Technical University of Denmark

“m=1” coatings

Cooper-Jensen, C.; Klinkby, Esben Bryndt; Beaucour, J.; Bentley, P.; Zimmer, O.

Publication date:
2013

Document Version
Publisher's PDF, also known as Version of record

“m=1” coatings

C. Cooper-Jensen[1], E. Klinkby[2], J. Beaucour[3], P. Bentley[1], O. Zimmer[1]

[1]European Spallation Source ESS AB, Lund, Sweden
[2]DTU Nutech, Technical University of Denmark, Lyngby, Denmark
[3]Institut Laue-Langevin, Grenoble, France

For neutrons the critical angle of Ni is defined as m=1. If one needs a coating with reflectivity above m=1, people have traditionally used Ni58 or Ni-based multilayers. The reason to use Ni is the high neutron scattering density and the fact that it is easy to coat Ni using magnetron sputtering.

For a neutron guide the cost of shielding around the guide is a substantial part of the total cost of the guide. We are therefore looking at other materials than Ni for m=1 coatings. Both Be and diamond have the same or higher neutron scattering density than Ni, and have a much smaller absorption cross section. Because of the lower absorption cross section, and because of fewer emitted gamma ray photons when a neutron is absorbed, these coatings are producing much less gamma radiation and therefore reduce the shielding costs.

Be is frequently used in a wide range of science and technology applications. The only chemical hazard after manufacture is Be dust if the sample is destroyed. We have a sample of 276 nm Be coated on a Si wafer for these tests.

Diamond Like Carbon (DLC) coatings with 99% sp3 bindings (meaning it is very close to diamond) are made commercially using CVD techniques. In the coating there will also be about 2% H which will reduce the neutron scattering density of the coating. But the total scattering density of these coatings should still be higher than for Ni. In the very near future we will present experimental results on these mirrors.

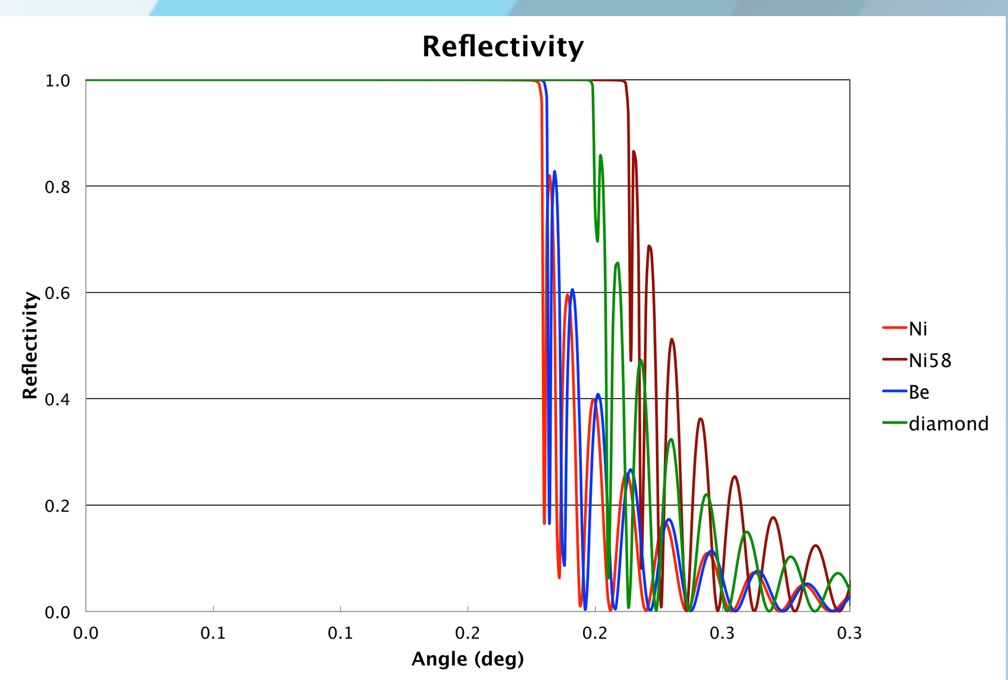
This research was funded by CRISP.

