This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.

Innovative beam windows for high-power accelerator applications

M.Tomut on behalf of task 4.3.

University of Münster/ GSI

iFAST

2nd Steering Committee Meeting (Open), 15 November 2021

IFAST – WP 4 - Managing innovation, new materials

Task 4.3- Innovative beam windows for high-power accelerator applications

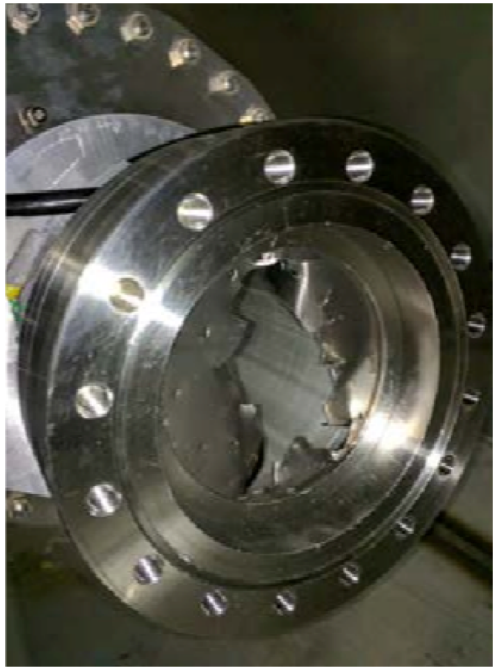
M. Losasso and M. Tomut

Beam windows for high-power accelerator applications – metallic alloys

Suspended graphenic membrane afor accelerator applications

Objectives:

- Production of innovative materials suitable for beam-windows applications in high power accelerators
- Particle transport and thermomechanical simulations for beam windows under high intensity operation conditions
- Characterisation of beam windows materials under thermomechanical load and extended radiation damage and their integration in accelerator environment
- **Participants**: CERN, GSI, WWU Münster, RHP
- **EC contribution: 200 k€** / **Duration: 32 months**



Failure of Ti beam window

Ader, C. R. et al.
"Overview of Fabrication Techniques and Lessons Learned with Accelerator Vacuum Windows." (2018).

iFAST

Task 4.3. Milestones and deliverables

Number	Title	WP	Lead Beneficiary	Due date	Type/level of Disemination
MS13	First characterisation of beam windows materials under thermomechanical load and extended radiation damage	WP 4.3	CERN/GSI	M16	Report
D 4.3.	Beam-windows prototypes. *Manufacture and test of 2 beam-windows prototypes.*	WP 4.3	CERN	M 32	DEM /PU

Task 4.3. Beneficiaries

- **CERN** **-** simulations on dpa,
  - thermomechanical simulations for operational conditions and irradiation experiments on deformations under pressure, thermal stresses and cooling conditions considering the high power deposited by the beam in the material
  - identify failure modes under load induced by the beam pulses

- **GSI** **-** irradiation experiments and beam induced high thermomechanical load studies on materials for beam windows

- **WWU** - investigations on beam-induced structural change of the material.
  - identifying and small scale preparation of special materials suitable for the manufacturing of beam windows for the accelerator environment
  - test and characterize stability of new materials in operating conditions of accumulated doses and beam intensities.

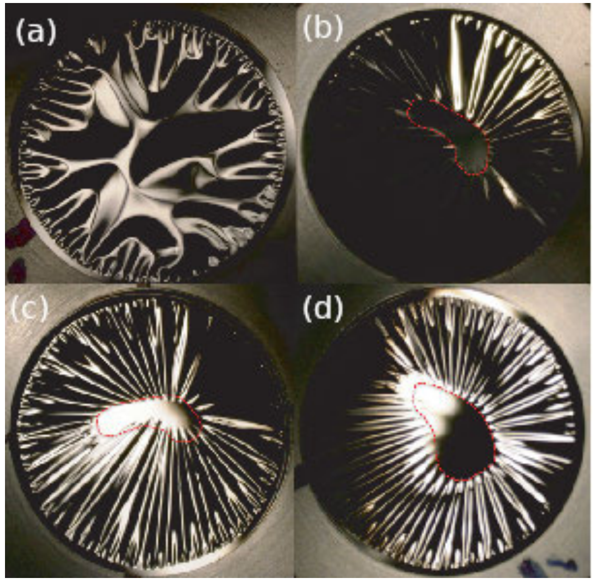
- **RHP** - will develop metallic materials for bem windows and integrate them into specific mountings

