Diffraction methods are the most reliable nondestructive methods of measuring residual stress. X-ray diffraction is restricted to penetration depths of some 10 µm, whereas neutron diffraction can provide information at significantly higher depths, but the cost is very high and the availability of facilities is much lower. A sensitive nondestructive probe of defect and stress measurements in thick materials (tens of cm) does not exist. The first highly penetrating system to measure stress/strain in thick materials based on using bremsstrahlung beams from small electron accelerators (3-6 MeV Linacs), will be presented. These bremsstrahlung beams, which exhibit excellent penetration, create positrons inside the materials via pair production. The positrons annihilate with the material electrons emitting 511 keV radiation, which is influenced by the momentum distributions of the atomic electrons. Because of the fact of positron trapping at defects, Positron annihilation is very sensitive to any change in the microstructure and it can probe nano-void defects. Open volume defects, voids or dislocations are clearly reflected in the line width of the 511 keV peak. Residual stresses have been measured in steel of several cm thick using this technique. This technique can be used to infer residual stress and defects in crystals, polymers, metals and alloys for material science and engineering applications. The low cost and small size of small electron accelerators, and the high penetrability of MeV bremsstrahlung beams allow the development of portable systems for commercial and industrial applications.

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