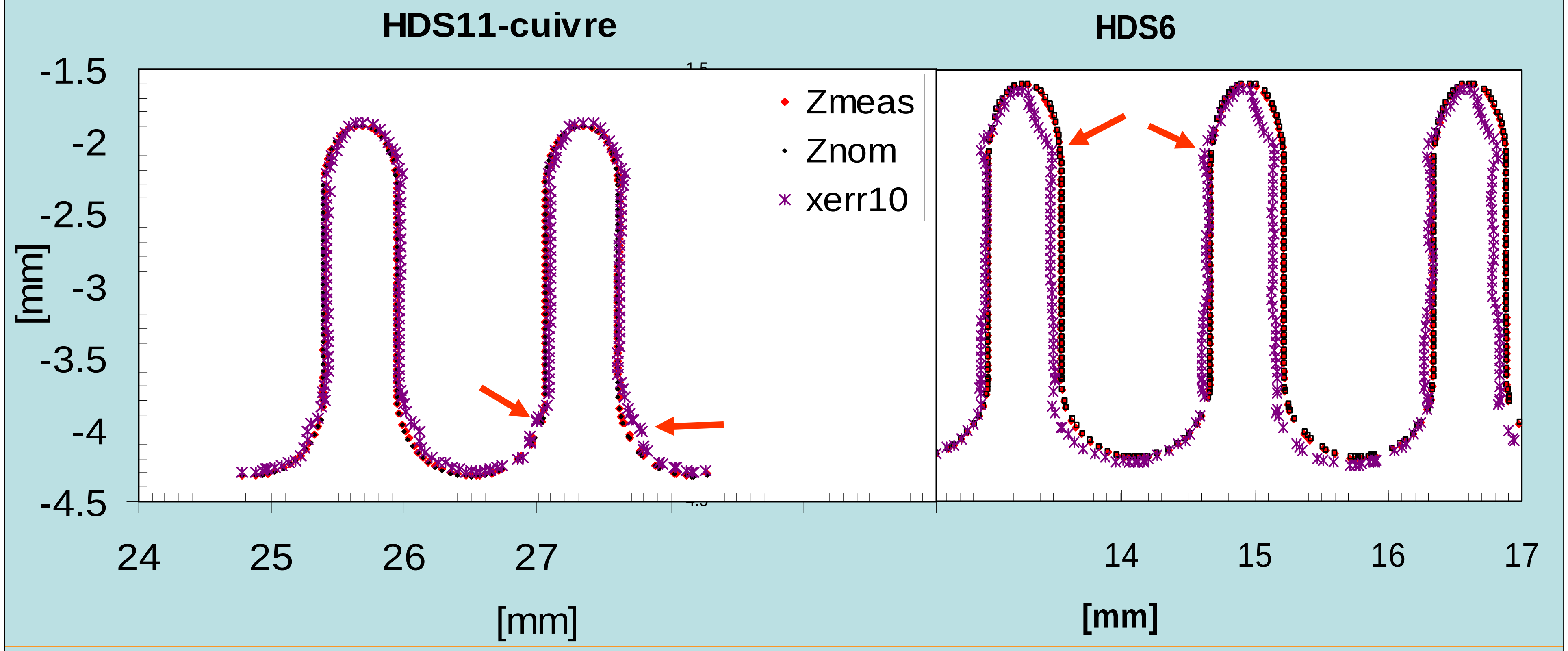
Metrology on copper quadrants

Measurement: coordinate measuring machine, contact with 0.1N force, accuracy +/-3 µm (at CERN), scan pt. by pt. on the surface ....in parallel with RF low power control



