Metallic substrates for advanced applications in neutron optics

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OUTLINE

Supermirror reflectivity

Tests

- Irradiation @ spallation source SINQ
- Temperature cycling

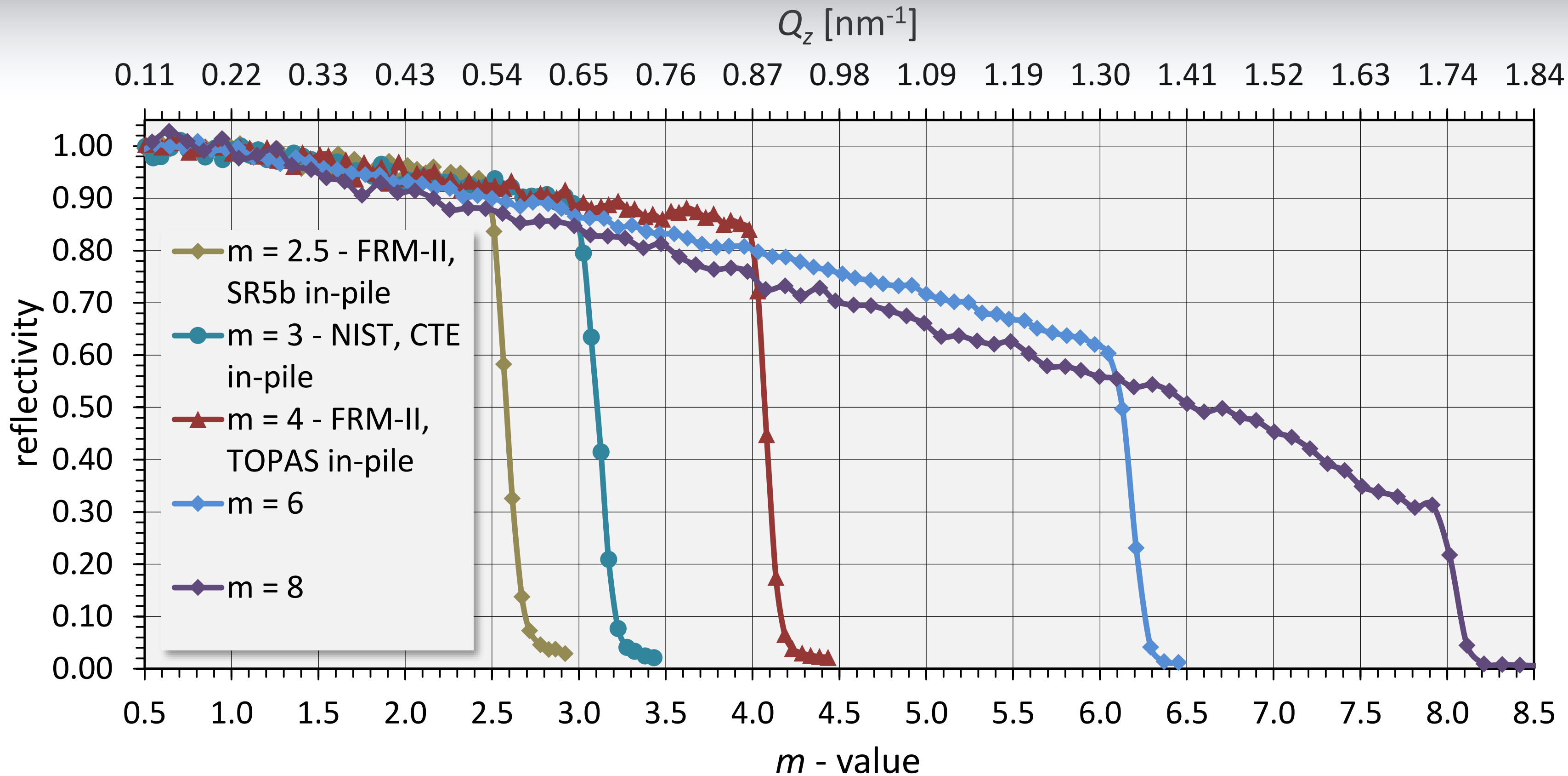
Options and applications of metallic substrates

