Fe—Al NEUTRON POLARIZING SUPERMIRROR ON Si CRYSTAL SUBSTRATE WITH ANTIREFLECTING Cd LAYER

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In the experiments where the neutron polarization analysis technique is used both polarizer and analyzer should have high polarizing efficiency and depend only slightly on the neutron wavelength in the range from λ_1 to λ_2, which is used in the experiment. At present the mirrors-polarizers on the glass substrates are known and used with the polarizing layer 60Co40Fe and the antireflecting sublayer 85Ti15Gd [1] as well as Fe—Ag supermirrors without sublayer [2,3] and Co—Ti supermirrors on the Ti—Gd sublayer [4]. The mirror on Si crystal substrate is also known [5] with bilateral polarizing covering: the layer of 50Co50Fe for reflection from vacuum, the layer of 15Co85Fe for that from Si crystal, and antireflecting layer of 82Ti18Gd between them.

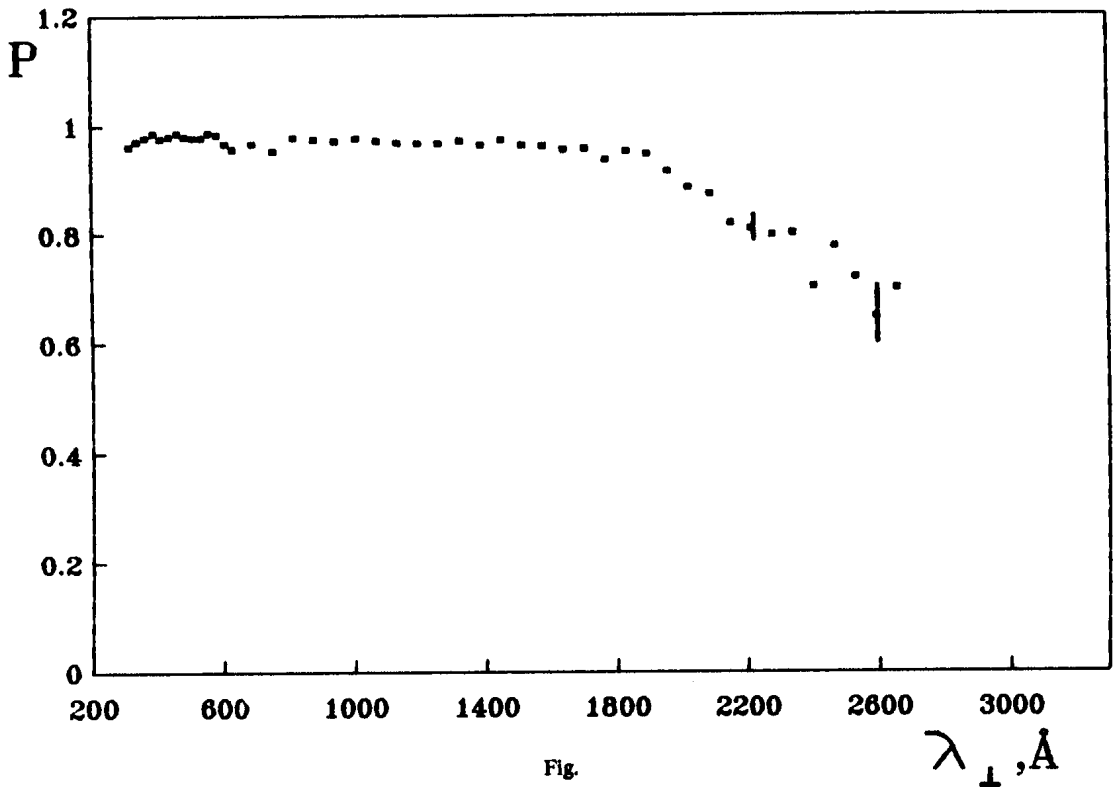

Fig.

In our opinion using the available data it is possible to compare the results in the range of "normal" wavelength from $\lambda_{|1}$ to $\lambda_{|2}$ where the mirror polarizing efficiency is $P>0.8$ ($\lambda_{|} = \lambda/\Theta$, where λ is the neutron wavelength, Θ is neutron glancing angle). The mentioned spectral range for the mirrors described in [1] which has been measured after the publication, is $\lambda_{|2}/\lambda_{|1} \approx 2.4$; for the mirrors presented in ref. [2,3] it is also $\lambda_{|2}/\lambda_{|1} \approx 2.4$. The mirror presented in [4] has considerably higher ratio $\lambda_{|2}/\lambda_{|1} \approx 10$.

The calculation and measurements [6] show that the spectral range of mirrors [1] with $\lambda_{|2}/\lambda_{|1} \approx 2.4$, used in the neutron guide is not adequate to obtain the integral polarization of beam of $P>0.9$ if there is a wide neutron beam distribution in λ.

In this paper we try to get the mirror with high reflectivity and extended range of wavelengths $\lambda_{|2}/\lambda_{|1}$, where $P(\lambda_{|})>0.8$.

The mirror which we have proposed and realized represents the substrate made of polished crystalline silicon with polarizing 35 pairs Fe—Al supermirror covering with Cd deposited on it. The falling and reflecting beams pass through the substrate. Deposition of polarizing covering is made by electron-beam evaporation in vacuum in the A700-Q device, LEYBOLD-HERAEUS. The real part of Cd scattering potential is close that of Si. The same is true for potentials of Si and Al. The Cd layer absorbs (-) spin neutrons almost completely and protects the polarizing covering from the external effects. Natural iron is used as a magnetic material with the addition of ^{54}Fe having the composition 79 ^{N}Fe21 ^{54}Fe in order to make it close to the Si and Al potentials for the (-) spin neutrons.

The measurements of polarizing efficiency $P(\lambda_{|})$ have been performed using the time-of-flight spectrometer of polarized neutrons at the WWR-M reactor, LNPI. It can be seen from the picture that the spectral range for polarizing efficiency $P>0.8$ for Fe—Al supermirror is $\lambda_{|2}/\lambda_{|1} \approx 7$. This value is essentially higher than those in [1,2,3] and is comparable with the result of [4].

The calculation shows that using the mixture 43 ^{N}Dy57 ^{162}Dy as an antireflecting layer, and 35-pair Fe—Al supermirror as the polarizing covering one can enlarge the wavelength range for $P>0.8$ and reach $\lambda_{|2}/\lambda_{|1} \approx 35$. The supermirror having such an antireflecting layer will be better by its polarizing properties than the supermirror used in [4]. This will allow to polarize the spectra of any width in λ which are used at research reactors. Moreover, the use of this supermirror in multichannel curved polarizers will allow to

decrease essentially their length in comparison with the polarizers using the mirrors on the glass substrates [4] due to the high ratio of the transparent substrate thickness to that of the antireflecting layer.

References

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