Invited Paper

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Abstract:

Stainless steel is one of the most used construction materials in vacuum technology. Especially in XHV applications a high temperature treatment (vacuum firing) is commonly used to reduce outgassing of this material. There is a considerable body of work on outgassing of hydrogen from stainless steel. The results are basically described by two models: the diffusion limited model and the recombination limited model. Since recombination is strongly related to surface morphology and composition, surface characterization has been performed by atomic force microscopy (AFM) and scanning tunneling microscopy (STM). The surface near composition has been measured by atom probe depth profiling analysis. After vacuum firing a significant change in surface morphology can be observed in AFM and STM. The high temperature treatment leads to a complete reconstruction of the surface. The recrystallization process leads to an increase of the overall surface roughness with deep grooves up to 1000 nm in depth at the grain boundaries. On top of the crystallites wide flat terraces over 100 nm in width bounded by bunched atomic steps and facets can be observed. The high resolution STM micrographs additionally show stacking faults and local defects on these terraces assigned to (111) planes. The atom probe depth profiling analysis on vacuum fired samples results in a noticeable surface enrichment of nickel and certain depletion of chromium in the first atomic layer. In the second atomic layer chromium enrichment was measured. From the knowledge of surface structure and surface composition a recombination limited outgassing is very unlikely. Comparison with experimental studies on hydrogen desorption by thermal desorption spectroscopy strongly support the explanation by the diffusion limited model. It can be assumed that subsurface defects form traps with different energetic levels. The increase in diffusion energy after emptying the higher subsurface levels may also explain the observed outgassing behaviour of stainless steel.

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