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systémů

Research Centre for
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Systems

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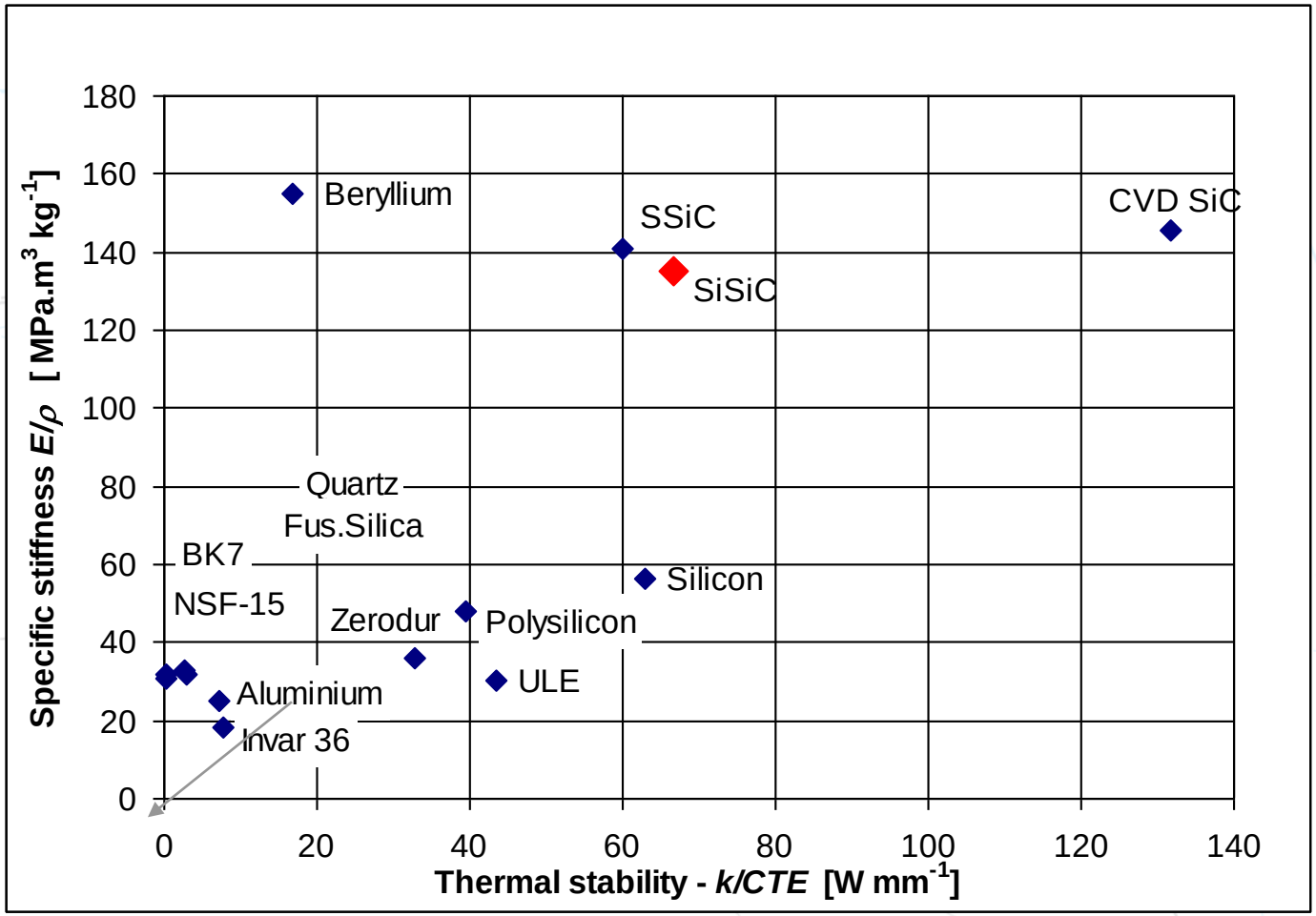
METIS coronagraph

