Fabrication of ^{93}Nb target on lead backing using cold rolling

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Introduction

Fabrication of target-backing combination foils of desired thickness plays crucial role in experimental nuclear physics. The selection of proper target of appropriate thickness is necessary to get desired reaction channel yields. In order to measure the lifetime of excited nuclear states using the Doppler Shift Attenuation Method (DSAM) [1], a very thin target of uniform thickness, high purity, homogeneity and high-Z material backing is essentially needed. These conditions ensure minimum energy loss of recoiling nuclei in target, minimum interference from undesired reaction channels and minimization of air gaps between target and backing. Fabrication of such specific thin targets requires special techniques depending on the physical & chemical properties of the material. Our primary aim is to find the lifetime of the excited states of ^{118}Xe which requires ^{93}Nb ~1 mg/cm^2 target with high Z material backing to stop the recoiling nuclei. Niobium is a soft, malleable metal having melting and boiling point as high as 2410°C and 5100°C respectively. Due to its malleable nature, cold rolling is the best method to obtain mechanically strong foils of thickness ~ 1 mg/cm^2. The target was fabricated with the help of rolling machine available at Inter-University Accelerator Center (IUAC), New Delhi.

Experimental Details

Metal rolling has been defined as deforming the metal shape by putting it under comprehensive stress by means of heavy rollers at different pressure. Pressure between the heavy rollers can be varied using the pressure control screw provided. A picture of such rolling machine, available at inter university accelerator center (IUAC), New Delhi is used in the present work is shown in Figure 1. Procedure for different metals vary depending on the mechanical properties, purity and starting shape of the metal. Stainless steel pack is usually used in which metal sheet is inserted while rolling under heavy rollers. Cleanliness of the environment is another important aspect of cold rolling. Any tiny dust particle on foil surface can lead to pinholes or tearing of foil, hence rolling should be performed in a dust free clean environment.

Fabrication of Nb foil

Due to high malleability of Nb, rolling is the best suited technique to fabricate Nb foils of thickness ~ 1mg/cm^2. Niobium metal was available in the form of sheet which is suitable for cold rolling. In cold rolling, small sheet of Nb metal was inserted in the SS pack and then allowed to pass through the heavy rollers of the rolling machine under the controlled pressure. Rolling was initiated at the lowest possible pressure as immediate stress can lead to breaking of foil. Pressure was increased slowly using the pressure control knob provided and SS pack containing Nb sheet was allowed to pass under the heavy rollers for multiple times. The monitoring of thickness of the Niobium foil after every 12-15 rolls was estimated by calculating mass by area ratio. Once thickness of Nb foil reaches around 5 mg/cm^2, extreme care was taken while rolling, condition of Nb foil was checked after every 5-6 rolls as it starts sticking on the mirror surface of rolling pack due to adhesion between them. Alcohol drops and butter paper were used to bring thin Nb foil out of the SS pack. Nb foil was rolled down successfully to thickness ~ 1.4 mg/cm^2 using cold rolling method.

Figure 1. Photograph of rolling machine at IUAC.

Fabrication of Pb foil

High Z material backing of appropriate thickness is highly essential for lifetime measurement of excited states using doppler shift attenuation method (DSAM) technique. Thick backing is used so that all the recoils gets stopped in the backing. Lead is a high-Z, very soft, dense, ductile and highly malleable material. Due to high malleability, it can be easily rolled to desired thickness. Small sheet of natural Pb was put into the SS pack and then allowed to roll repeatedly under the cylindrical shaped rollers of the rolling machine. One-way rolling technique was used to roll lead as it is very soft material, two-way rolling will lead to non-uniformity of lead foil which will ultimately result in tearing of the foil. Also, due to its softness lead was sticking to polished mirror surface of SS pack. To avoid sticking of lead to polished surface, alcohol was used while rolling so that it keeps floating while rolling and does not stick to the surface. Pb was rolled successfully and foils of desired thickness (~14 mg/cm^2) were obtained.

Rolling Niobium & lead together to form backed target

In order to make the backed target, the 1.4 mg/cm^2 ^{93}Nb foil and 14 mg/cm^2 Pb placed on top of each other & then allowed to roll one-way under the hard rollers inside SS plate. The foils stick together during this rolling ensuring there is no air gap in between.

Figure 2. Picture of fabricated ^{93}Nb and Pb backing target.

Conclusion

Pb-backed ^{93}Nb target of desired thickness was successfully fabricated using cold rolling method. This backed monoisotopic Nb target was used recently in the lifetime measurement experiment using DSAM technique. Thickness using EDXRF technique has been measured and found out to be 0.87 mg/cm^2 and 5 mg/cm^2 for Nb and Pb respectively.

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