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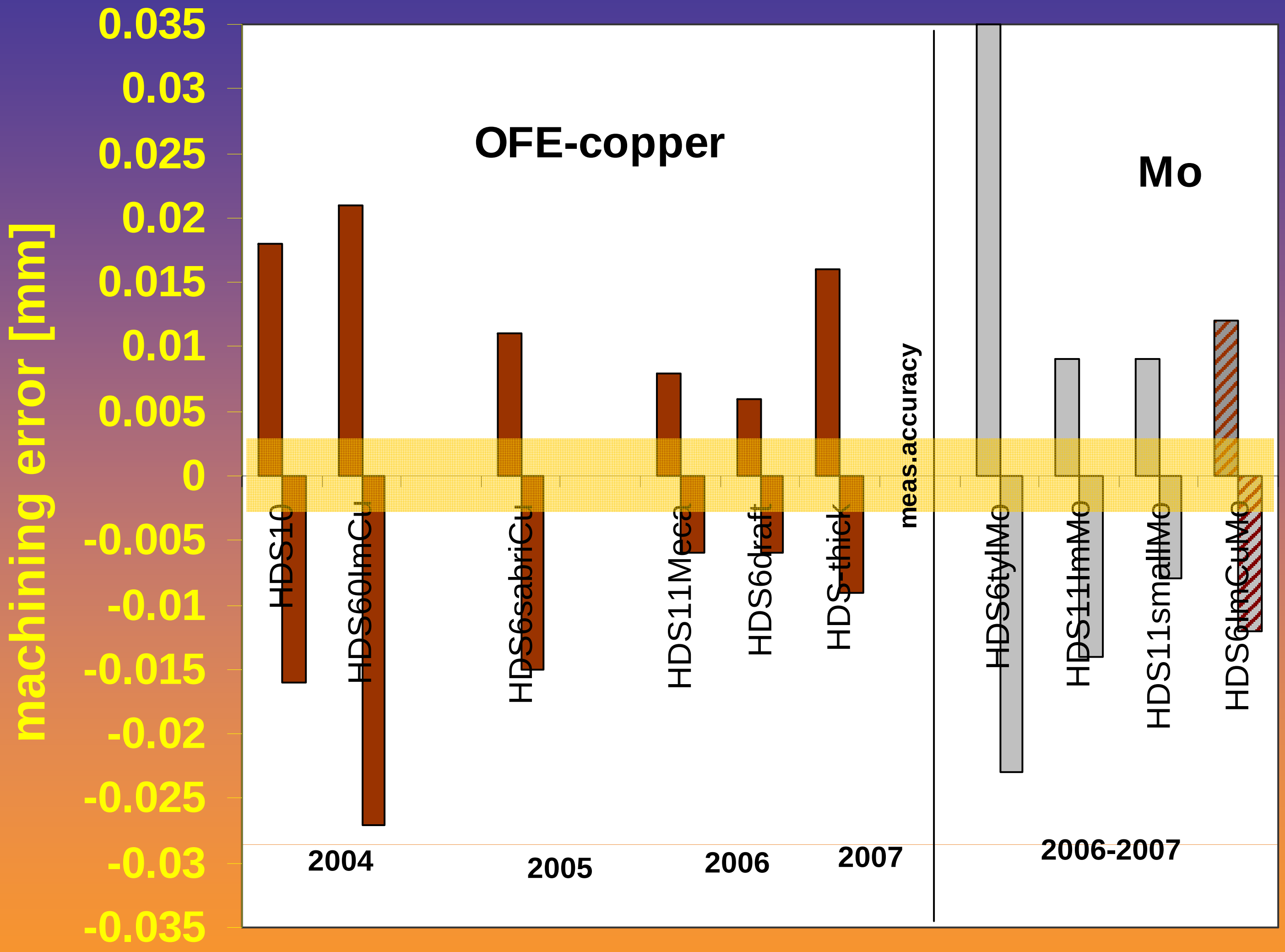
Achieved shape accuracy



Surface finishing on copper, Ra=0.1-0.4 mm

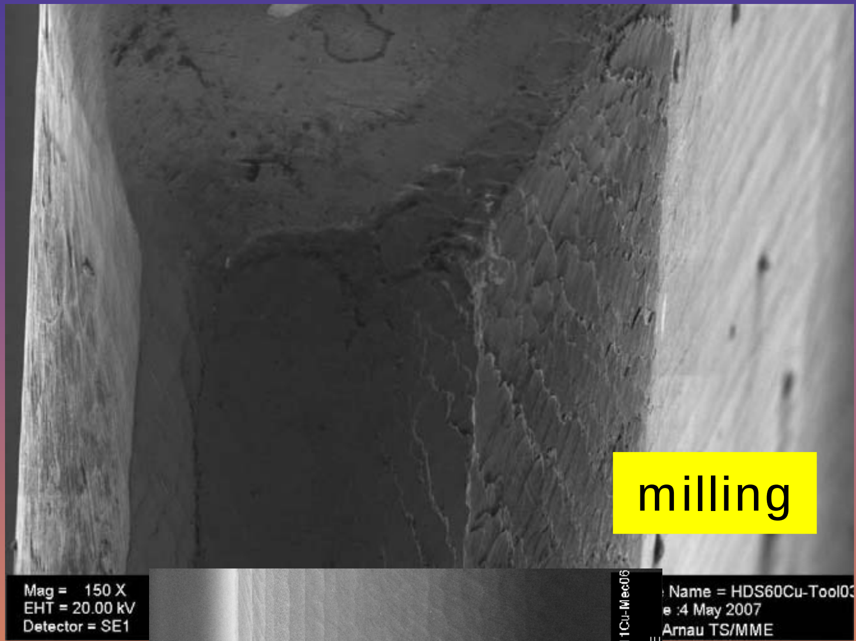
Possible sources of the error in 3D milling