Progress on mirrors M1 and M2

Selection of the material



SiSiC – hard material needs special technology for cutting and grinding

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Material properties

SiSiC

- Youngs modulus = 380MPa
- Poissons constant = 0.17
- Density = 3.07 g cm^{-3}
- Bending strength = 340MPa

ZERODUR

- Youngs modulus = 90MPa
- Poissons constant = 0.24
- Density = 2.53 g cm^{-3}
- Bending strength = 109MPa

NSF-15

- Youngs modulus = 90MPa
- Poissons constant = 0.24
- Density = 2.92 g cm-3
- Bending strength = 20MPa?

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How to manufacture

- Silicon-infiltrated silicon carbide **(SiSiC) -** substrate

+ Si coating (self organized structure)

20 μ layer
for ion-beam figuring/polishing

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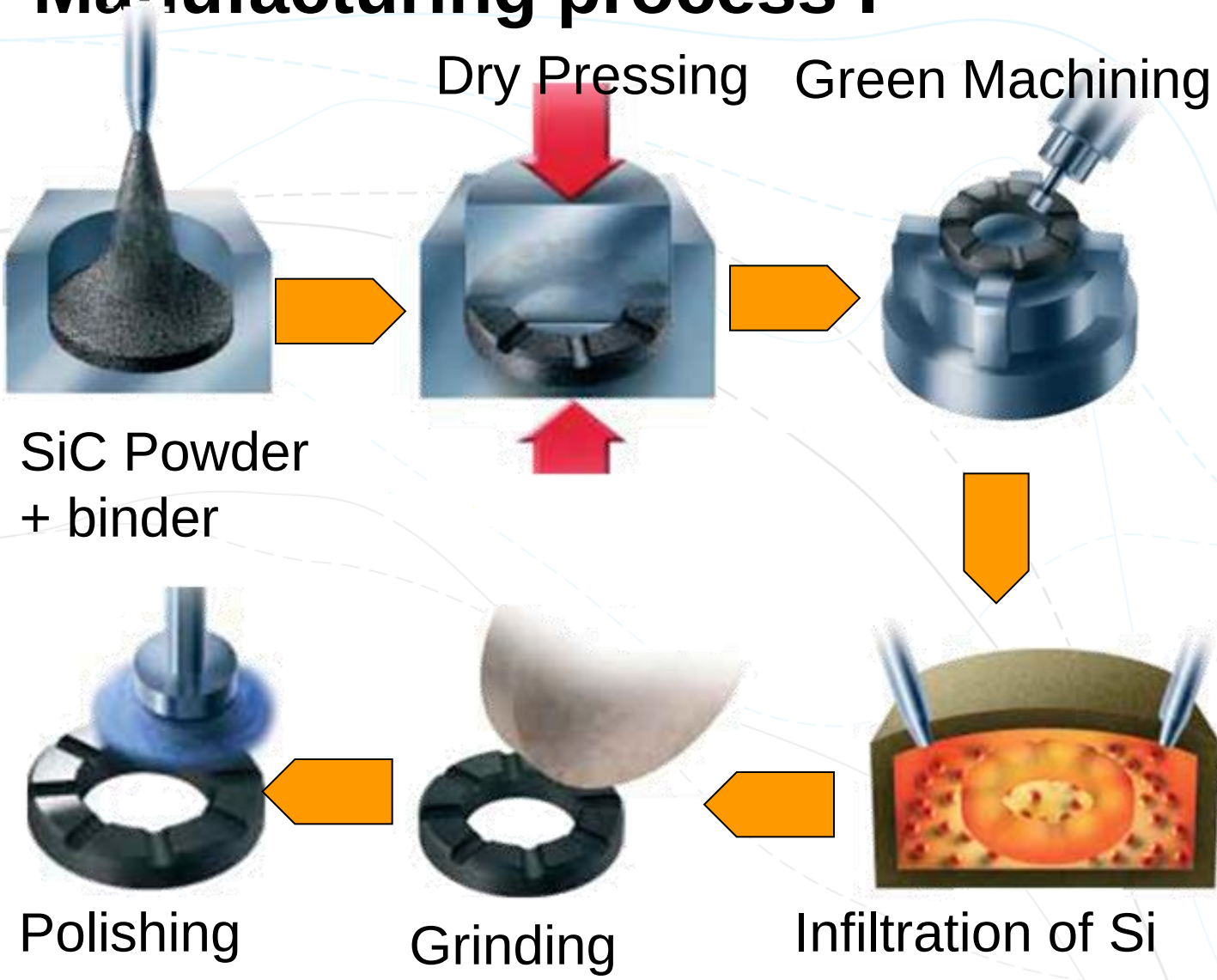
Manufacturing process I