iFAST

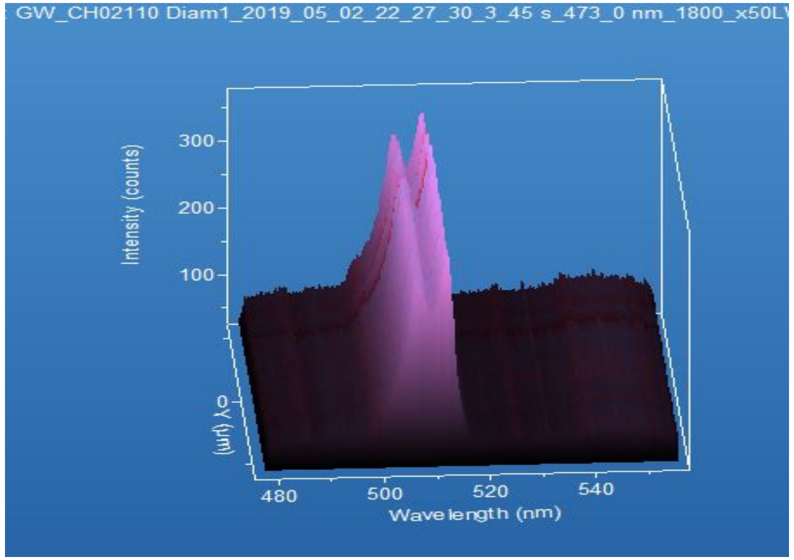
First structural investigations of graphenic mebranes

Irradiation and Raman spectroscopy analysis of structural homogeneity of graphenic membranes on Mo rings