-Error on tool diameter, tool length, tool run-out : dynamic dimensions
-Error on tool shape
-Tool flexure (larger tools at 11GHz should be favourable)
-Tool consumption during machining

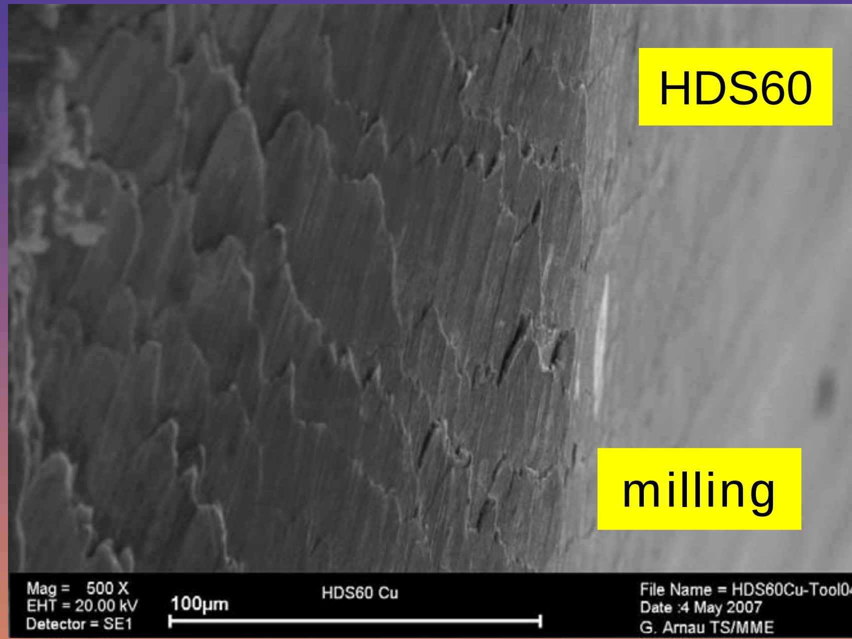
-Thermal expansion of the piece...probably not relevant for the present short prototypes

-Temperature stability, dynamics of the machine tool
-Positioning accuracy of the machine tool (machine tool with higher nominal accuracy give better surface finish)

