On the characterization of MPA CVD diamond for fracture toughness measurements

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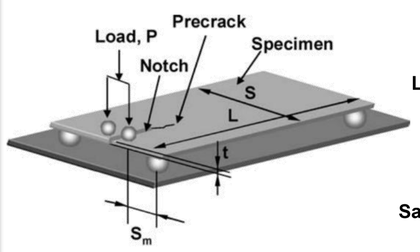
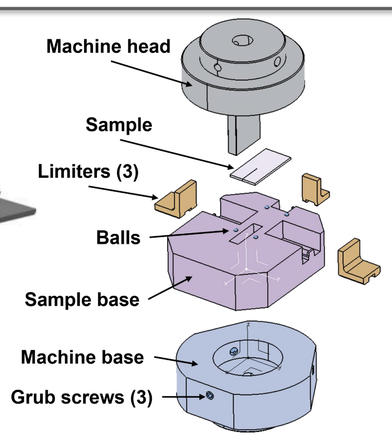
Methods

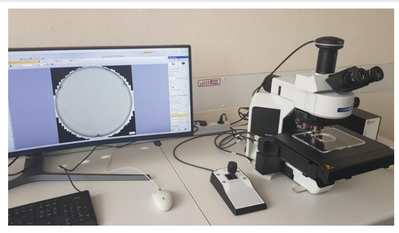
Double Torsion

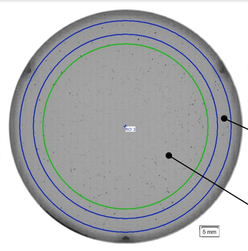


$$K = P S_m \left(\frac{3}{S t^4 (1-\nu)\psi} \right)^{1/2}$$



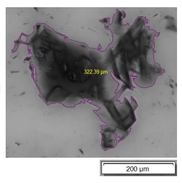
Failure to fracture in diamond disks: Fracture toughness & Integrity assessment