graphenic membrane



graphenic membranes exposed to 5 MeV/u Ne ions at RIKEN

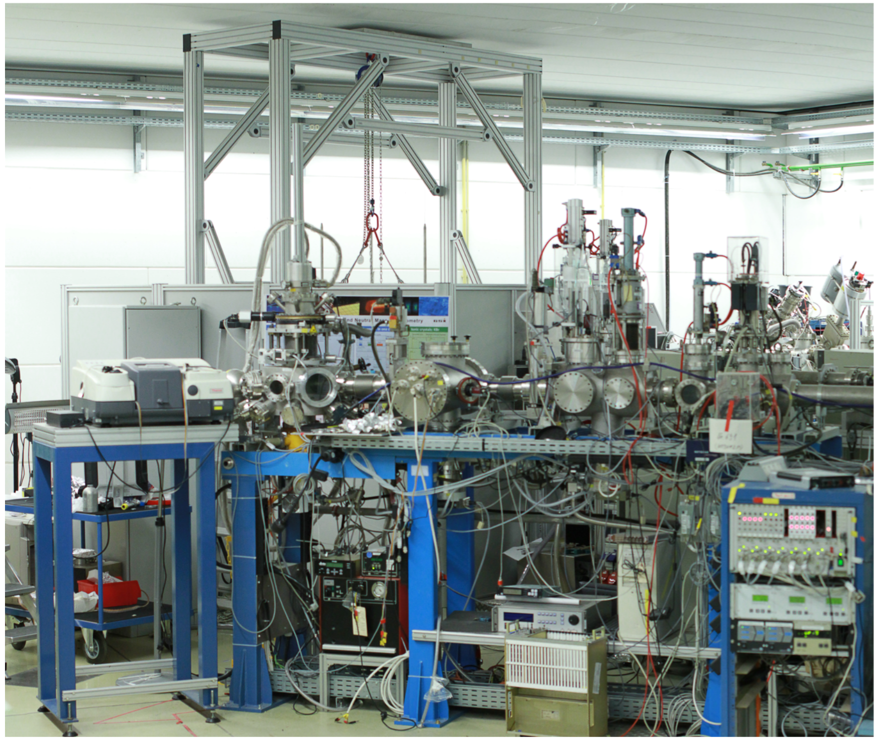


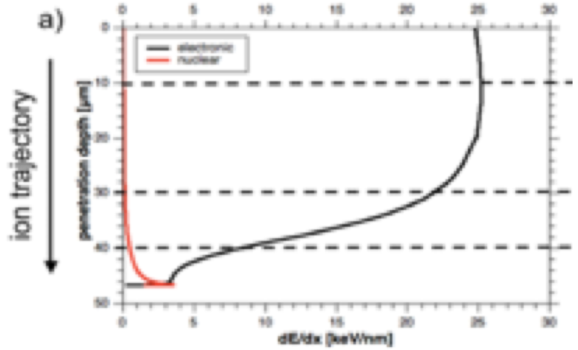
Raman spectra of pristine graphenic membrane

Irradiation of pyrolytic graphite foils

- Pyrolitic graphite foils- stacked for 4.8 MeV/u ^{197}Au-irradiation on 2 sample holders

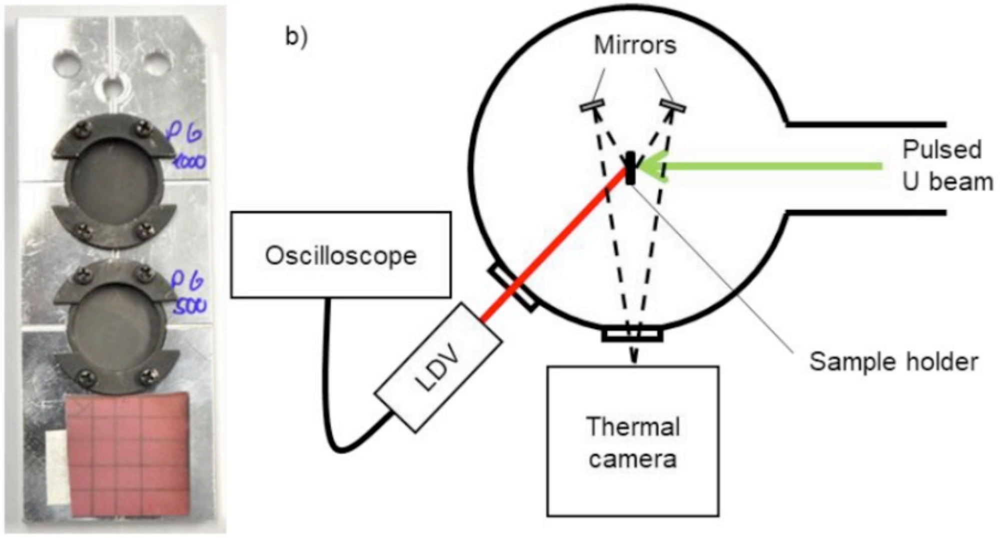
  - Stack thickness covers an ion range of approx. 47 μm
  - probing different energy loss levels along ion path

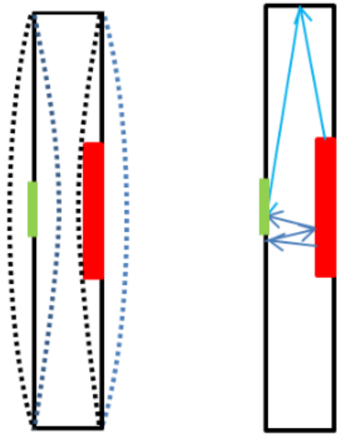


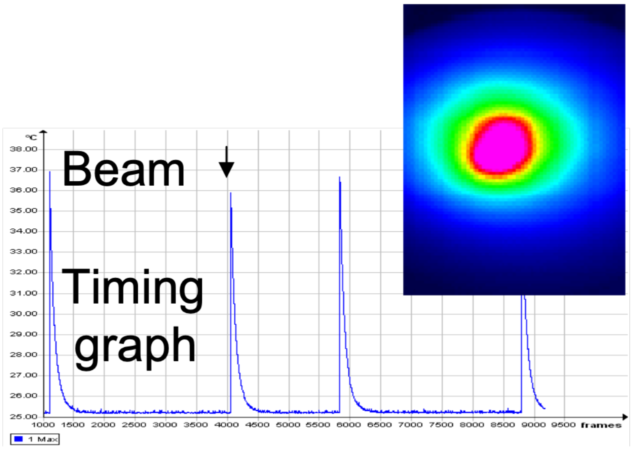


Graphitic samples on M3 holder for 4.8 MeV/n ^{197}Au-irradiation

Exposure of materials for beam window to intense short pulse 1 GeV U ion beams at UNILAC, GSI