Surface quality: on copper

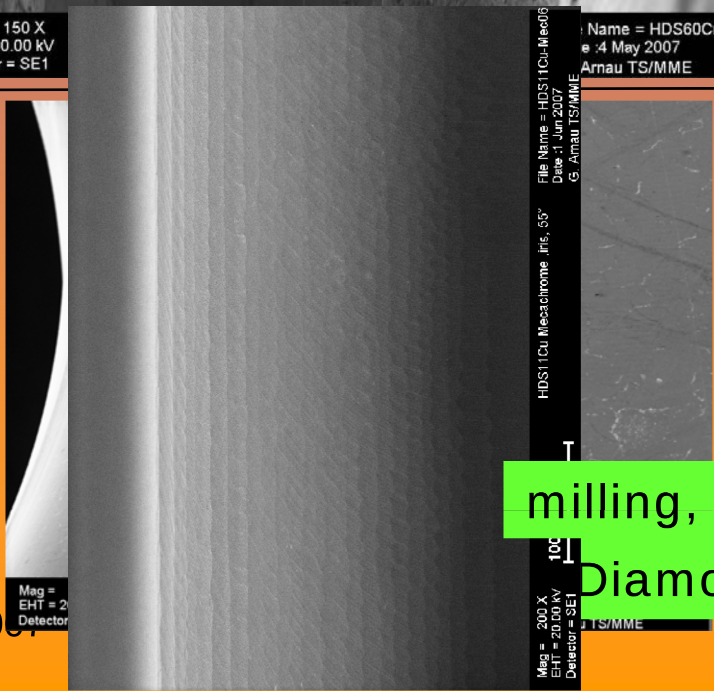


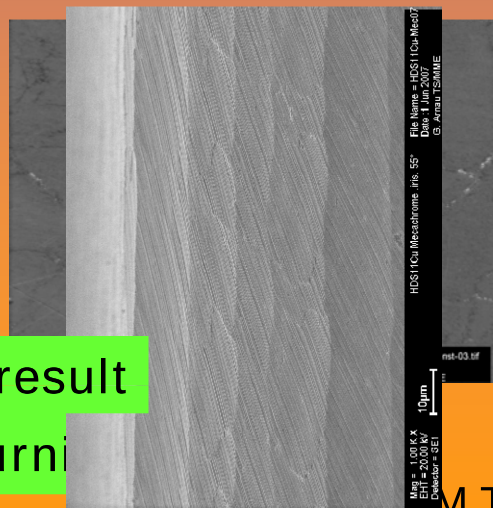
milling



HDS60

milling





milling, best result

Diamond turni

Other materials and bi-metal

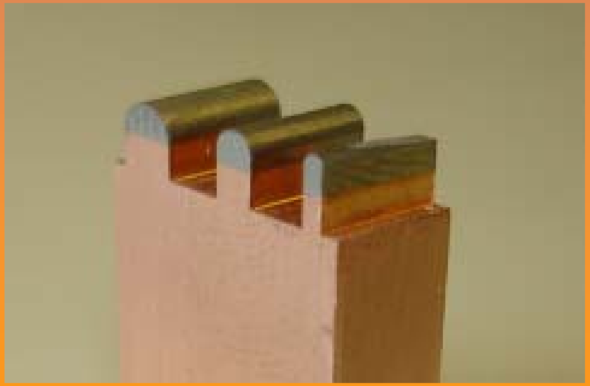
Full structure in single material for rf testing

Cu, Mo, Al, StSt, Ti

Joining Mo to CuZr C15000 alloy by diffusion bonding through HIP or explosion bonding; tested by machining, shear and pull strength test