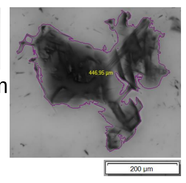


60 ITER disks, Ø70 mm, 1.11 mm

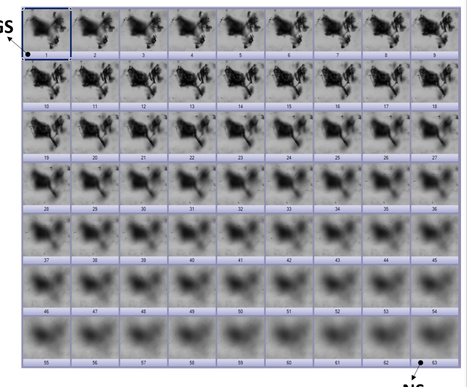
322 µm



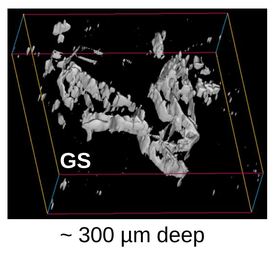
447 µm



GS

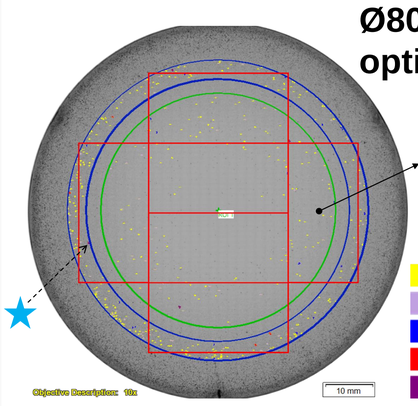


NS

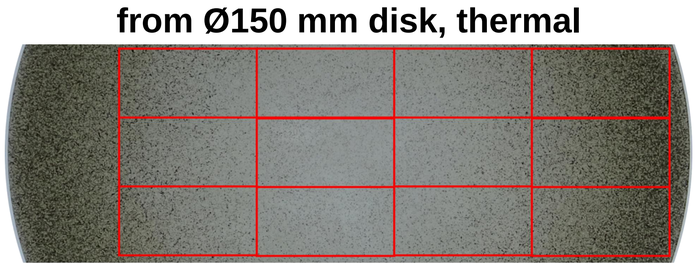


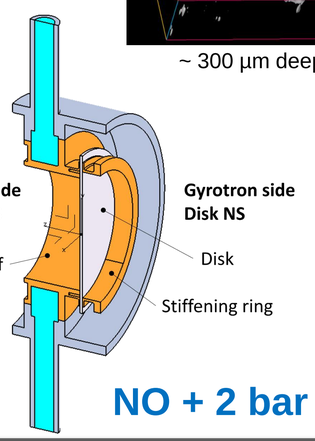
~ 300 µm deep

Ø80 mm disk, optical

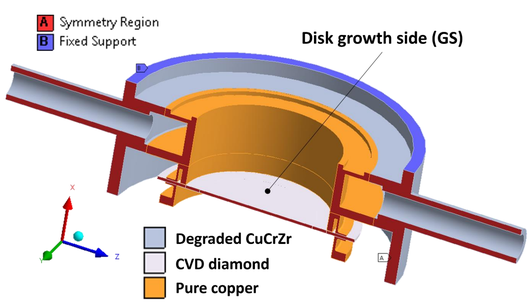


from Ø150 mm disk, thermal

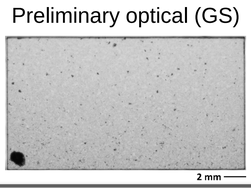




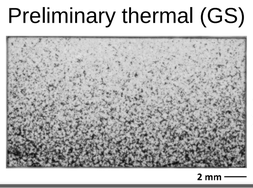
NO + 2 bar



Preliminary optical (GS)



Preliminary thermal (GS)

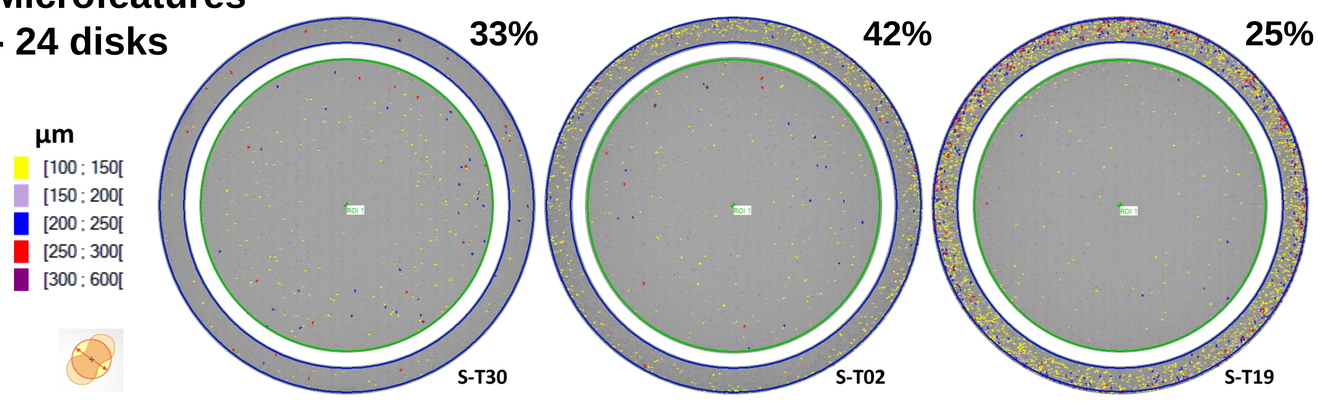


12 mm x 22 mm
x 1.11 mm

- Microscopy
- EBSD
- Raman
- Loss tangent
- XRD
- Pillar splitting

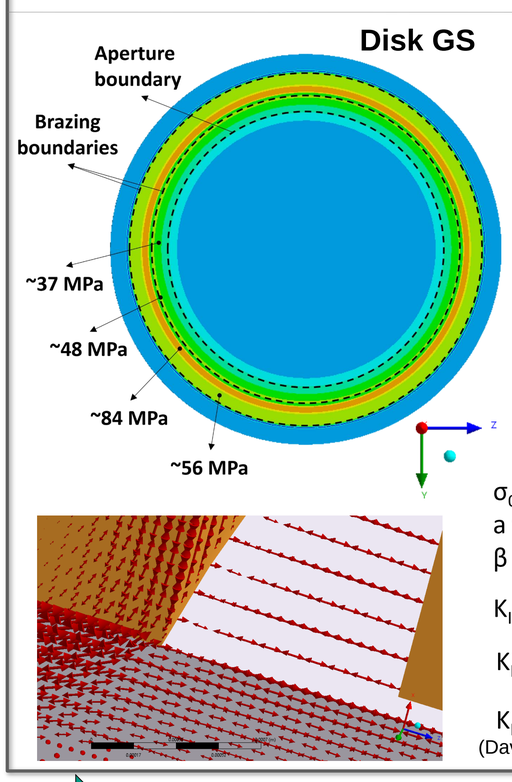
Results

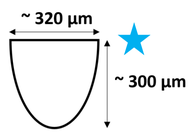
Microfeatures - 24 disks



$\rho_{micr.,braz.} / \rho_{micr.,aper.} < 3$

$\rho_{micr.,braz.} / \rho_{micr.,aper.} > 20$





$\sigma_0 \sim 84$ MPa
a ~ 320 µm
β ~ 1 (rough estimation)

