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The adsorption-sputtering-dissociation-deposition model in plasma nitriding

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The sputtering and deposition mechanism is widely accepted as the main mechanism of plasma nitriding technology which has been widely employed in industry. However, the details of reactive sputtering and the behaviors of sputtered particles in plasma remain unclear. In the work, the sputtering and deposition mechanism is experimentally and theoretically studied from the view of plasma chemistry and plasma transport theory using plasma source nitriding of iron-based materials. Nitriding dose is employed to quantify the nitriding effect on metallic workpieces. According to the possible generation mechanisms and steady diffusion equations of iron nitrides, a function is established to describe the relationship that nitriding effect changes exponentially with the distance between workpieces at floating potential and cathodic sputtering source. The experiments in plasma source nitriding that nitriding effect decreases with the distance allow the relationship to be simplified and described as the “adsorption-sputtering-dissociation-desorption” model. The model indicates that iron nitrides are the only media that transport nitrogen species in plasma and completely generated by high energy ions on cathode surface and partially dissociated by collision with electrons in plasma. In contrast to existing plasma nitriding models, only way of iron nitrides generations by reactive sputtering is verified and the dissociation of iron nitrides in plasma is emphasized. The sputtering rate of iron nitrides is calculated to optimize nitriding process parameters under a certain supplied power. The dissociation is also calculated to decrease nitriding effect about two times for every increase of the distance between metallic workpieces and cathode by 100 mm during plasma nitriding.

Keywords
Plasma nitriding
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Reactive sputtering
Dissociation
Iron nitrides