- Intense pulsed U beam causes bending and stress waves
- Velocity of the back surface of the samples is measured by LDV
- Beam induced thermal spike recorded using a fast IR camera
- Dynamic response with accumulation of radiation damage

iFAST

Overview of irradiation experiments using high intensity U beams at UNILAC, GSI

	Material properties		Calculated	Measured	
	thickness [cm]	diameter [cm]	f bend free [kHz]	f bend [kHz]	initial direction
3D-CFC tr	0.5	2	6.68	6.5	n
3D-CFC tr	0.2	1	10.69	10	m
3D-CFC ip	0.2	1	10.69	9.5	m
Cantor	0.3	1.2	#DIV/0!		n
Cu	0.21	2	3.43	3.27	n
CuDia	1.77	1	178.14	1.36	n
CuDia	1.6	2	40.26	1.35	n
FG	0.15	2	0.45	3.6	p
Foam	1.4	2	16.83	11.8	p
Foam HTC	1.5	2	13.44		p
GC	0.265	1	24.21	23.5	m
HEA-BCC	6.2	1	#DIV/0!	4.2	n
HEA-Ni60	0.4	1	#DIV/0!	28	n
MG6403	0.535	1	24.62	35.8	m
MG6541	0.37	1	17.00	16.7	m
Ni88	0.45	1	#DIV/0!	34.9	n
PdNiP	0.55	1	#DIV/0!	20.4	n
Prem ip	0.53	2	11.37	11.5	m
Prem ip	0.21	1	18.01	17.9	m
Prem tr	0.57	1	48.90	36.5	m
Prem PyC ip	0.21	1	14.61	14.4	p
Prem PyC tr	0.49	1	33.25	30	p

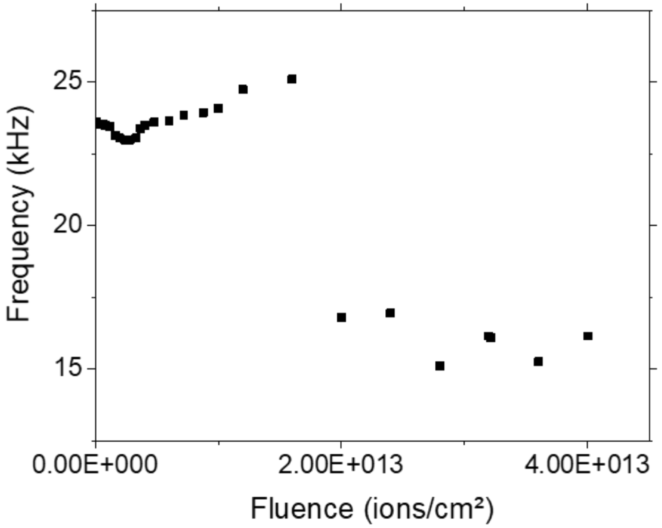
	Material properties		Calculated	Measured	
	thickness [cm]	diameter [cm]	f bend free [kHz]	f bend [kHz]	initial direction
R6300	0.21	1	8.39	6	n
R6300	0.49	2	4.89	3.6	n
R6650	0.21	1	8.94	5	n
R6650	0.49	1	20.85	26	n
R6650	1	1	42.56	40	n
R6650	0.042	2	0.45	3.85	n
R6650	0.18	2	1.92	2	n
R6650	0.51	2	5.43	5.4	n
Ta	0.2	2	2.86	2.3	n
TG	0.42	1	#DIV/0!	27.9	n
TiAlV	0.18	2	3.89	4.8	n
W	0.112	2	2.16	2.2	n
ZEE	0.2	1	9.53	10.7	n
ZEE	0.54	2	6.43	6.8	n
	0		#DIV/0!		
CFC Ac150 tr	1.06	1	88.40		p
CFC Ac150 ip	1.1	1	94.03		p
MG ip	0.2	2	2.30	4	n
R6650 1e13	0.93	1	39.58	40	n
R6650 5e13	0.62	1	26.39	30	n