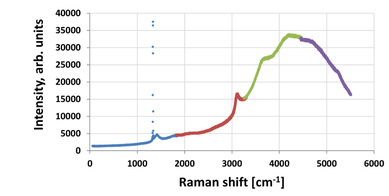
$K_I = \beta \sigma_0 (\pi a)^{1/2}$

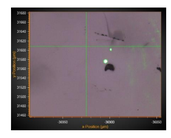
$K_I \sim 2.6$ MPa $m^{1/2}$

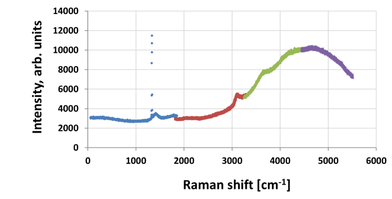
$K_{IC} \sim 8$ MPa $m^{1/2}$
(Davies, J. Mater. Sci, 2004)

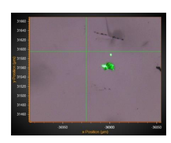
Number of microfeatures in brazing region

Disk/Ranges [µm]	100 - 150	150 - 200	200 - 250	250 - 300	300 - 600
S-T02	534	121	31	6	1
S-T03	299	53	12	4	1
S-T04	94	17	7	5	1
S-T05	447	82	21	7	0
S-T06	25	17	9	5	0
S-T17	1213	400	171	53	26
S-T09	326	71	11	4	2
S-T12	257	94	24	10	5
S-T08	164	27	15	10	1
S-T10	108	14	6	0	0
S-T13	82	13	4	2	1
S-T15	482	142	42	22	7
S-T16	80	10	1	1	0
S-T19	1422	580	255	102	64
S-T21	332	73	18	7	3
S-T23	1153	424	136	63	28
S-T14	264	69	14	4	1
S-T20	268	80	38	15	9
S-T24	1008	365	127	45	36
S-T27	452	101	27	4	1
S-T28	809	228	83	22	6
S-T30	40	15	6	10	1
S-T31	62	19	6	2	1
S-T33	85	21	6	0	1
Average	417	127	45	17	8





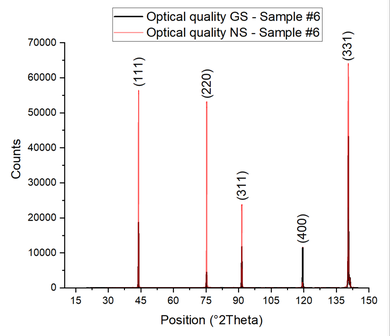




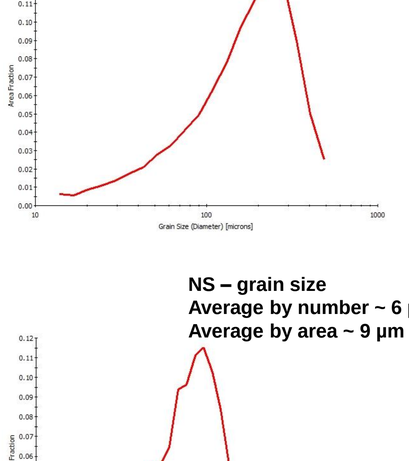
Optical, XRD sin²Ψ method

Φ (°)	GS σ (MPa)	NS σ (MPa)
0	74.7 ± 112	-8.8 ± 47.9
45	-114 ± 88.7	93.9 ± 45.9
90	-84.6 ± 110	-67.5 ± 34.6

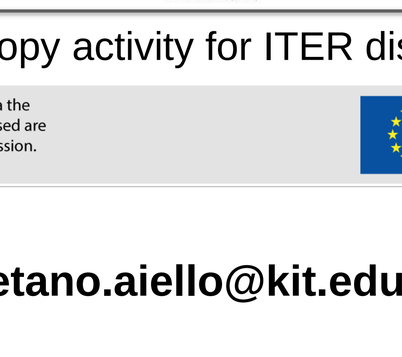
Preliminary samples



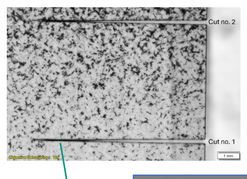
GS – grain size
Average by number ~ 50 µm
Average by area ~ 200 µm



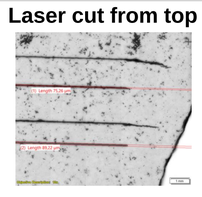
NS – grain size
Average by number ~ 6 µm
Average by area ~ 9 µm

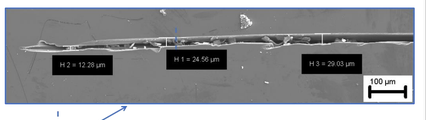


Laser cut from side

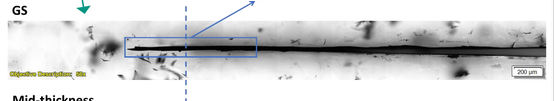


Laser cut from top



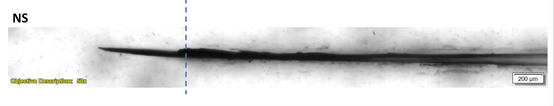


GS



Mid-thickness

NS



Finalize experimental setup design for manufacturing, complete microscopy activity for ITER disks, characterize real-size samples

EUROfusion

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