- Welding
- Truly curved guides
- Extended machining options

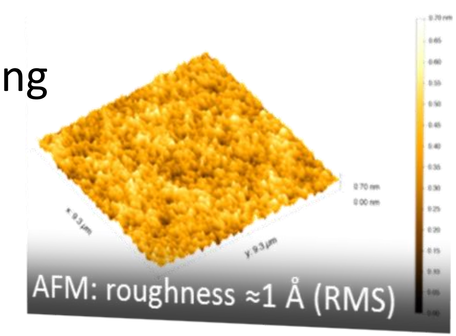
Alternative metals

Conclusions

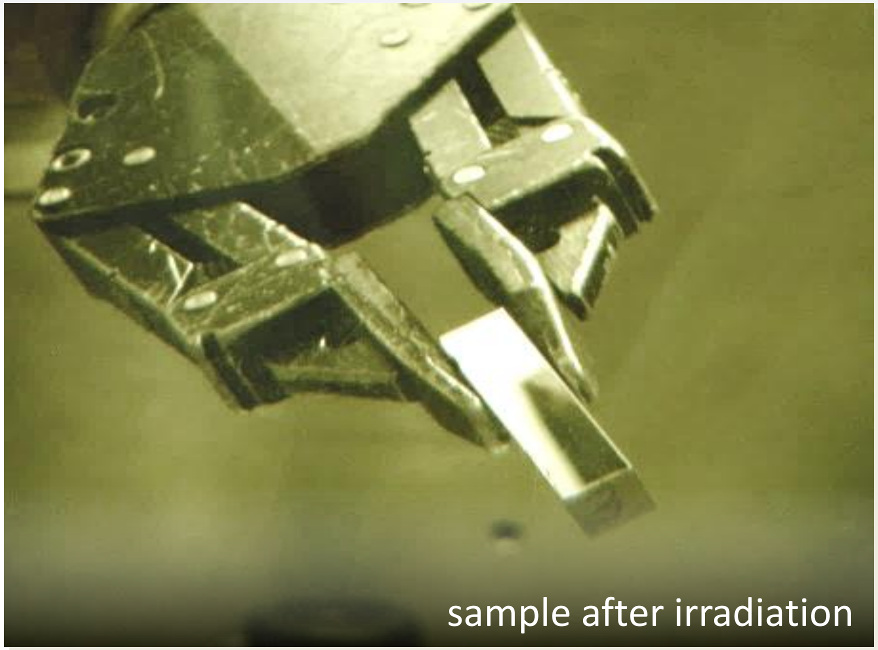
PERFORMANCE OF SUPERMIRRORS ON METAL SUBSTRATES



- sophisticated processes for large area super-polishing and coating
- stabilization of interface roughness
  ⇔ slope of R independent of m-value
- large m-values and high reflectivity ⇔ no compromises



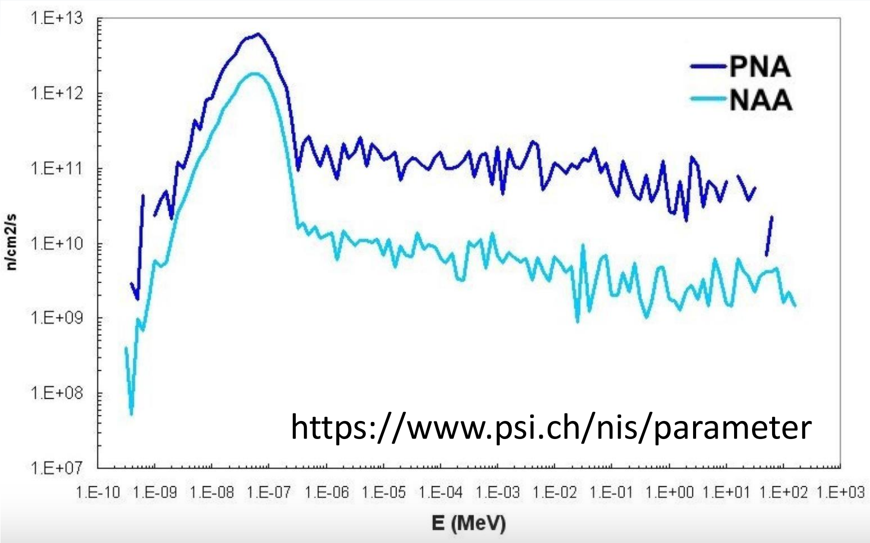
IRRADIATION TESTS


sample after irradiation

Characteristics of samples

- material: aluminum
- dimensions: $50 \times 10 \times 10$ mm^3
- supermirror coating: Ni/Ti, $m = 2$
- quantity: 3

