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Non-Vacuum Plasma Nitriding with Nitrogen-Based Gases

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In contrast to the conventional nitriding techniques with low-pressure plasmas, our original nitriding utilizes atmospheric-pressure plasmas. The advantages of the atmospheric-pressure plasma nitriding include that vacuum equipment is unnecessary, that the treatment process is simple, and that the capital cost is low. We have developed a novel atmospheric-pressure plasma nitriding using the pulsed-arc (PA) plasma jet with nitrogen-based gases. The PA jet nitriding is available for a partial surface area of steels and titanium alloys. Here, we detail recent demonstration of nitriding to austenitic stainless steel.
Stainless steels are relatively difficult to perform nitriding to because of the barrier effect of passive layer against nitrogen diffusion. In the conventional low-pressure plasma nitriding, the passive layer is removed by ion sputtering. On the other hand, ion sputtering is not available in atmospheric-pressure plasmas for too short a mean free path. To overcome this issue, we control the hydrogen addition to the operating nitrogen gas to reduce the passive layer. Without hydrogen addition, the expanded austenite phase, a nitrided layer formed on austenitic steel, cannot be produced owing to the passive layer. However, adding hydrogen at the flow ratio of 1 to 5% provides the expanded austenite phase. This is the first achievement of expanded austenite formation by atmospheric-pressure plasmas. Here, the thickness of the expanded austenite layer tends to decrease with increasing the hydrogen flow ratio. In the conference, we discuss the method in which the hydrogen flow ratio is purposely changed in the middle of treatment process to provide a thicker expanded austenite layer.
Moreover, the feasibility of another atmospheric-pressure plasma nitriding with dielectric barrier discharge is also presented.

Keywords
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