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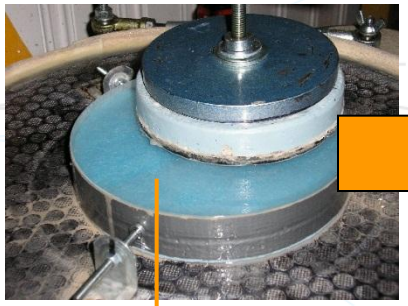
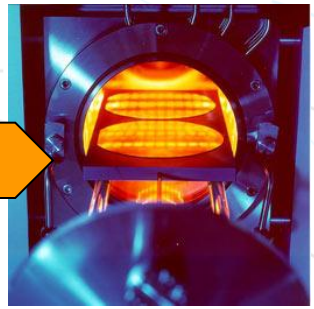
Manufacturing process II

CMP Polishing
(100Å; λ/10)

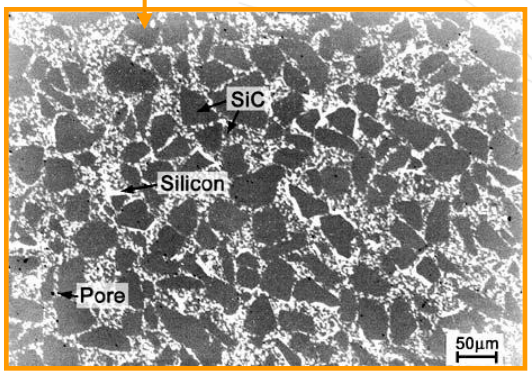


CVD of Si



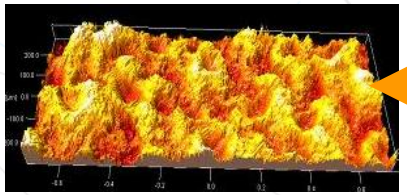
≈ 10-20 µ

Superpolishing



Sufficient for most of applications
But not for UV and EUV

Measurement



Goal of 2Å microroughness

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Numerical Tests - parameters

- FEM –Abaqus, MSC.Nastran
- Topology optimization – ATOM (Dassault Systèmes)
- Structured hexahedral mesh
  (60 000 elements)
- Linear material model, model (E, flexular strength) for SiSiC validated by banding test