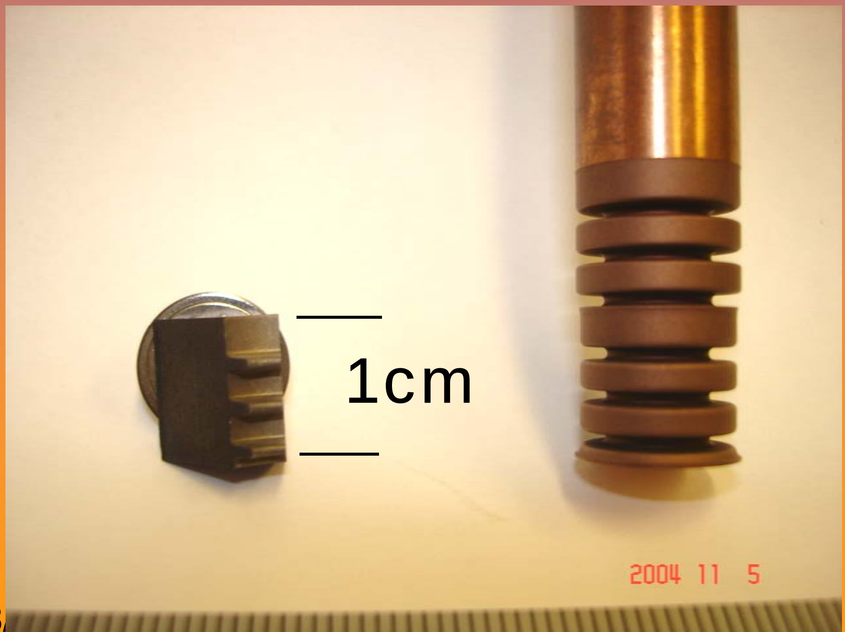
HIP diffusion bonding

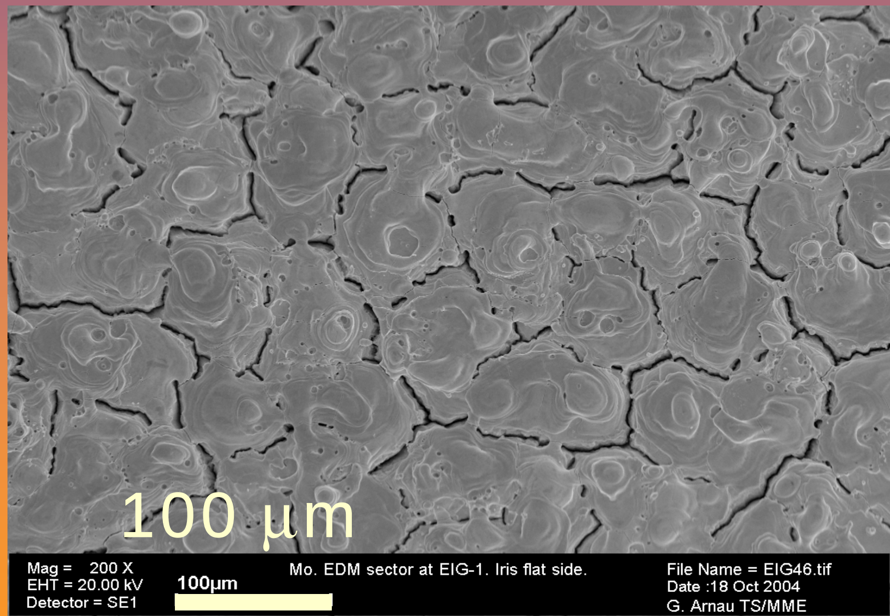
Explosion bonding



Other machining techniques:

-3D milling of copper with single crystal diamond tool?
-Elliptical vibration milling of copper?
-Electrochemical machining sufficiently accurate?
-Electro discharge machining of refractory metals
(micro-cracks on molybdenum), development in progress





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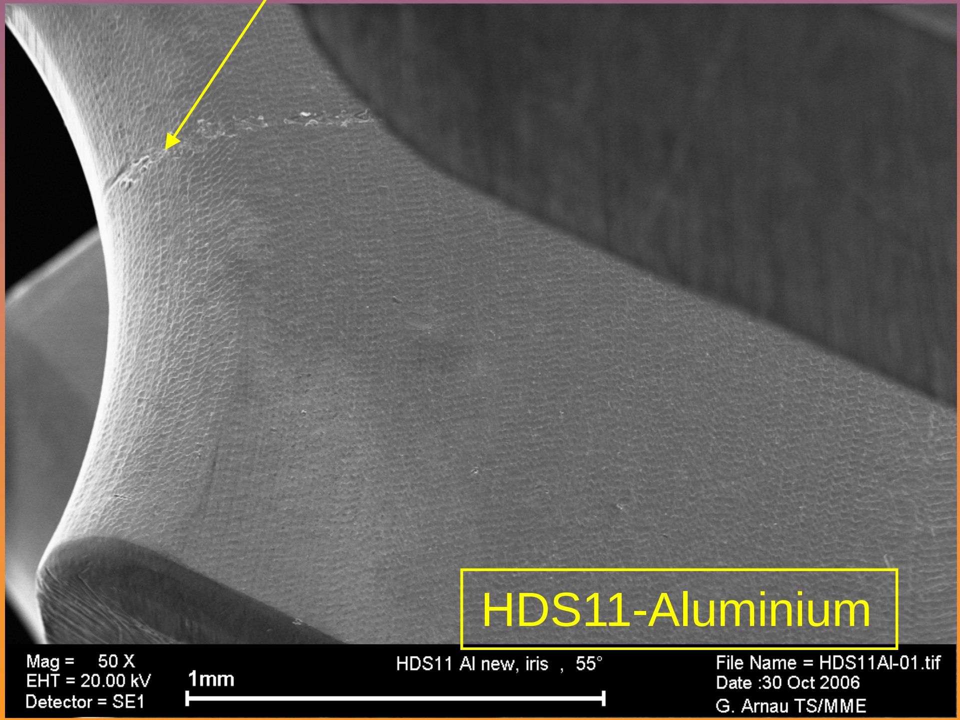
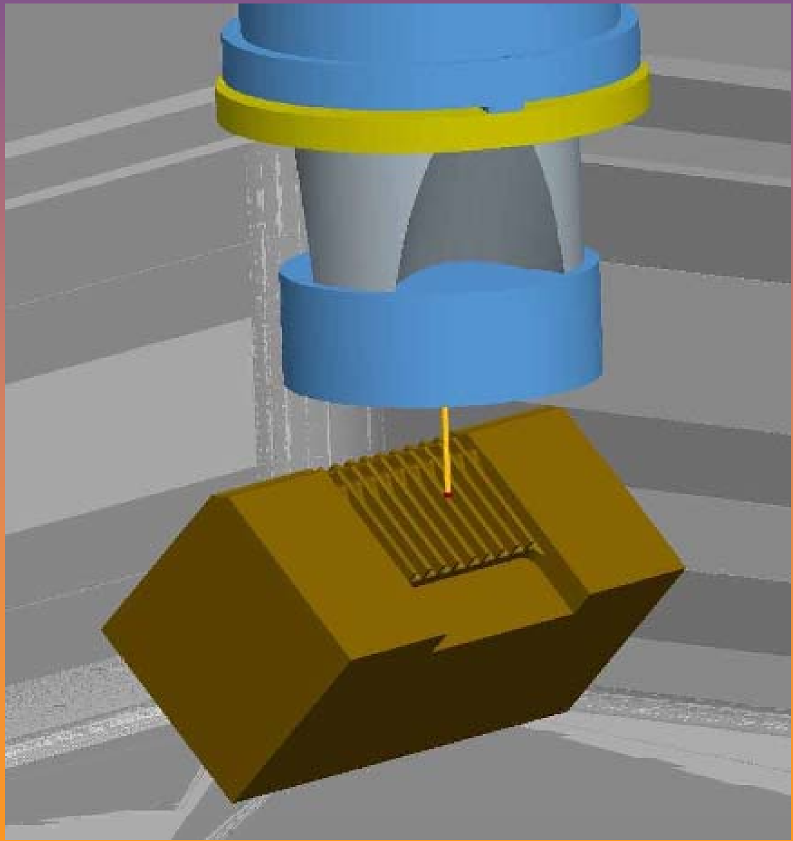
Metrology problems

