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Positron reemission from clean and LiF coated W(100): Effect of oxygen exposure

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Abstract. Positron reemission has been measured from clean and oxygen exposed W(100), as well as W(100) with LiF deposited on the surface at an incident positron energy of 600eV. The reemitted positron yield was found to be much lower from LiF deposited W(100) than from clean W(100). Oxygen exposure caused a drastic reduction in the reemission yield from W(100) but did not cause any major changes in the LiF deposited sample.

1. Introduction

Tungsten is one of a number of materials with a negative work function for positrons, emitting thermalised positrons with a kinetic energy equivalent to its work function. Its simplicity of use has led frequently to its use as a moderator in slow positron beams for many years in many laboratories [1]. The experimental results for various parameters that influence the positron reemission yield and other associated parameters of reemission vary considerably among different samples. For example, oxygen adsorption on GaAs(100) was shown to enhance the reemitted positron yield because of reduction in the Ps yield by the conversion of Ps atoms to positrons at the surface [2]. Lynn and Lutz, in measurements on Al(111) and Al(100), showed that oxygen exposure increases positronium formation and reduces the positron reemission yield [3].Suzuki *et al.* reported a significantly higher positron reemission yield from W(110) and polycrystalline tungsten foil when the samples were exposed to 10^{-7} mbar of O_2 and held at a temperature of 900-1000 ºC [4], and in contrast at room temperature, oxygen exposure caused a reduction in the positron reemission yield in W(100) [5]. Recipes for conditioning of moderators such as tungsten have been optimized over the years by trial and error, however, the physics governing the conditioning procedures is not fully understood and calls for further investigation. In the present experiments, the influence of oxygen exposure on the reemitted positron yield and energy spectrum have been measured for clean W(100) and W(100) with over layers of LiF.

2. Experiment

Reemission measurements were performed using the electrostatic slow-positron beam at The University of Western Australia. Details of the positron beam and associated experimental facilities

are described in Ref. 6. The W(100) single crystal was cleaned by heating the crystal to about ~1200 ^{0}C in the presence of oxygen (10^{-8} mbar) for 5 min and followed by a high-temperature flash at ~2400 ^{0}C using electron bombardment. The procedure was repeated until no further improvements in the thermal-positron yield could be observed. For oxygen exposure studies, the sample was allowed to cool for 1.5 hours before admitting oxygen into the chamber. LiF was evaporated onto the W(100) surface and the amount of LiF was measured using a microbalance under identical conditions. The reemitted positron yield was measured as a function of time using a large acceptance angle retarding field analyser in order to ensure good collection efficiency. Since our detection system is at a fixed angle of 45° with respect to the beam direction, the angle of the sample was changed so that positrons emitted in the direction normal to crystal surface reached the detector. In that way the positrons from the beam were incident on the crystal surface at an angle of 45°.

3. Results and discussion

The retarding curves of reemitted positrons in the direction normal to the crystal surface were recorded for clean W(100) and W(100) with over layers of LiF; these are shown in Fig.1. The negative of the derivative of this curve gives the energy spectrum of the emitted positrons (also given in Fig.1). As seen from the figure, the reemitted positron intensity in the direction normal to the surface reduces with increasing thickness of LiF deposited on the surface. There were no new peaks in the LiF reemitted positron energy spectra showing that LiF has a positive or near zero work function for positrons. The reemitted positron energy spectrum from LiF coated W(100) is broader, has a marginally higher contribution in the low energy range and a lower mean energy than clean W(100). These features might be due to either greater contribution from inelastic scattering of positrons in the LiF over layers or modified work function of the material due to the change in the surface dipole.

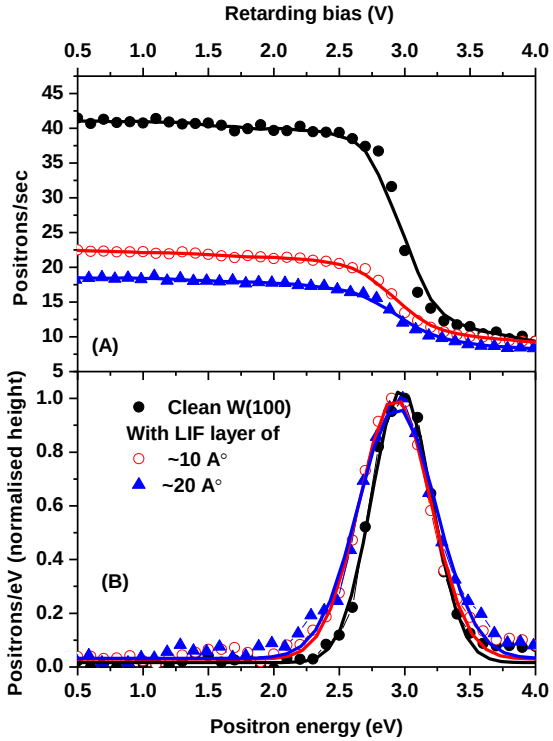

Fig.1.(A) Retarding curves of positrons and(B) reemitted positron energy spectra in the direction normal to the surface from clean W(100) and from W(100) with over layers of LiF. The incident positron energy is 600 eV.

Clean W(100) and about 20 Å of LiF coated W(100) were exposed to O_2 at a pressure of 1×10^{-8} mbar and retarding curves of the reemitted positrons were recorded at voltage steps of 0.5 eV. Positrons in the energy range of 2 to 4 eV were taken as reemitted positrons. The yield as a function of

oxygen exposure time from clean and from LiF coated W(100) are shown in Fig.2. The yield at zero exposure time has been normalized to unity. It can be seen that the reemitted positron yield decreased exponentially with oxygen exposure time in case of clean W(100) while there was no significant change for the LiF coated W(100).