IRRADIATION TESTS



spectrum at SINQ irradiation facilities

Characteristics of irradiation

- facility: SINQ, PNA
- neutron flux: 3.4×10^{12} n/cm²/s

	irradiation time	n-fluence [n/cm²]
sample 1	7 h	$\approx 8.5 \times 10^{17}$
sample 2	72 h	$\approx 8.8 \times 10^{18}$
sample 3	960 h (20 d)	$\approx 9.6 \times 10^{19}$

activation of sample 3

Activation of samples

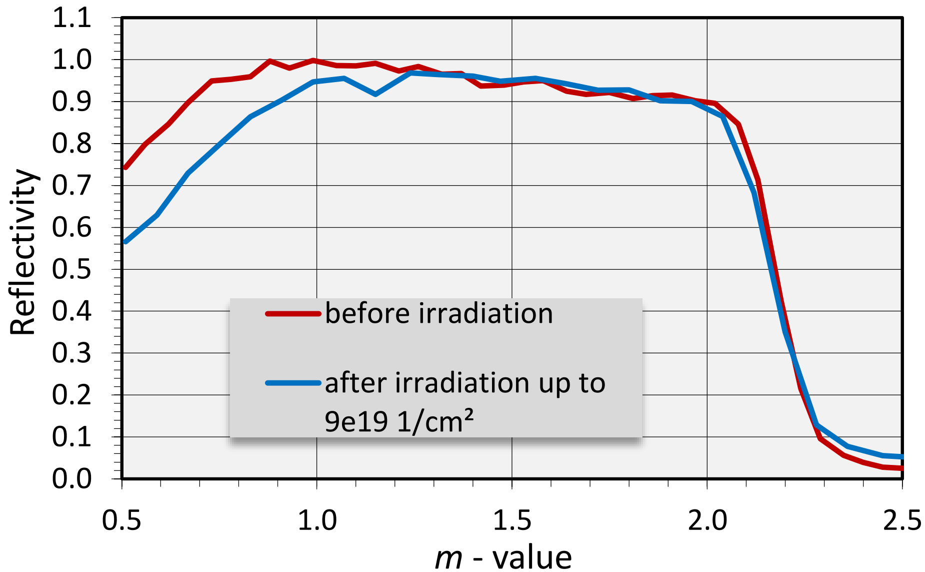
- gamma dose rate was measured approx. 4 years after irradiation

	irradiation time	gamma dose rate
sample 1	7 h	15 µS/h
sample 2	72 h	145 µS/h
sample 3	960 h (20 d)	1.41 mS/h