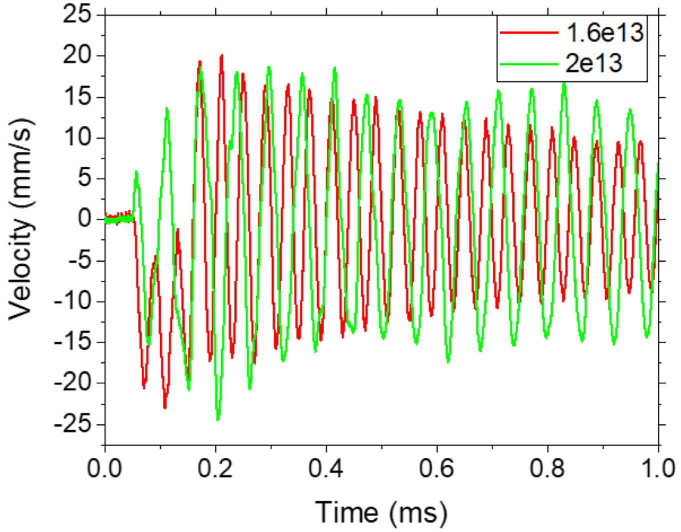
- 43 samples measured
- 23 different materials

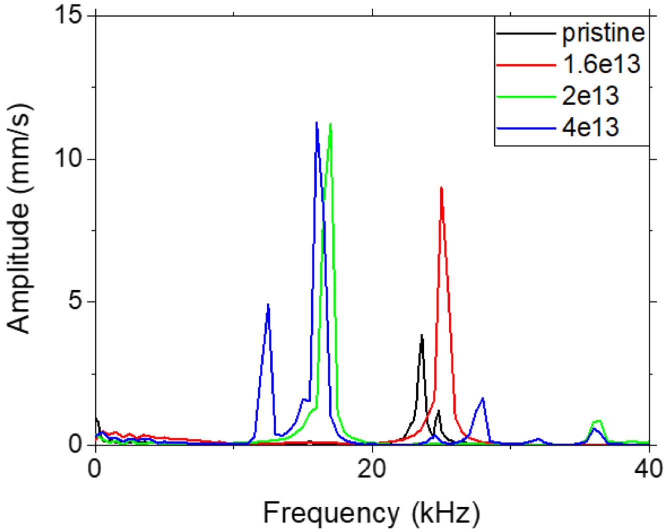
Carbon based:
graphenic membranes, CFC, flexible graphite, glassy carbon, molybdenum graphite