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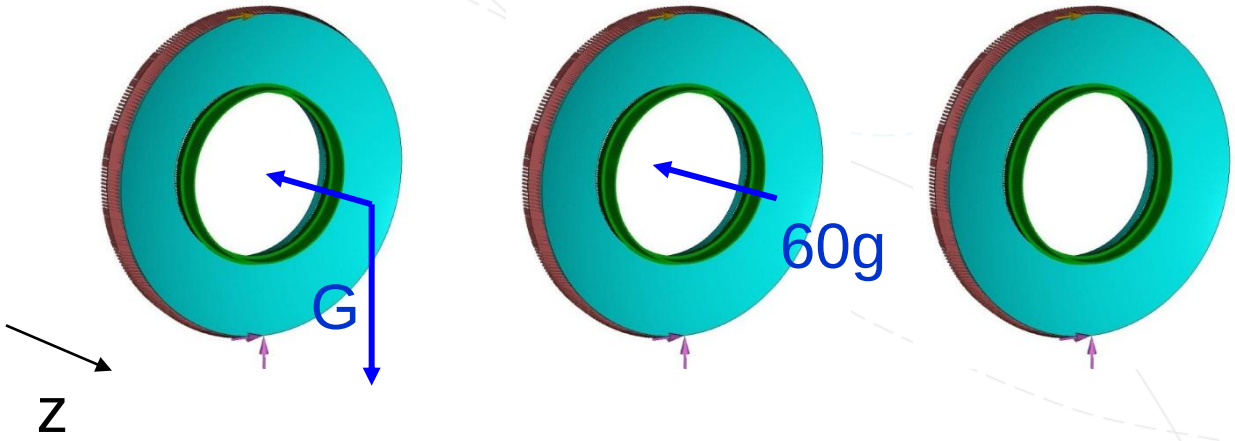
Numerical Tests

1. Modal analysis
2. Deformation of the mirror under its own weight (axial and vertical load)
3. Shock load 60g
4. Stiffness (perpendicular to mirror plane)
5. Random load, sine load, shock load



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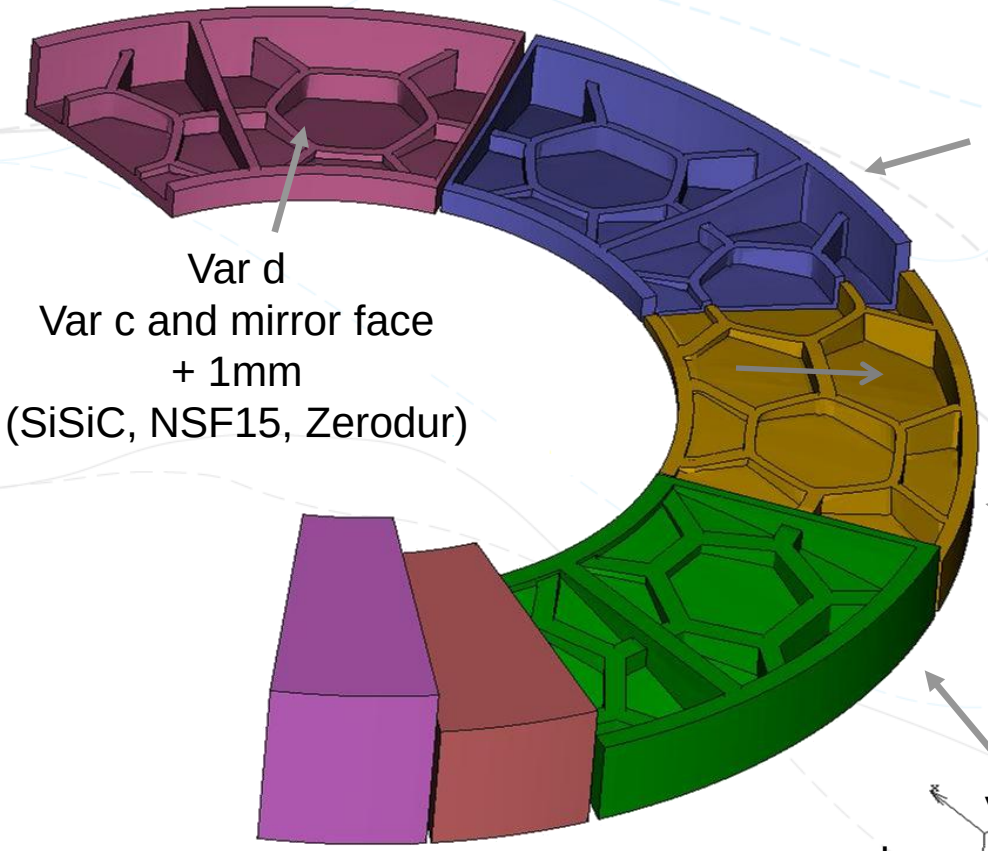
Variants – design + material