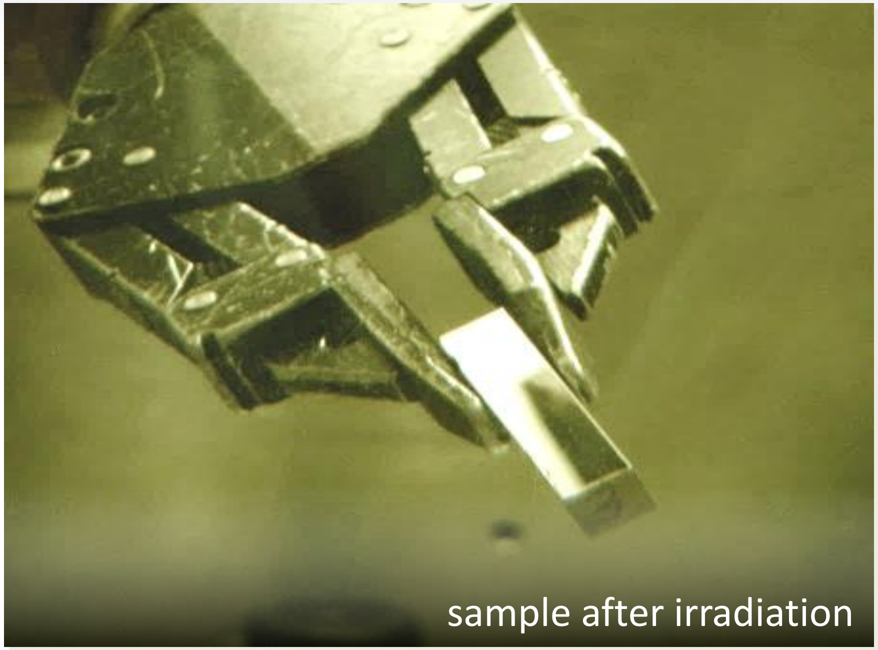
IRRADIATION TESTS

Reflectivity of supermirror

- reflectometer: NARZISS @ SINQ
- wavelenght: λ = 5 Å



IRRADIATION TESTS


sample after irradiation

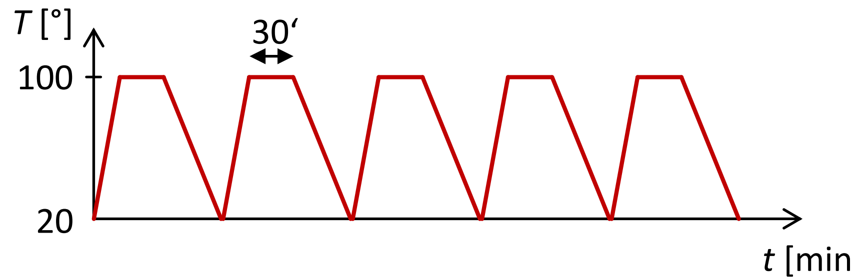
Conclusions of irradiation tests

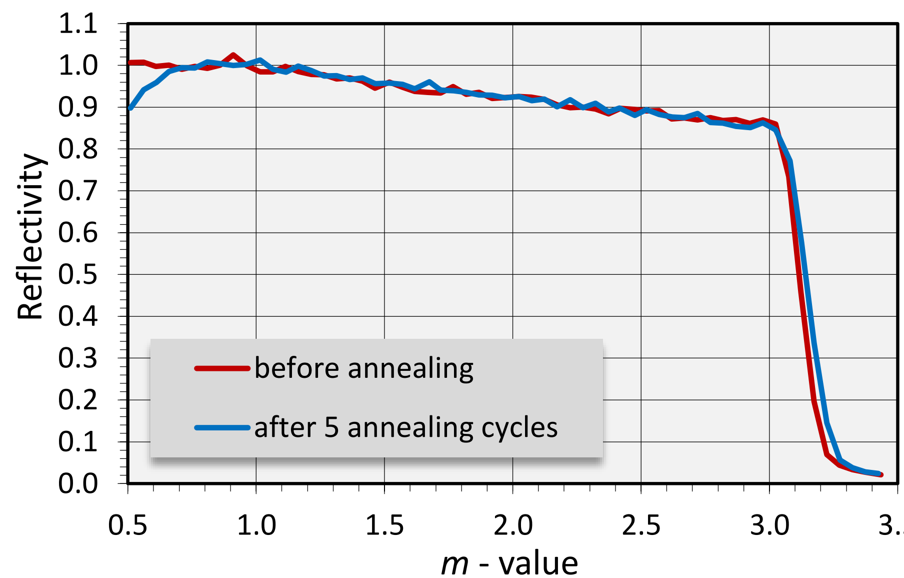
- accumulated fluence at spallation source SNIQ up to 9.6×10^{19} n/cm²
- no degradation of substrate
- no degradation of supermirror coating (no peeling, etc.)
- no degradaton of reflectivity

annealing tests @ 100 °C

Cycling of temperature

- temperature: 20° - 100°
- number of cycles: 5



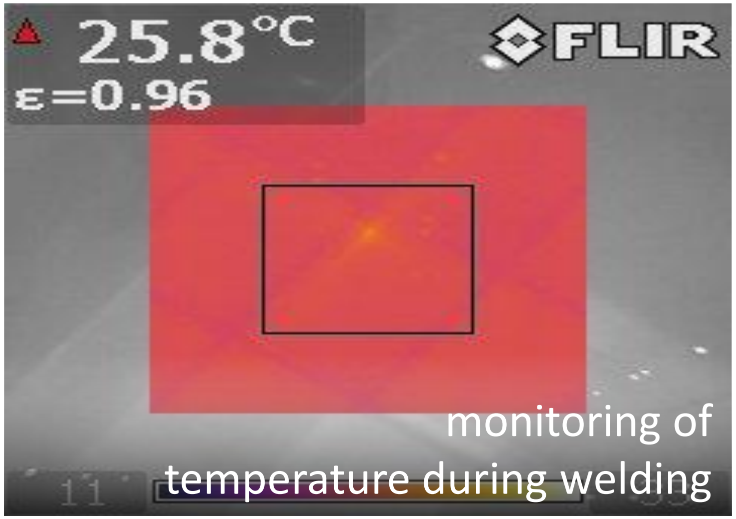


WELDED NEUTRON GUIDES

H5 @ ILL – welded assembly

H5 @ ILL
in-pile guide as welded assembly

- spatial constraints do not allow accommodation of screws
- ↳ connection of plates by welding
- temperature at supermirror coating <26°C