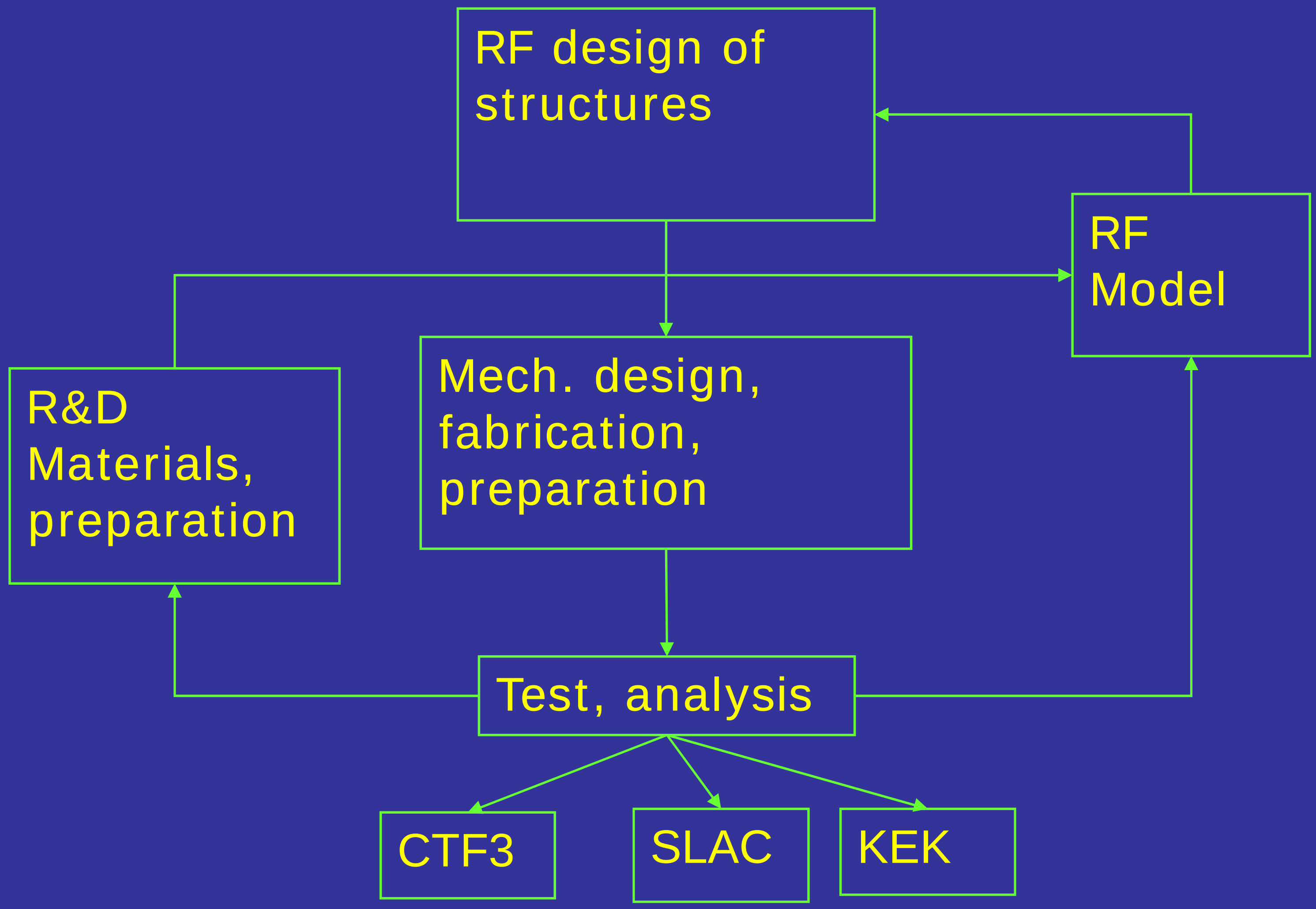
Requires high accuracy, ideally 0.1 μm to control at 1 μm level
Force of the sensor should be low (0.1 N leaves marks)
Available optical methods are not adapted for complex 3D shapes