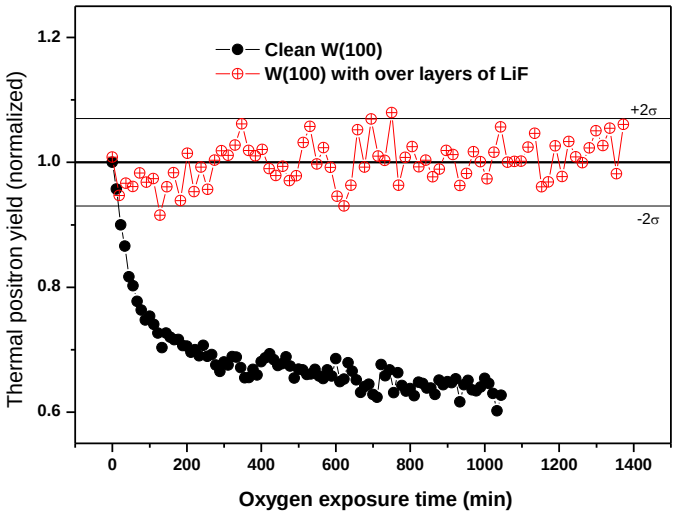

Fig.2. Change in positron reemission yield with oxygen exposure time. The yield is normalized to the yield without oxygen exposure. Oxygen pressure is 1×10^{-8} mbar.

To monitor changes in the reemitted positron energy spectra due to oxygen exposure, retarding curves of remitted positrons in the direction normal to the surface were recorded on samples exposed to oxygen for about 15 hours.

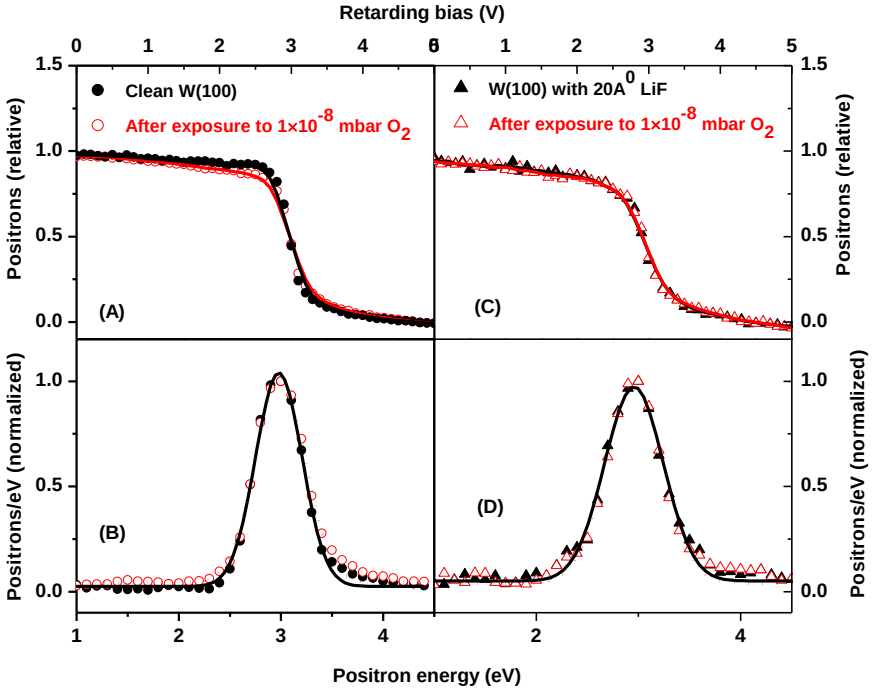

Fig. 3 (A) Retarding curves of reemitted positrons from clean and oxygen exposed W(100). (B) Energy spectra of reemitted positrons from clean and oxygen exposed W(100). (C) Retarding curves of reemitted positrons from LiF coated W(100) with and without oxygen exposure. (D) Energy spectra of reemitted positrons from LiF coated W(100) with and without oxygen exposure.

Retarding curves of reemitted positrons from oxygen exposed samples of W(100) and LiF coated W(100) are shown in Figs 3A and 3C, along with those taken before oxygen exposure. The corresponding reemitted positron energy spectra are also shown in Figs 3B and 3D. For W(100), oxygen exposure caused a reduction in the yield of reemitted positrons and increased the contribution from inelastically scattered positrons. However, for the LiF covered sample, oxygen exposure did not change either the positron reemission yield or any other parameters associated with the energy spectra. This might be due to a low sticking coefficient for oxygen on LiF compared to W(100).

4. Conclusion

Positron reemission spectra were measured from W(100) and LiF coated W(100), before and after exposure to oxygen at a pressure of 1×10^{-8} mbar. The positron yield was also determined as a function of oxygen exposure time. In the case of clean W(100), oxygen exposure caused an exponential decrease in the reemission positron yield. Oxygen exposure also caused an increase in the fraction of inelastically scattered positrons. Although the LiF coated sample showed a lower reemission yield than clean W(100), the yield was insensitive to oxygen exposure. Also the clean W(100) surface gave higher reemission yields, the yield was very sensitive to surface cleanliness. Although the presence of oxygen or LiF on clean W(100) decreased the reemission yield, they appeared to be helpful in maintaining constant reemission yield.

5. References

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