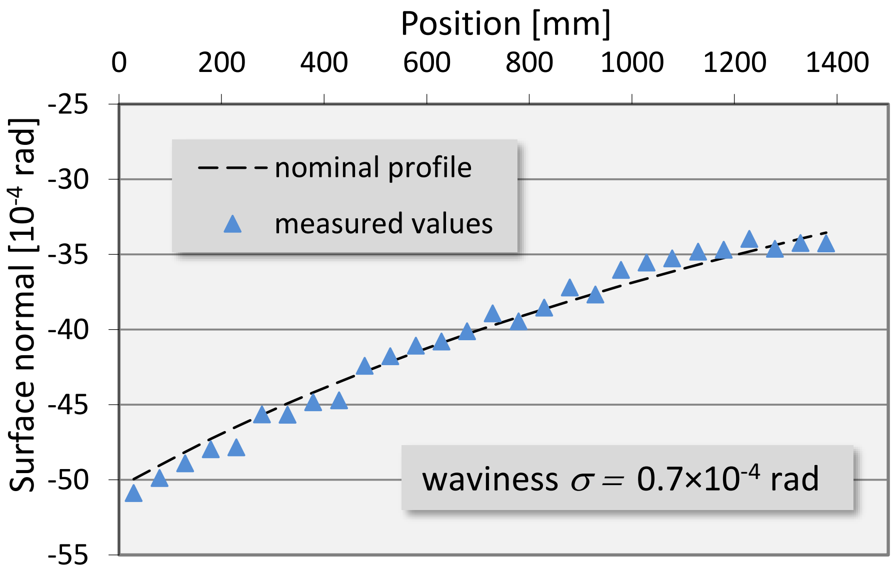
monitoring of temperature during welding