Trace of sensor contact





Production of structures



The goal is the fabrication of 1 geometry in 4 months and 10 geometries per year

Present production situation

CLIC accelerating structures

Frequency	Structure	Status
CTF3 30 GHz tests	Cu $\pi/2$ circular - 30CNSD1p3Cu	UNDER TESTING
	W $2\pi/3$ clamped	at CERN
	Pulse heating cavity	at CERN
	Mo HDS11-small - 30HDS11S_Mo	at CERN
	Cu HDS11-small - 30HDS11S_Cu	ODERERD
	Ti HDS11-small - 30HDS11S_Ti	at CERN
	Cu HDS thick #1 - 30HDS__TkCu	at CERN
	Cu HDS thick #2 - 30HDS__TkCu	at CERN
	Mo HDS thick - 30HDS__TkMo	MECH.DESIGN
	Cu quadrant circular thick #1 - 30CNSQ_TkCu	ODERERD
	Cu quadrant circular thick #2 - 30CNSQ_TkCu	ODERERD
	Mo quadrant circular thick - 30CNSQ_TkMo	MECH.DESIGN
	Cu quadrant circular thin - - 30CNSQ_ThCu	ODERERD
	Cu HDS R1.2 - 30HDS12XSCu	MECH.DESIGN
	Cu $2\pi/3$ quadrant - 30CNSQ2p3Cu	UNDER MECH. DESIGN
	long taper coupler and speed bump coupler	UNDER RF DESIGN
	Bi-metal structure	under consideration
	Total number of structures for 30 GHz tests: 17	
X-band @ SLAC 11.4 GHz tests	Mo HDX-11 - 11HDS11__Mo	at SLAC
	Cu CLIC_vg1 quadrant undamped (P3) – 11WUSQvg1Cu	RF design done
	CLIC_vg1 quadrant damped (P1) - 11WNSQvg1Cu	UNDER MECH. DESIGN
	CLIC_vg1 disk undamped – 11WNSDvg1Cu	UNDER RF DESIGN
	CLIC_vg1 disk damped - 11WDSDvg1Cu	UNDER RF DESIGN
	T23VG3 disk undamped (P2) - 11T23vg3DCu	collaboration CERN/SLAC
	HDX 70° quadrant damped - 11HDSQ70_Cu	UNDER RF DESIGN
	HDX 70° disk undamped - 11HNSD70_Cu	UNDER RF DESIGN
	CLIC_full structure	waiting for complete quadrant manufacturing
	Total number of structures for x-band tests: 9	

Available
Under production
Under mech. Design.
Under RF design

Thank you

HDS11-small-Mo