Var d
Var c and mirror face
+ 1mm
(SiSiC, NSF15, Zerodur)

Var c
honeycomb
with radial ribs
a higher inner
and outer ring
ribs 2mm
(SiSiC)

Var a
light honeycomb
structure ribs
2mm
(SiSiC)

Var b
honeycomb with
radial ribs-ribs 4mm
(SiSiC)

Var g - h/D = 1/6
(NSF15)

Var h - h/D - 1/8
(NSF15)

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Results

				Loadcase 1	Loadcase 2		Loadcase 3	Loadcase 4	
Var.	Design	Material	Mass	1st Eigenfrq.	Displacement z		Max. Eq. Stress	Stiffness	Stiffness/ Mass
					g_y	g_z	60g(z)		
			[g]	[Hz]	[nm]	[nm]	[MPa]	[kN mm^{-1}]	[N (mm g)$^{-1}$]
a	D1	SiSiC	340	950	69	42	1.8	24	71
b	D2	SiSiC	520	1 384	51	43	2.3	33	64
c	D3	SiSiC	420	1 295	49	35	2.5	50	119
d	D4	SiSiC	520	1 378	43	35	2.6	51	98
e	D4	Zerodur	429	742	145	121	1.9	12	28
f	D4	NSF-15	495	688	173	143	2.2	12	24
g	1/6	NSF-15	3 003	2 080	83	46	0.8	255	85
h	1/8	NSF-15	2 057	1 493	123	83	1.4	93	45

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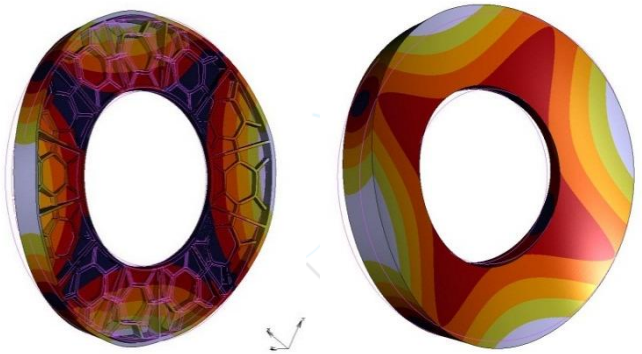
Results LC 1 and 2