↳ vacuum tight metallic guides

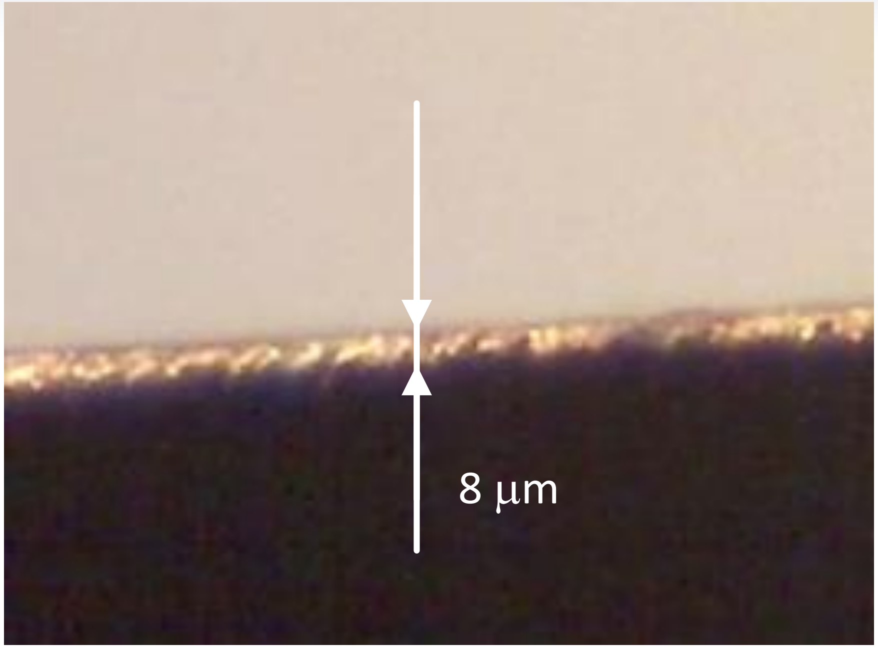
NON-LINEAR TAPERED TRULY CURVED GUIDES

POWTEX @ FRM-II
truly curved elliptic guide

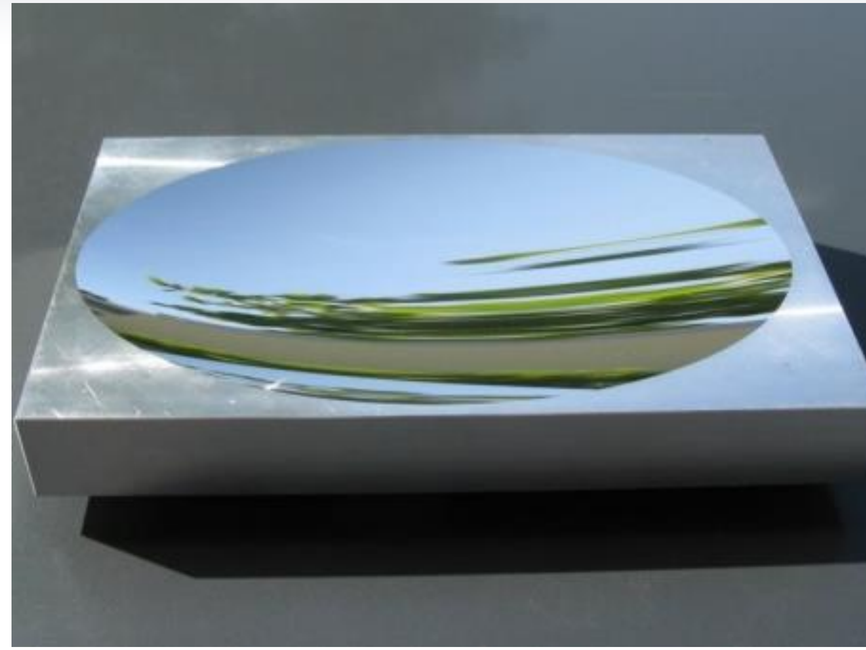
- in-pile neutron guides made from aluminum substrates
- thickness of substrates 6 mm
- truly curved elliptic guide profile



EXTENDED MACHINING OPTIONS

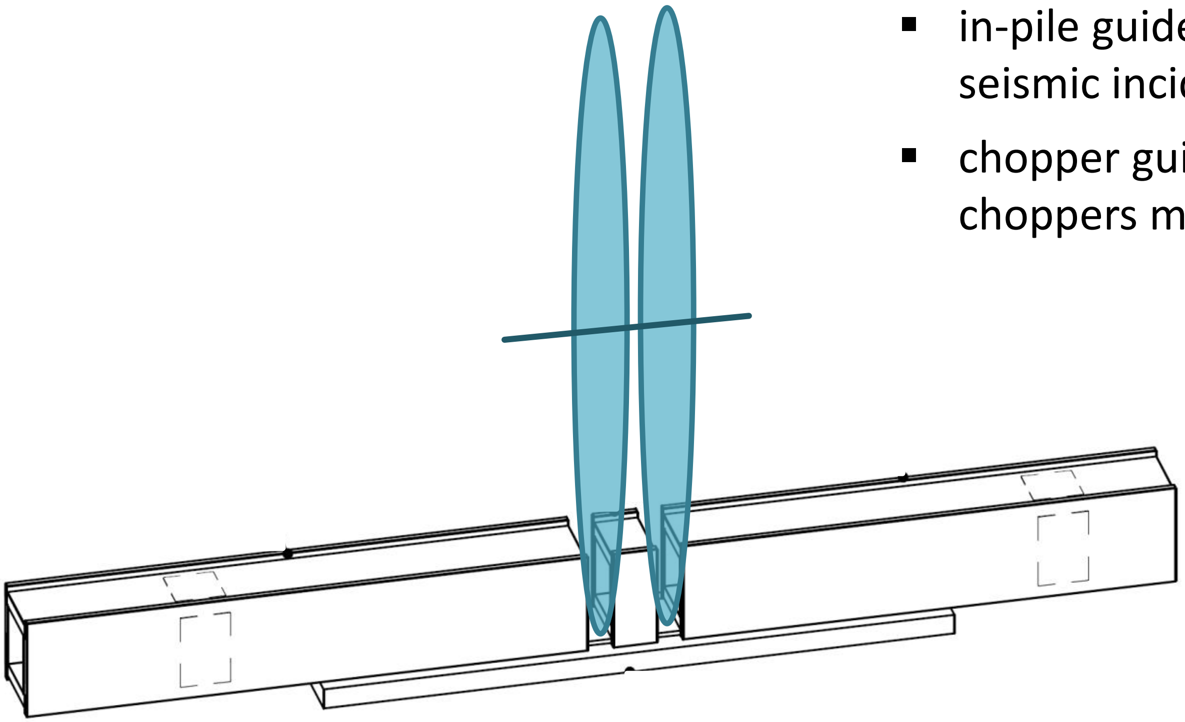


- machining of sharp and precise edges
- required for Montel optics (nested mirrors)