Metallic :
TiAlV alloy, special Ni alloy, Ta, W

Glassy carbon -already tested in HiRadMat as beam windows

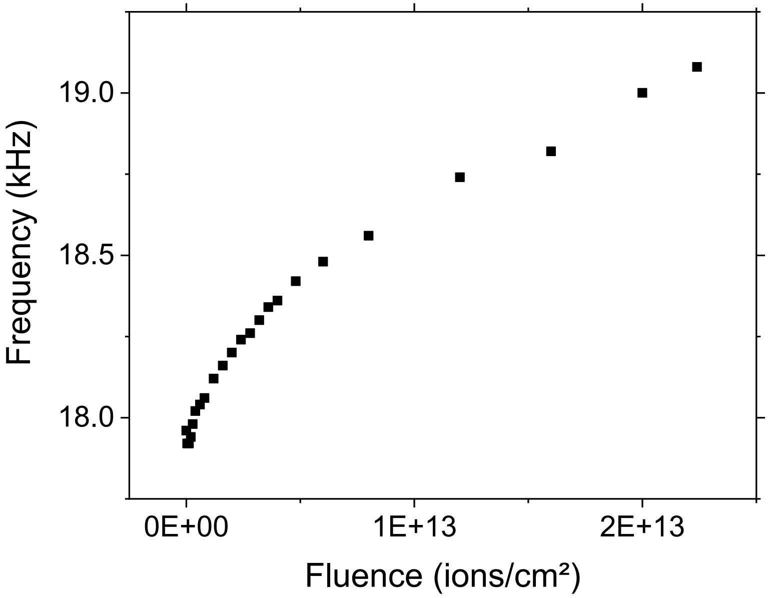


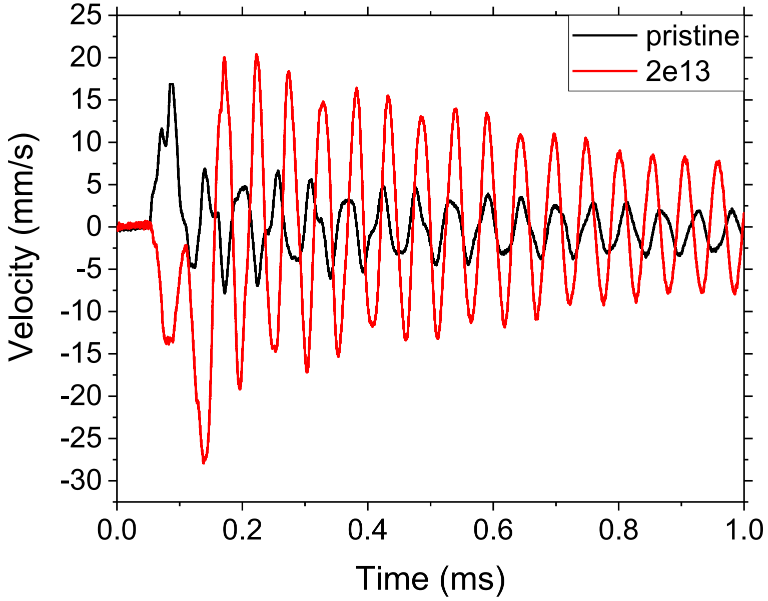


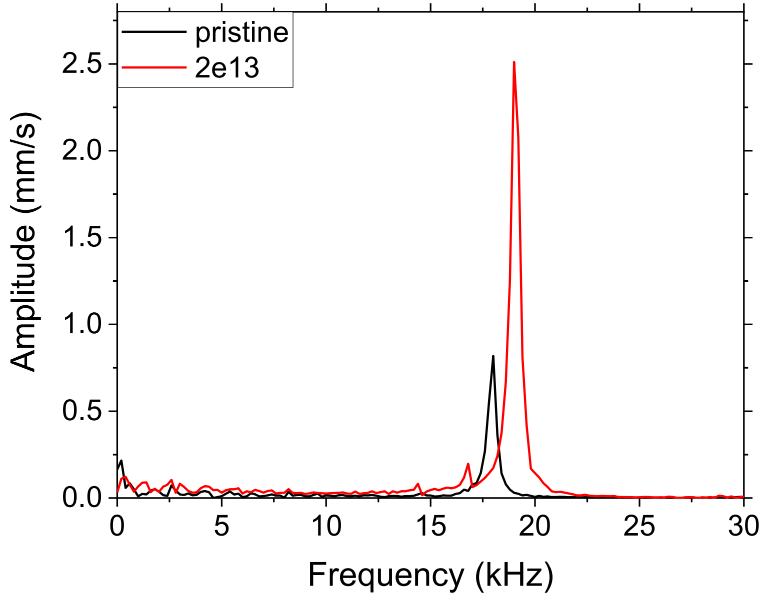


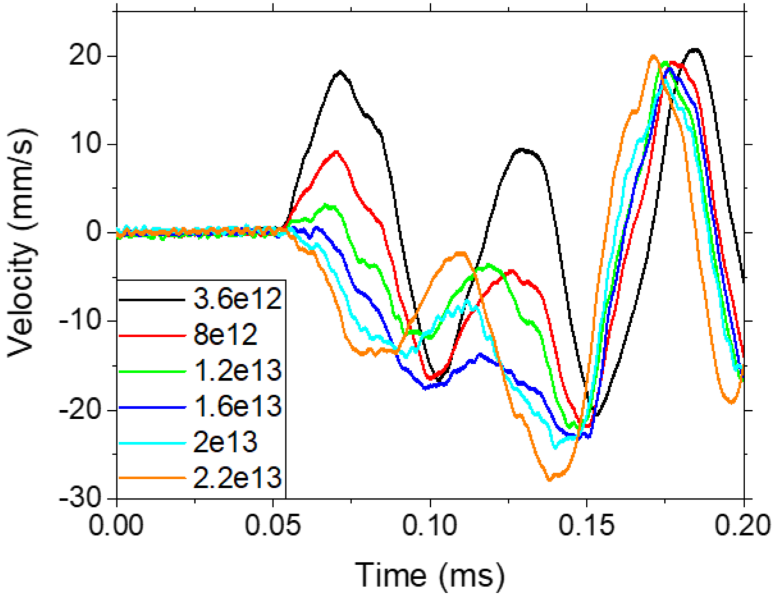
- Calculated bending frequency 24.2 kHz
- Sample fractured at the top
- Frequency of ~17 kHz corresponds to a thickness of 0.19 mm,
- Reduced thickness would be slightly higher than ion penetration depth
- Discs- diam:1 cm thickness: 0.265 mm