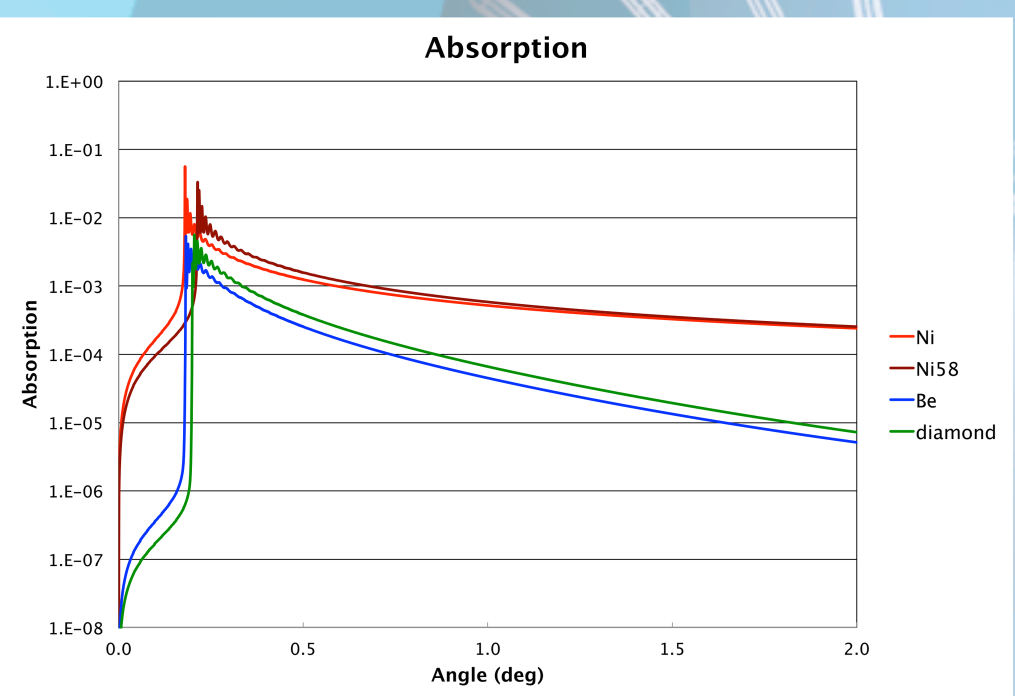
Neutron scattering density and absorption cross section for 2200 m/s neutrons.

	Neutron scattering density (1E14 m^{-2})	Absorption cross section (1E−28 m^2)	Total probability of gamma ray emitted when a neutron is absorbed	Gamma ray emitted from 300 nm thick coating* (arbitrary unit)
Be	9.63	0.0088	1.6	1.8E−7
Diamond	11.70	0.0035	1.5	2.0E−7
Ni	9.41	4.49	1.5	6.6E−5
Ni58	13.14	4.50	1.6	

www.ncnr.nist.gov/resources/n-lengths/
www-nds.iaea.org/pgaa/pgaa7/index.html
*MCNPX calculations and details given below

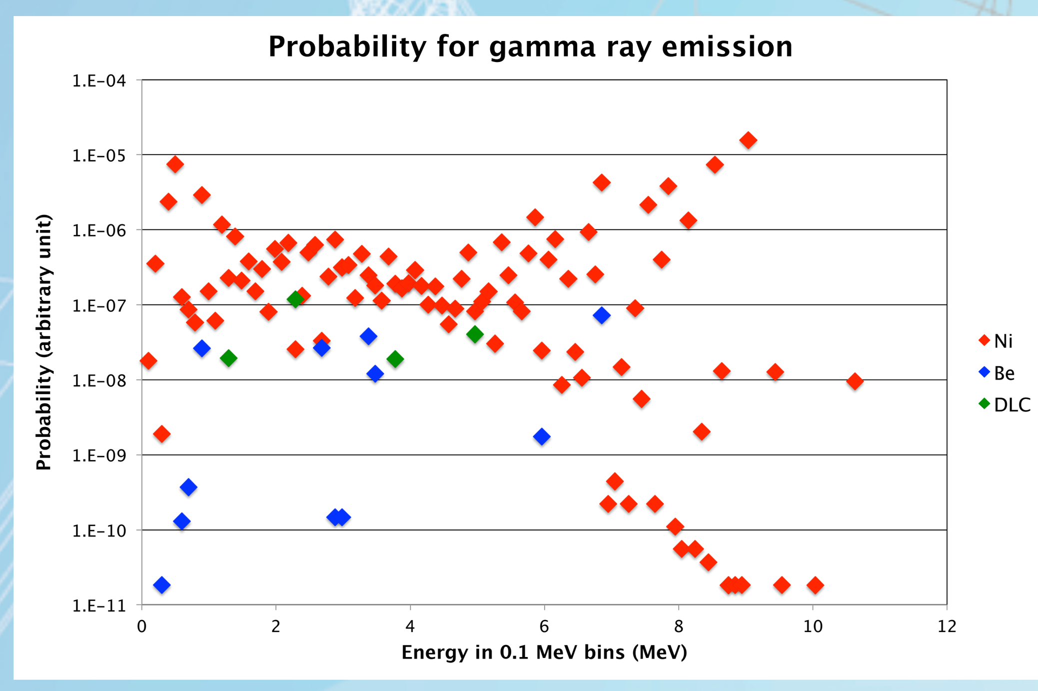
Reflectivity and absorption calculated as function of incidence angle for different 200 nm thick coatings on Si. Calculation is done for 2200 m/s neutrons using IMD with optical constants from NOP.





D.L. Windt, “IMD-Software for modeling the optical properties of multilayer films”, Computers in Physics 12, 360-370, 1998.
L. Alianelli, M. Sánchez del Río, R. Felici, “NOP: a new software tool for neutron optics”, Physica B 350, e737-e741, 2004.

MCNPX calculation of probability for emitted gamma ray as function of the gamma ray energy (0.1 MeV energy bins) from different coatings. Each coating is 300 nm thick, the incidence angle of the neutrons is 0.3 degree and 1,000,000,000 thermal neutrons (2200 m/s) are calculated for each material.



8 keV X-ray measurements of 276 nm Be on Si wafer.