- 3d mirror surfaces – super-polished
- e.g. ellipsoids

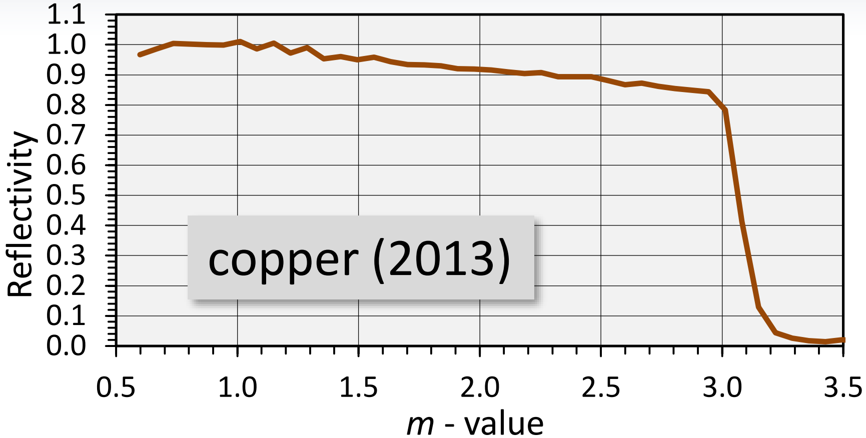
EXTENDED OPTIONS FOR GUIDE INTEGRATION

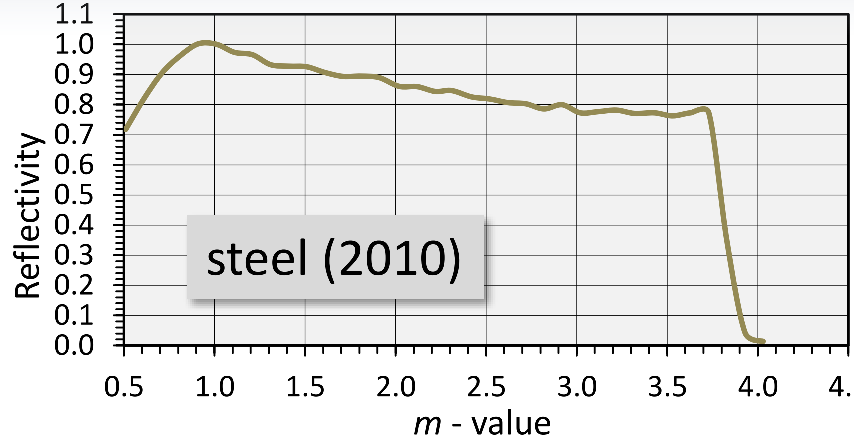


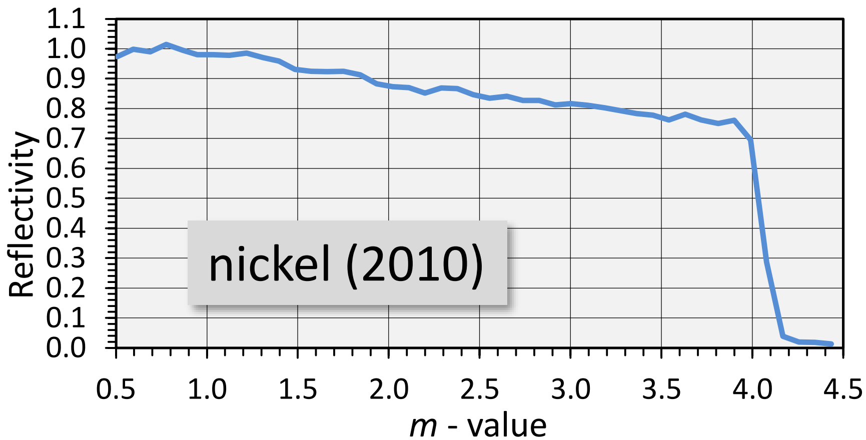
Safety aspects

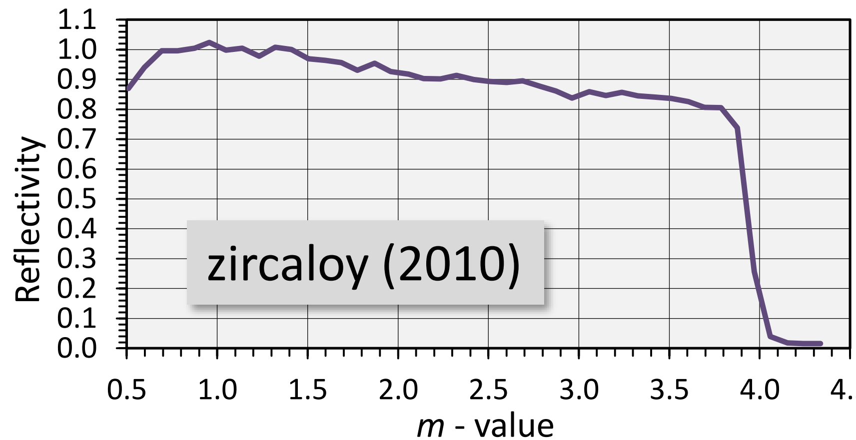
- extended options for the fixation of guide against movement at critical areas
- in-pile guides ⇔ integrity of source at seismic incidences or others
- chopper guides ⇔ vibration from choppers may cause movement of guides