Loadcase 1

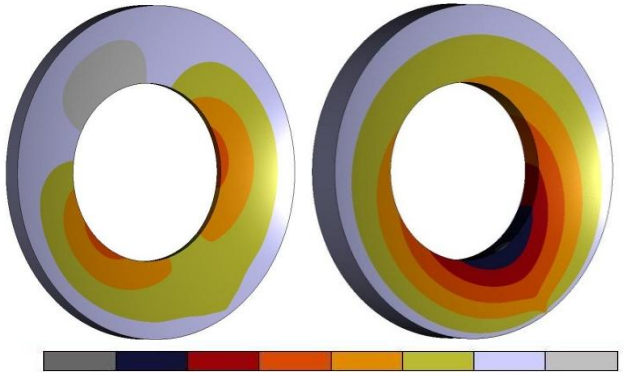
Var d Var g



1378Hz 2080Hz

Loadcase 2 – Gy

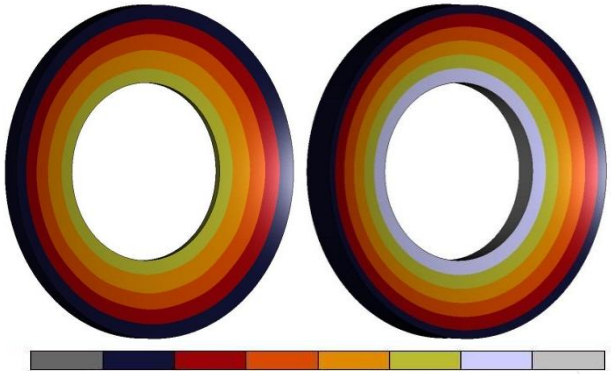
Var d Var g



-82nm displacement z 5nm

Loadcase 2 – Gz

Var d Var g



0nm displacement z 46nm

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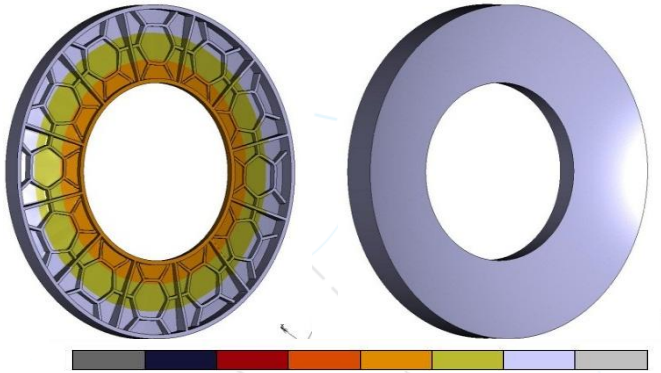
Results LC 3 and 4