Carbon-carbon composite- SGL Premium –tested in HiRadMat experiments



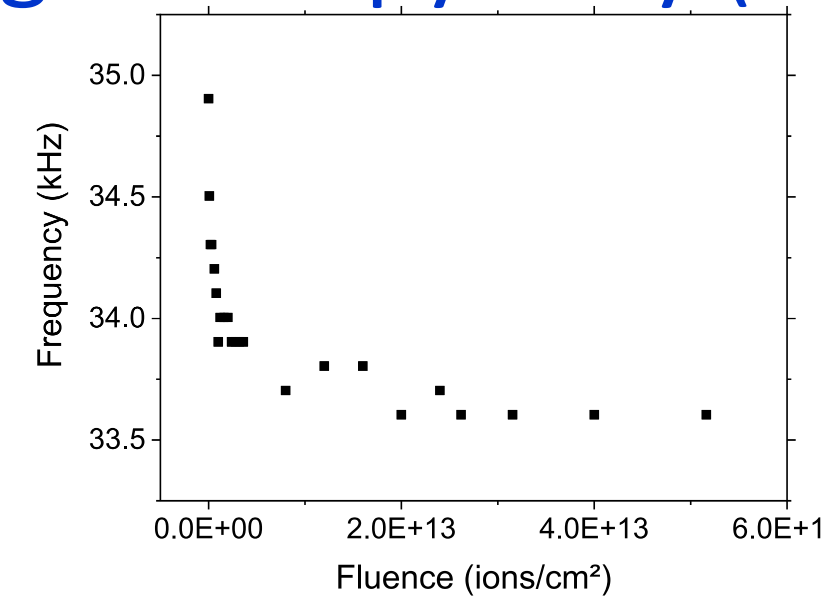


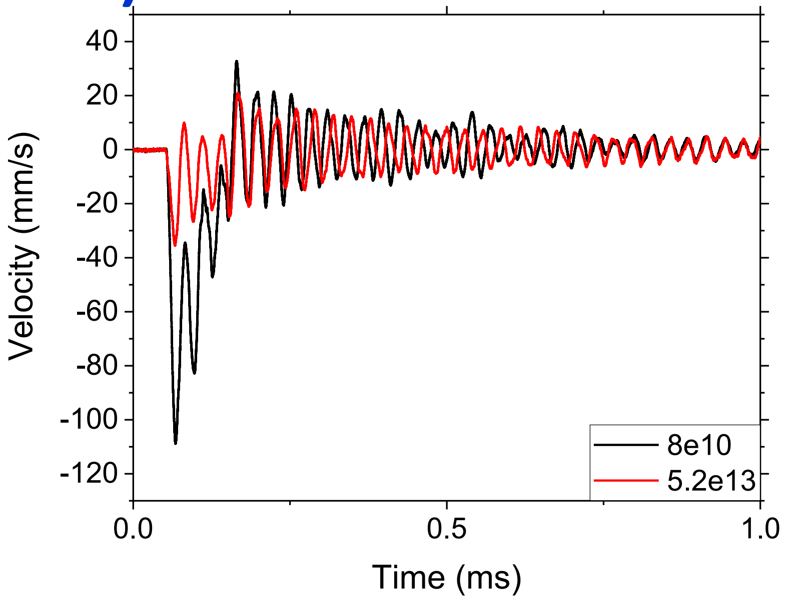