ALTERNATIVE METALS



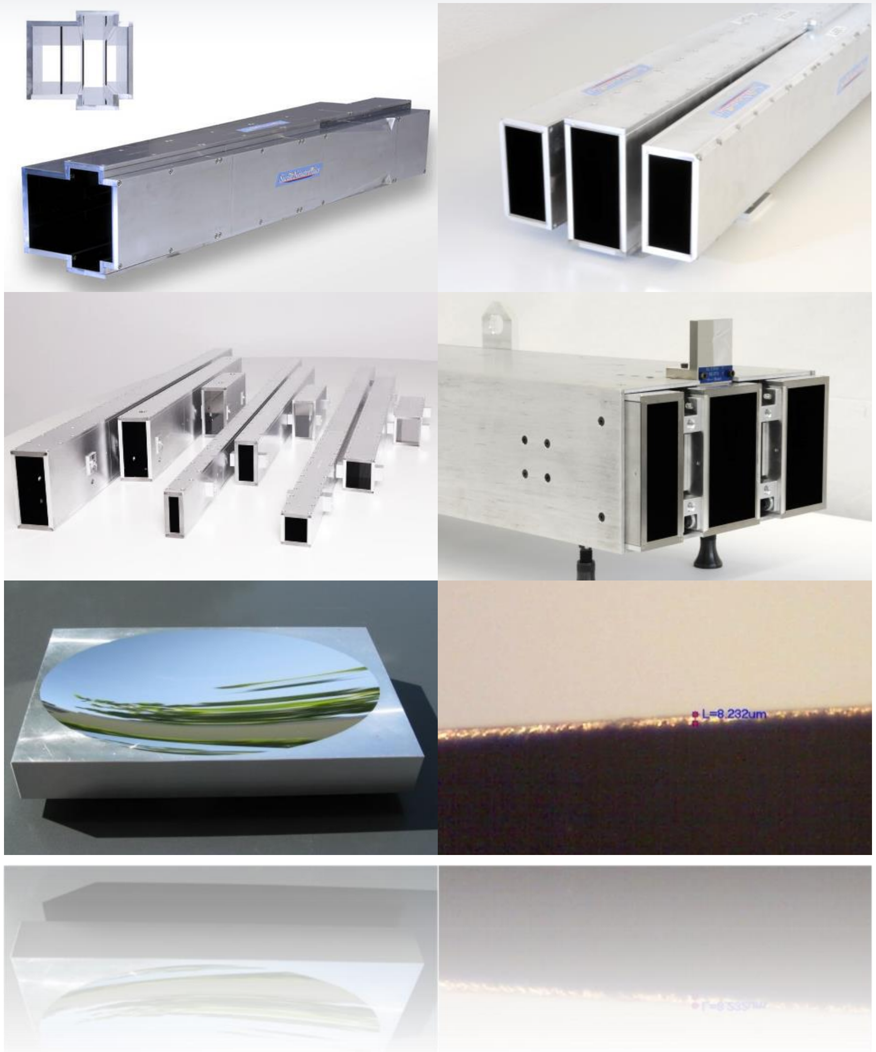






Current R&D: borated metals as a substrate for neutron optics

APPLICATIONS / CUSTOMER PROJECTS



instrument / laboratory	substrate material	year
POWTEX in-pile @ FRM-II	Al	2015
SR5b in-pile @ FRM-II	Al	2015
TOPAS in-pile @ FRM-II	Al	2015
CANDOR @ NIST	Al	2015
ESS	Al, Cu, steel	2014
CTC in-pile @ NIST	Al	2013
H5 in-pile @ ILL	Al	2013
CTE in-pile @ NIST	Al	2011
Ultra cold neutrons @ ILL	Al	2011
Montel mirrors	Al	2010
Test substrates @ ILL	Al, Ni, zircaloy	2010
SR4b in-pile @ FRM-II	Al	2010
NG-A to D in-pile @ NIST	Al	2009

CONCLUSIONS

- Supermirror with excellent reflectivity and large *m*-values are available on various metal substrates
- Robustness against irradiation and elevated temperatures is proven
- Welding => vacuum tight metallic guides
- New possibilities for design due to extended options for machining and integration

Metal substrates
⇔
solution for dedicated applications within modern guide systems

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