Loadcase 4

Var d

Var g

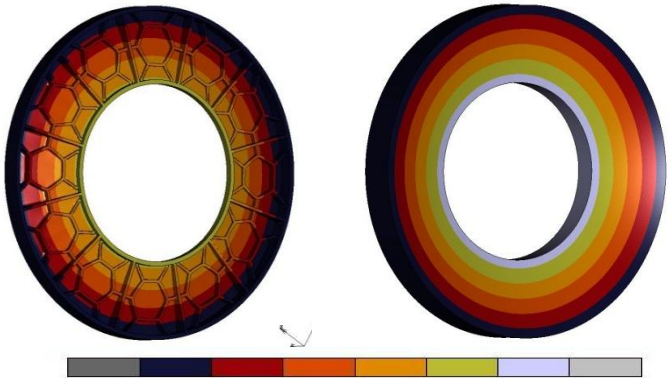


-4000nm displacement z 0nm

Loadcase 3

Var d

Var g

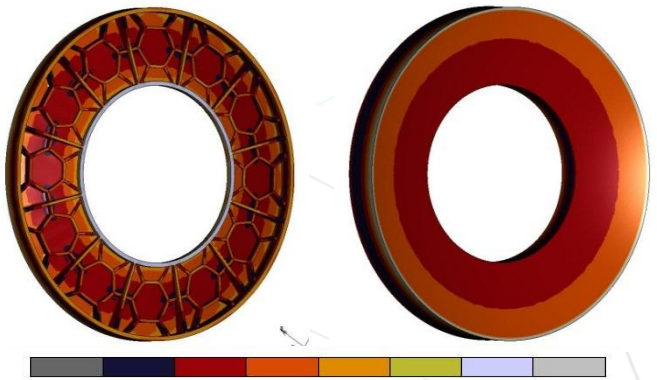


0nm displacement z 3000nm

Loadcase 3

Var d

Var g



0MPa eq. stress 2MPa

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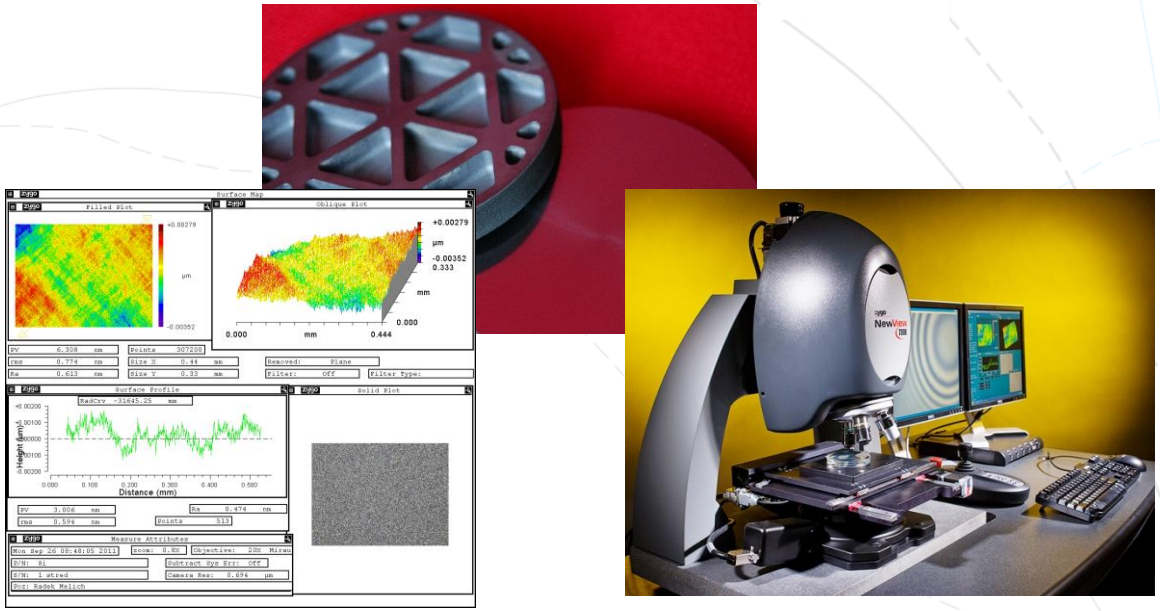
M1 and M2 baseplates

- Gringing and polishing tests on SiSiC sample baseplates
- Polishing test (not IBF) on amorphous Si block proved 6 Å microroughness



WL interferometer to test the surface quality

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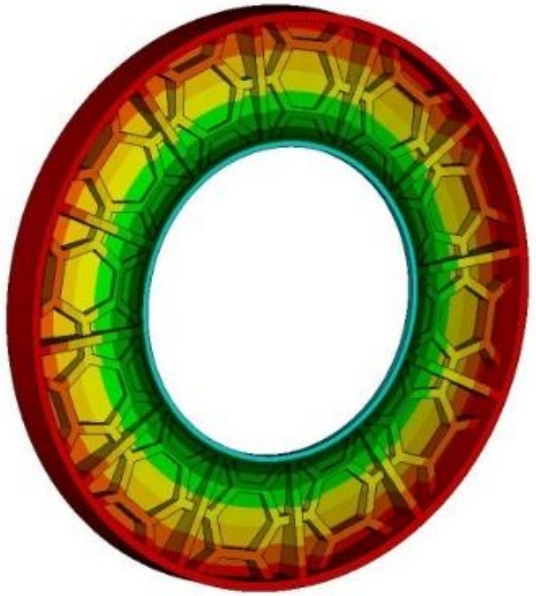
M1 and M2 baseplates II

Currently we have ordered 1:1 scale sample base-plates which are being produced by CERAMTECH (USA, CZ)

C/D phases

final tests & manufacturing



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Polishing test

We are ready for polishing tests on 1:1 scale samples:

- Polishing of the substrate
- Si layer CVD (chemical vapour deposition) on a baseplate
- polishing of the Si layer
- IBF (Ion beam finishing) to reach the required microroughness

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ESA-PRODEX contracts

Czech contribution to METIS is covered by PRODEX (fully confirmed)

- Czech PRODEX confirmed the phase B in June 2010, including the budget
- since then no action at ESTEC office !
- negotiations with ESA-PRODEX office only since June 2012
- electronic version of signed contract delivered to TOPTEC on 29/11/2012

- Czech PRODEX confirmed the phase C/D in 2012
- Negotiations with ESA-PRODEX office to prepare contract with TOPTEC