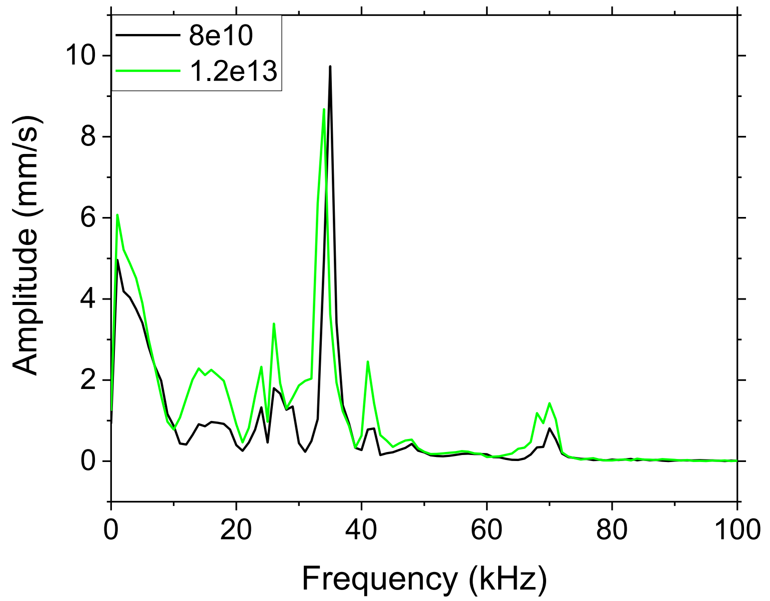


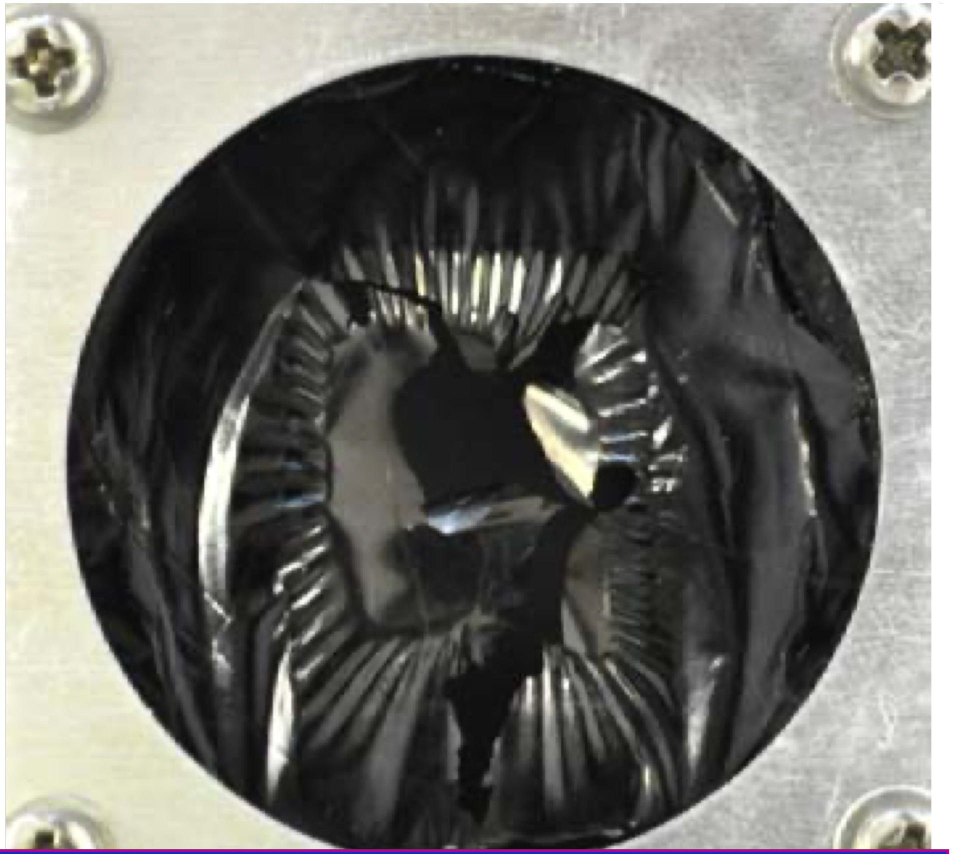
Orientation: ip
Discs: 1cm 0.2mm

High entropy alloy (Ni88)









Thank you for your attention!